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Volume III (Poster Papers)

25th Asian-Pacific Weed Science Society Conference

Hyderabad, India

Organized by

Indian Society of Weed Science

In collaboration with

Indian Council of Agricultural Research
Directorate of Weed Research
PJT State Agricultural University

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Cover page: Major weed species in the Asian-Pacific region (in sequence): *Cyperus*, *Ageratum*, *Parthenium* (croplands), *Chromolaena*, *Mimosa*, *Saccharum (*non-croplands), and *Striga*, *Orobanche*, *Cuscuta* (parasitic) (Designed by: Mr. V.K.S. Meshram and Mr. Sandeep Dhagat, ICAR-DWR, Jabalpur, India)

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PREFACE

Weeds are a major biotic constraint in agricultural production systems worldwide. Besides reducing crop yield and quality, these unwanted plants adversely affect biodiversity, animal health and environmental security. In fact the problem of weeds is as old as the agriculture itself as almost all crop plants have been domesticated from their wild relatives only. Despite the development of weed management technologies, the weed related problems have been virtually increasing. This is due to adoption of so-called modern cultivation methods which also promote the growth of weeds. The threats posed by climate change, globalization, herbicide resistance development in weeds and commercialization of herbicide-tolerant crops are bound to accentuate the problem.

Realizing the growing weed infestations in the cropped and non-cropped lands, agricultural scientists of the world have been undertaking research and sharing their findings at various platforms. One such initiative was taken way back in 1967 when weed scientists of 22 countries of the Asian-Pacific region met at the Hawaiian Island of Kauai to establish linkages and discuss what should be done in weed science in this part of the world. This meeting led to the birth of the Asian-Pacific Weed Science Society, and since then, the Society has grown and developed into a major regional and international weed science society.

Over the years, the discipline of weed science has also developed in many countries of the region and professional societies dealing with the subject have been established for mutual exchange and sharing of knowledge. Besides organizing various activities including conferences and symposia at the national level, these professional societies have also been providing a platform for sharing of international experiences on emerging issues in weed science. The APWSS has been providing a major platform for these regional weed science societies for organizing the APWSS Conferences every two years. These Conferences have been organized in different countries of the Asian-Pacific region like Philippines (1969, 1983, 2003), Malaysia (1971, 1997), New Zealand (1973), Japan (1975, 1995), Indonesia (1977, 1991, 2013), Australia (1979, 1993, 2011), India (1981), Thailand (1985, 1999), Taiwan (1987), Korea (1989), China (2001, Vietnam (2005), Sri Lanka (2007) and Pakistan (2010) by the respective weed science societies. It is matter of great honour for the weed scientists of India to organize the 25th Asian-Pacific Weed Science Society Conference after a gap of 34 years since the 8th APWSS Conference was held at Bengaluru in 1981.

On the special occasion of the Silver Jubilee of the APWSS Conferences being organized at Hyderabad, India during 13-16 October, 2015, a series of publications were brought out on the status of weed science research in the Asian-Pacific region. This compilation is based on the contributory articles presented in the poster sessions of the Conference. A shortened version of each article is presented as an Extended Summary highlighting the salient achievements made by the authors. A total of 627 articles are included in this Volume under 19 different themes. The members of the publication committee (Dr. B.S. Chauhan, Australia; Dr. M.D. Reddy, Hyderabad; Dr. J.S. Mishra, Patna; Dr. G.N. Dhanapal, Bengaluru; Dr. Gita Kulshreshtha, New Delhi; Dr. C.T. Abraham, Thrissur; Dr. Sushil Kumar, Jabalpur; Dr. Shobha Sondhia, Jabalpur; Dr. K.A. Gopinath, Hyderabad; Dr. T.K. Das, New Delhi; Dr. C. Chinnusamy, Coimbatore; Dr. A.N. Rao, Hyderabad; Dr. M.B.B. Prasad Babu, Hyderabad; Dr. M.T. Sanjay, Bengaluru; Dr. Prashant Bodake, Nasik) and Convener, Dr. TVR Prasad under the Chairmanship of Dr. S.V.R. Shetty have undertaken the voluminous task of compiling, editing and presenting these articles in a systematic manner. It is hoped that this volume will be useful to scientists, teachers, students, administrators and policy makers who are concerned with weed management in respective countries.

The financial assistance received from Research and Development Fund of National Bank for Agriculture and Rural Development (NABARD) towards this publication is gratefully acknowledged.

13 October, 2015

Dr. N.T. Yaduraju
President, APWSS

Dr. A.R. Sharma
Organizing Secretary

ACKNOWLEGDEMENTS

Publication Committee of the 25th APWSS Conference is pleased to present the Volume-III of e-Proceedings (poster papers) containing the general papers submitted by the weed science community for presentation in the Conference. For some of the members of the Publications Committee this is the second opportunity to participate in the editing of the papers received, the first being about 34 years ago when the 8th APWSS Conference was held at Bangalore, India. The Committee received a large number of papers covering a wide range of themes from 14 countries. The papers were reviewed by the members of the committee and others invited for both technical content and editorial quality. Additionally, the editors were requested to grade the papers for their quality so that priority could be given for higher quality papers for oral presentations. Given the large number of papers received and the short time period available, most of the reviewers completed the process of editing meticulously and on time. Some of the senior editors worked tirelessly always willing to take extra load and volunteering to complete the process of editing in a very short time period.

The Publication Committee noted that though the papers, in general, covered the main theme of the Conference well, the number of papers on weed control in individual field crops far outnumber than those on other sub-themes. Further, papers on chemical weed control / herbicides are many but very few papers focused on other control measures and habitat management approaches in integrated cropping/farming systems. The papers on other relevant sub-themes, such as economics, ecology, weed utilization, weed science education, participatory research are also minimal. It is hoped that some of these neglect areas / gaps would be addressed adequately during the Symposia and lead/plenary paper presentations. It was noted that large number of papers clearly highlighted the role of weed science in contributing to agricultural productivity. However, only a few papers focusing on other developmental challenges as biodiversity conservation, environmental degradation and climate change were received indicating that weed science addressing these global challenges is yet to be intensified in the Asian–Pacific region.

We thank Dr. N.T. Yaduraju, President, APWSS and Dr. A.R. Sharma, Organizing Secretary, 25th APWSS Conference for give us this opportunity and proving their guidance and full support for bring out these proceedings. We also thank all the authors for submitting articles for presentation at this prestigious Conference. Special assistance provided by the following scientists in editing the articles and completing the assigned work within the specified time is gratefully acknowledged: Dr. Anil Kumar, Jammu; Dr. C. Chandrika, Tirupati; Dr. C. Sarathambal, Jabalpur; Dr. D.J. Rajkhowa, Shillong; Dr. J.P. Deshmukh, Akola; Dr. J.S. Mishra, Patna; Dr. Jayanta Deka, Jorhat; Dr. K.A. Gopinath, Hyderabad; Dr. M.D. Reddy, Hyderabad; Dr. M.T. Sanjay, Bengaluru; Dr. Meenal Rathore, Jabalpur; Dr. Narender Kumar, Kanpur; Dr. Neelam Sharma, Palampur; Dr. P. Janaki, Coimbatore; Dr. R. Poonguzhalan, Karaikal; Dr. Simerjeet Kaur, Ludhiana; Dr. T. Ramprakash, Hyderabad; Mr. Subhash Chander Singhariya, Jabalpur; Mr. Vikash Chander Tyagi, Jabalpur and Dr. V.S.G.R. Naidu, Rajahmundry. We admire the efforts of the team led by Mr. Gyanendra Singh in processing and formatting of all the articles, and bringing out the proceedings in a record time.

13 October, 2015 **Publication Committee**

Contents

Theme 1

Weed biology and ecology

Weed suppression ability of two rice varieties in aerobic rice

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Weeds have been a major biotic constraint in aerobic rice system of rice cultivation due to 1) wide diversity in weed flora, 2) simultaneous germination of rice and weeds and 3) conducive aerobic conditions for weed growth. The extent of yield loss due to weeds varies from 50-100% depending on the cultural methods, rice cultivars and associated weed species density and duration of competition. Although herbicides have been the economical method of weed control, the degree of weed control achieved by herbicides may vary with rice cultivar as genetic variation in their competitive ability against weeds exist. Enhancing crop competitiveness against weeds could reduce weed control costs by 30% (Sanint *et al.* 1998) and its harnessing can be important for weed management in aerobic rice.

METHODOLOGY

A field experiment was conducted during the summer 2012 and 2013 at Punjab Agricultural University, Ludhiana, India. The experiment was laid out in a split-plot design with two cultivars (PR 114, of 145 days (d) duration; and PR 115, of 125 d duration) as main plots treatments and 12 weed control timings [weedy and weed free conditions, each of which, maintained until 14, 28, 42, 56, and 70 days after sowing (DAS) and until crop harvest]as the sub-plots treatments. rice was sown at 25 kg/ha seed rate with seed-drill in 20 cm wide rows. The field was irrigated immediately after sowing and was kept moist throughout the season. Weeds were removed by hand hoeing as per the treatments. Weeds in the weedy plots were ime of weed removal. In the plots that were kept weed-free for different periods, weeds sampling was done at harvest. Weed biomass data was pooled over the years and square-root transformed for statistical analysis and actual biomass values are presented for clarity. The GLM procedure in SAS 9.3 was used to evaluate the statistical differences among treatments at P=0.05.

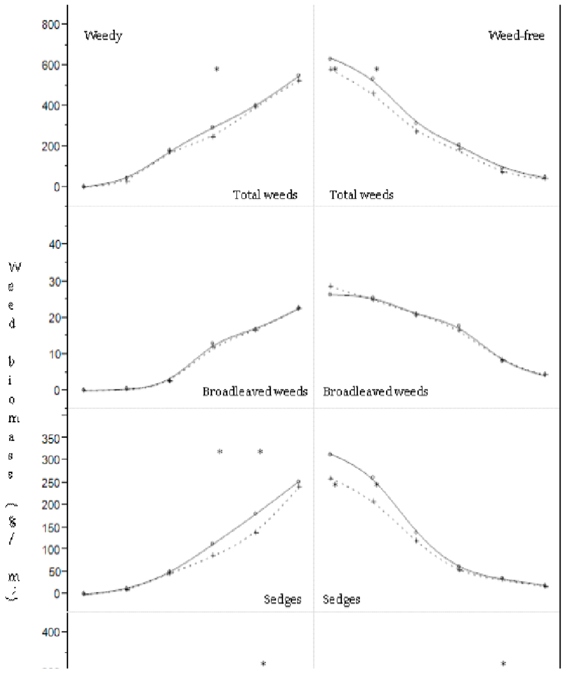

Fig. 1. Weed biomass with rice varieties in different weed control timings (*represents the significant difference between varieties at particular weed control timing)

RESULTS

Biomass of all the weed types was dependent on the weedy duration in the crop. For the initial weedy duration, the weed biomass increased with the time of weedy duration in rice, while for the initial weed free duration, the weed biomass decreased with the delayed period of allowing weeds to emerge. Grasses and sedges were dominant weeds in this study.

Grass weed biomass was same with both varieties for initial 42 days, in weedy or weed free conditions. At 56 days of rice seeding (DAS), greater grass weed biomass was recorded in PR 115 than in PR 114. Under weed free conditions also, at 56 DAS, weed biomass was comparatively lower with PR 115 (30 g/m^2) over PR 114 (50 g/m^2). Sedges biomass was same in both the varieties when kept weedy up to 28 DASand beyond 28 DAS of initial weed free period. At 42 and 56 DAS, sedges biomass was less by 23.6 and 22.6 %, respectively in association with PR 115 compared to biomass recorded with PR 114. Similarly, under weedy upto harvest and initial weed free period of 14 days, lesser sedges biomass(16.8 and 20.3%) was recorded with PR 115 than with PR 114. Beyond 14 days of weed free maintenance showed similar competitive ability by both the varieties. Varietal difference was not observed in their competitive ability against broadleaved weeds, probably because of the lesser biomass of broadleaf weeds. Total weed biomass was lesser in association with PR 115 (244 g/m^2) compared to PR 114 (291 g/m^2), at 42 days of initial weedy conditions while, under initial weed free period of 14 days and weedy up to harvest treatments, weed biomass at harvest reduced by 13.5 and 8.8 % under PR 115.

CONCLUSION

This study indicated higher weed competitive ability, especially against sedges of PR 115 than PR 114. However, for grasses, such difference in weed suppression among the varieties was observed when plots were kept weed free upto 56 DAS.

REFERENCE

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Weed flora of aerobic rice in the coastal region of Karaikal, Puducherry

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Aerobic rice system has been evolved as the most promising water saving technology in rice culture wherein the rice is established by direct seeding in non-puddled and non-flooded fields (Anwar *et al*. 2010). In addition, aerobic rice requires less labour and capital input with saving of 29% of the total rice production cost. In aerobic rice system, the dry tillage and aerobic soil conditions are highly conducive for germination and higher growth of weeds which results in greater rice grain yield losses as compared to puddle transplanted rice. Uncontrolled weeds reduce the yield by 96 per cent to 100 per cent in dry direct-seeded rice (Maity and Mukherjee 2008). Hence, developing an effective weed management approach has been a challenge for widespread adoption of aerobic rice cultivation. It is essential to know the species composition of weed flora and their life forms in order to identify a suitable method for managing weeds. Hence, this study was undertaken to analyse the weed flora associated with aerobic rice in the coastal region of Karaikal, U.T. of Puducherry

METHODOLOGY

A field experiment was conducted during *Rabi* 2013 in the farm lands of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry. The soil of the experimental site was loamy sand in texture and pH was alkaline (8.2). The soil was low in available nitrogen (60.6 kg/ha) and phosphorus (10.5 kg/ha) and medium in available potassium (184.4 kg/ha). A medium duration (135 days) rice cv. *'ADT(R) 46'* was sown on September 5, 2013 and the recommended package of practices for aerobic rice was followed. The data on weed flora, absolute density and relative density were recorded at 30 and 60 days after seeding (DAS), using a quadrat by following the standard procedures.

RESULTS

Diverse weed flora was observed in aerobic rice field at Karaikal region. In total, 29 species (Table 1) of weeds belonging to 22 genera and 17 families were noticed in the experimental field of aerobic rice. Among these,four grasses, six sedges and nineteen broad leaved weeds were noticed. Out of these 29 species, five were perennials and the rest were annuals.

During initial stages of rice growth, sedges dominated (38.3%) the experimental field while at later stages (60 DAS) broad leaved weeds dominated (42.5%). Grasses were relatively less dominant at both 30 and 60 DAS. *Cyperus haspan* L., and *Scirpus articulatus L.* among the sedges and *Corchorus tridens* L., *Marsilea quadrifolia* L., *Melochia corchorifolia* L., *Sphaeranthus indicus* L. and *Trianthema portulacastrum* L. among the broad leaved weeds were observed at later stages of crop growth (90 DAS and later).

Table 1. Weeds density and relative density in aerobic rice, Karaikal

Name	Family	Life Form	Weed density (no./m^2)		Relative density (%)	
			30 DAS	60 DAS	30 DAS	60 DAS
Echinochloa colona. Link.	Poaceae	Annual	265.0	362.3	17.9	28.1
Echinochloa crussgalli L.	Poaceae	Annual	163.0	79.0	11.0	6.1
Leptochloa chinensis(L.) Nees.	Poaceae	Annual	0.0	16.0	0.0	1.2
Panicum repens L.	Poaceae	Perennial	0.0	4.0	0.0	0.3
Total grasses			428.0	461.3	28.9	35.7
*Cyperus difformis*L.	Cyperaceae	Annual	293.0	125.0	19.8	9.7
Cyperus haspan L.	Cyperaceae	Perennial	--	--	–	–
Cyperus iria L.	Cyperaceae	Annual	146.7	108.0	9.9	8.4
Cyperus rotundus L.	Cyperaceae	Perennial	127.0	32.3	8.6	2.5
Fimbristylis miliacea L.	Cyperaceae	Annual	0.0	16.0	0.0	1.2
Scirpus articulates	Cyperaceae	Annual	--	--	–	–
Total sedges			566.7	281.3	38.3	21.8
Aeschynomene indica L.	Fabaceae	Annual	0.0	24.0	0.0	1.9
Aponogetonmono stachyon L.	Aponogetonaceae	Annual	4.0	12.0	0.3	0.9
Bergia capensis L.	Elatinaceae	Annual	0.0	11.0	0.0	0.8
Cleome viscose L.	Capparidaceae	Annual	0.0	17.0	0.0	1.3
Corchorus tridens L.	Tiliaceae	Annual	--	--	–	–
Eclipta alba (L.) Hassk.	Asteraceae	Annual	8.0	5.0	0.5	0.4
Glinus oppositi folius L.	Molluginaceae	Annual	0.0	6.0	0.0	0.5
Hydrolea zeylanica (L.) Vahl.	Hydrophyllaceae	Perennial	0.0	33.0	0.0	2.6
Lindernia crustacea	Scrophulariaceae	Annual	0.0	19.0	0.0	1.5
Lindernia oppositifolia	Scrophulariaceae	Annual	8.0	38.0	0.5	2.9
Lindernia procumbens Krock.)	Scrophulariaceae	Annual	0.0	18.0	0.0	1.4
Ludwigia abyssinica	Onagraceae	Annual	326.4	361.0	22.0	28.0
*Ludwigia parviflora*Roxb.	Onagraceae	Annual	132.3	0.0	8.9	0.0
Marsilea quadrifolia L.	Marsileceae	Perennial	--	--	–	–
Melochiacorcorifolia L.	Sterculiaceae	Annual	--	--	–	–
Oldenlandi acorymbosa L.	Rubiaceae	Annual	8.0	0.0	0.6	0.0
Phyllanthus niruri L.	Euphorbiaceae	Annual	0.0	4.0	0.0	0.3
Sphaeranthus indicus L.	Asteraceae	Annual	--	--	–	–
Trianthema portulacastrum L.	Aizoaceae	Annual	--	--	–	–
Total broad-leaved weeds			486.7	548.0	32.9	42.5
All weeds			1481.4	1290.6	100.0	100.0

CONCLUSION

In aerobic rice fields of Karaikal, U.T. of Puducherry, the most predominant weeds were: *Echinochloa colona* Link. *fb Echinochloa cruss-galli* (L.) Beauv. among the grasses; *Cyperus difformis* L. followed by *Cyperus iria* L among sedges and *Ludwigia abyssinica,* among the broad leaved weeds.

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Biology and management of nutsedge in garden-land crops

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Weeds in general cause 45% annual loss in agricultural production and their competitive ability and aggressiveness increase with increasing resource availability like nutrients and soil moisture. Purple nut-sedge (*Cyperus rotundus* L.) is one of the most noxious perennial weeds in 52 crops in more than 90 tropical and sub-tropical countries and ranked as world's worst weed (Bendixen and Nandihalli 1987). The growth habit and mode of propagation of the weed pose tremendous problems in its control. The present thrust in weed research is to study the biology of weeds and to formulate integrated management practices by combining chemical and cultural methods which are efficient, economical and eco-friendly. Enormous tuber production and adoption to disperse with the help of various agents, *viz.* animals and water help the weeds to evade several of the control options when attempted independently. Hence, a comprehensive study was taken up to bring out the distribution pattern of nutsedge, competitive ability and the efficiency of integrated management practices to tackle the weed menace.

METHODOLOGY

Phyto sociological weed survey was conducted in different garden-land crops to study predominant weed flora.

RESULTS

Weed flora in the garden-land crops, *viz.* sugarcane, sunflower and gingelly, comprised of 15 weed species. Among the weed species, *C. rotundus* was found to be predominant with the highest importance value index (IVI) of 27.83 and *Trianthema portulacastrum* was found to be next in order with an IVI value of 19.92.

The density of active tubers of *C.rotundus* observed through the counts of seedling emergence at different soil depths. The 20 cm layer of the soil showed the highest tuber reserves (65%) as compared to other soil depths. The field experiment on periodicity of germination of *C. rotundus* revealed that the fields prepared during August, June and July months showed the higher germination than the other months of field preparation. Different soil moisture regimes exerted significant influence over the emergence of *C. rotundus* and 60% available soil moisture (ASM) regime favoured higher germination than the other soil moisture regimes. Eco physiological study revealed that the different qualities of light also significantly influenced the germination of *C. rotundu s*tubers and tubers exposed to blue light followed by infra-red light recorded quick germination of tubers. Integrated weed control experiments on irrigated maize revealed that glyphosate spray at 1.5 kg/ha during off season followed by pre-sowing soil incorporation of fluchloralin 1.5 kg/ha + inter cropping with black gram during cropping period recorded the least weed parameters, the highest growth and yield parameters and yield of maize and offered an efficient and economic control over *C .rotundus.*

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Characterization of metal tolerant and plant growth promoting rhizobacteria colonizing in weed rhizosphere

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The use of weeds for the phytoremediation of heavy metal-contaminated lands appears to have considerable potential as more attractive alternative than traditional methods to the approaches that are currently in use. It has been reported to be an effective, in situ, non-intrusive, low-cost, aesthetically pleasing, ecologically benign, socially accepted technology to remediate polluted sites. It also helps prevent landscape destruction and enhances activity and diversity of soil microorganisms to maintain healthy ecosystems. Studies of the interactions between plant roots and diverse soil microbiota are important for elucidating ecological interactions between plants, microbes, soils and climatic factors in the phytoremediation of contaminated soils. The present study aimed at isolating and characterising the metal tolerant and plant growth promoting bacteria colonizing in the rhizosphere of weedy grass species grown at metal contaminated areas.

METHODOLOGY

Soil and plant samples were collected from different heavy metal contaminated areas of Jabalpur district. Based on their predominance in each region, nine weed species, *viz. Typha latifolia*, *Rumex crispus*, *Ageratum conyzoides*, *Chenopodium album*, *Eichhorniacrassipes*, *Ammannia auriculata*, *Sida acuta* and *Cyperus* sp. were sampled in January 2014. Plant growth promoting rhizobacteria were isolated using serial dilution technique on King's B medium. An aliquot was taken from each pure culture for evaluation of plant growth promoting characteristics. Siderophore production was checked using the Chrome Azurol S (CAS) agar plates and solubilization of insoluble phosphates were also assayed. ACC deaminase activity was determined by growing the cells in minimal medium with 3 mM ACC as the sole N source. Production of á-ketobutyrate as a result of enzymatic cleavage of ACC by ACC deaminase was measured at 540 nm, as per Penrose and Glick (2003) and compared with a standard curve of á-ketobutyrate.

RESULTS

Among bacterial colonies, 12 were gram positive and rest were gram negative. They were mostly circular, irregular and were mostly of yellow, creamy white and orange colour.

Table 1. Plant growth promoting activities of isolates from rhizosphere of grass weed species in metal contaminated areas of Jabalpur

Isolate	Siderophore (µg /m protein)	ACC deaminase (n mole /mg protein/ h)	P- solubilization efficiency (%)	Available P (µg/ g)
TLB1	20.9 (± 1.15)^{fg}	ND	140 (± 11.64)^{ef}	0.46 (± 0.04)^{ghi}
TLB2	66.3 (± 3.21)^{a}	76.8 (± 2.98)^{c}	233 (±1 3.10)^{a}	0.96 (± 0.01)^{a}
TLB 7	13.5 (± 1.18)^{ghi}	87.9 (± 3.29)^{ab}	50 (± 2.17)^{ij}	0.81 (± 0.01)^{ab}
RCB1	22.4 (± 1.10)^{de}	ND	60 (± 1.14)^{ij}	0.34 (± 0.03)^{hij}
RCB4	54.6 (± 2.14)^{b}	92.5 (± 8.12)^{a}	225 (± 12.16)^{ab}	0.67 (± 0.02)$^{c-f}$
RCB5	38.4 (±1.19)^{d}	74.3 (± 7.98)^{c}	200 (± 2.64)^{bc}	0.55 (± 0.06)^{efg}
AAP4	18.9 (± 1.24)^{fg}	ND	150 (± 11.19)^{def}	0.68 (± 0.03)^{cde}
SAU6	13.5 (± 1.13)^{ghi}	ND	250 (± 13.53)^{a}	0.67 (± 0.04)$^{c-f}$
RCP4	23.5 (± 2.11)^{de}	83.9 (± 4.96)^{ab}	125 (± 11.29)^{fg}	0.55 (± 0.01)^{efg}
ACR3	18.4 (± 1.70)^{fgh}	ND	150 (± 12.10)^{def}	0.29 (± 0.01)^{j}
ECU6	20.4 (± 2.24)^{fg}	ND	33 (± 0.98)^{j}	0.26 (± 0.01)^{j}
CRP1	20.9 (±2.26)^{fg}	ND	167 (± 11.54)^{de}	0.32 (± 0.03)^{ij}

Values followed by the same letter in each column are not significantly different from each other as detected by DMRT (p 0.05); ND: Not detected.

The isolates were screened based on maximum tolerance concentration (MTC) of various heavy metals, *viz.* Cd^{2+}, Hg^{2+}, Co^{2+}, Ni^{2+} and Zn^{2+}. The 16S rRNA gene sequence analysis has identified the isolates that belong to genus of *Bacillus* spp, *B. subtilis* and *B. licheniformis*.These gitive bacteria may tolerate heavy metal by spore forming ability and by relatively high GC content (Dib *et al.* 2008). Among weedy plants *Ageratum conyzoides* harboured more number of metal tolerant bacteria followed by *Typha latifolia* (8), *Cyperus* sp.(7) and *Chenopodium album* (7).

Plant growth promoting traits of all the selected isolates were analysed. The isolates were found to produce phytohormone, siderophores, solubilized mineral, isolates also produced enzyme such as ACC deaminase that can modulate plant growth and development (Table 1). The experimental results indicated that the isolates were highly compatible with each other bioinoculants. These selected strains do not cause any disease symptoms to tomato plants.

CONCLUSION

This study conducted in metal-contaminated sites has identified the potential of microorganisms associated with weeds which have potential of utilising in bioremediation. From this investigation, the elite bacteria with multiple beneficial characters identified in this investigation could be very useful in the formulation of new microbial inocula along with the weed species and could be great value for bioremediation of metal contaminated medium.

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Functional microbial diversity in the rhizosphere of selected weeds in semi-arid tropics

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A complete understanding of the diversity and functioning of diazotrophic microorganisms, especially those that have symbiotic relationships with weed species is of great value for agricultural research and application. The knowledge on the diversity of diazotrophic bacteria is required not only for understanding their ecological importance but also for their utilization in sustainable agriculture as inoculants of various crops. There is now increasing evidence that the use of beneficial microbes can enhance plant's resistance to adverse environmental stresses, *e.g.* drought, salts, nutrient deficiency and heavy metal contaminations. The present investigation is focused to identify and characterize the unexplored culturable rhizosphere diazotrophic diversity of selected weedy grass species of India.

METHODOLOGY

Based on their dominance in each physiographical region of the country, a total of 10 different weed species (*Brachiaria reptans*, *Cenchrus glaucus*, *Saccharum spontaneum*, *Panicum repens*, *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Chlorisbarbata*, *Oryza rufipogon*, *Cyanodon dactylon* and *Setaria verticillata*) along with rhizosphere soils were sampled and the analysis was conducted during 2012-2013. Diazotrophic microorganisms were enumerated and isolated using serial dilution technique on selective N-free malate medium (NFM). Diazotrophic isolates identified by 16S rRNA gene sequencing. The identity of 16S rRNA sequence was estabilished by performing a similarity search against the Gene Bank database (http://www.ncbi.nih.gov/BLAST) and the multifaceted plant growth promoting traits evaluated for isolates.

RESULTS

The diazotrophic isolates from weed species were characterized for nitrogenase activity by acetylene reduction assay (ARA) and 16S rRNA gene sequencing. The ARA activity of the isolates ranged from 50.83 to 172.25 n moles ethylene/mg protein/h and the putative diazotrophs from rhizosphere of grass species were identified by *nifH* gene amplification. The 16S rRNA gene sequence analysis identified the isolates to be members of alpha Proteobacteria and Firmicutes (Table 1). Plant growth promoting traits of all the selected diazotrophic isolates were analysed and results revealed that among the rhizosphere diazotrophic isolates, the amount of IAA and GA production, P-solubilization, siderophore and HCN production are higher in *Serratia marcescens* (CD1) (Ahmad *et al*. 2008). Based on the presence of multiple plant growth promoting traits, the isolates were selected for inoculation studies. In gnotobiotic experiment, inoculation of diazotrophic isolates significantly improved the growth of rice.

CONCLUSION

The present study, unravel the diversity and richness of diazotrophic bacteria colonizing the rhizosphere of naturally growing weed species in different parts of India. The novel efficient isolates of *Serratia* sp. and *Klebsiella pneumonia*, obtained from the weeds rhizosphere, with multifaceted plant growth promoting activity under stressed condition may be employed in nutrient deficient and problematic soils for stress mitigation and sustainable crop production with limited chemical inputs.

Table 1. Authentication of diazotrophic isolates from weed species of different physiographic regions by 16S rRNA gene sequence homology

Isolate	Weed species	Species homology	Percent homology	GeneBank Accession No
BR1	*B. repens*	*Enterobacter* sp.	99	KF906826
CG1	*C. glaucus*	*Klebsiella* sp.	94	KF906827
CG3	*C. glaucus*	*Enterobacter* sp.	98	KF906828
CG5	*C. glaucus*	*Bacillus* sp.	99	KF906830
CR3	*C. rotundus*	*Klebsiella pneumoniae*	99	KF906829
CB2	*C. barbata*	*Serratia* sp.	99	KF906831
OR3	*O. rufipogon*	*Serratia* sp.	96	KF906832
OR5	*O. rufipogon*	*Staphylococcus saprophyticus*	99	KF906833
OR7	*O. rufipogon*	*Klebsiella* sp.	98	KF906834
CD1	*C. dactylon*	*Serratia marcescens*	97	KF906835
SV1	*S.verticillata*	*Klebsiella pneumoniae*	99	KF906836

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Effect of weed management practices on weed seed bank in soybean

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Weed seed bank refers to the weed seeds in the soil that is able to germinate under convenient conditions. Monitoring the changes in weed seed bank for extended period enables us to have an insight into efficiency of the applied measures of weed control and to predict weed occurrence in the following period (Ambrosio *et al*. 2004).Therefore, the present study was undertaken to determine the effective of weed management practices which reduce weed seed bank in soybean.

METHODOLOGY

Field experiments were conducted at the Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University, during winter (*Rabi)* 2011-12 and rainy season (*Kharif*)2012 to evaluate sulfentrazone (48% F) and clomazone (FMS 50% EC) in managing weeds in soybean and their effect on soil weed seed bank. Fourteen treatments consisting of pre-emergence application (PE) of sulfentrazone at 240, 300, 360, 480 and 720 g/ha and clomazone at 750, 1000, 1250 and 2000 g/ha were compared with recommended preemergence (PE) pendimethalin at 750 g/ha and post emergence application of (POE) imazethapyr at 100 g/ha, hand weeding and mechanical weeding by twin wheel hoe (TWH). In all the herbicidal treatments, uniform hand-weeding (HW) was done on 40 days after seeding (DAS). The experiment was laid out in randomized block design and replicated thrice. Soybean variety CO (Soy) 3 released by TNAU was used for the study. After the harvest of soybean, soil samples taken from individual treatment plots for soil weed seed bank assessment and spread on shallow plastic trays (holding one kg of individual soil sample). Soil samples were left undisturbed with exposure to sun at optimum soil moisture. Individual weed seed germination was recorded cumulatively up to seven days. After 15 days, the germinated weed seedlings were uprooted and the soil was treated with GA_3 to induce dormant weed seeds for germination. Further seed germination was recorded for every kg of soil and expressed as weed seed density (no./kg of soil) in soil weed seed bank.

RESULTS

There was variation in density of grasses, sedges and broad leaved weeds under different doses of sulfentrazone, clomazone, pendimethalin and imazethapyr treatments in terms of herbicidal effect on weed seed bank at 0-15 cm and 15-30 cm soil depths. Total weed density with PE sulfentrazone at 240 to 720 g/ha (Table-1) was significantly lower as compared to PE clomazone at 750 to 2000 g/ha. There was complete control of broad leaved weeds with PE sulfentrazone and grass weeds with PE clomazone. There were no sedge weeds in all the treatments. However, total weed density was higher with hand weeding on 20 and 40 DAS and twin wheel hoe weeding on 20 and 40 DAS and unweeded control when compared to all other herbicide treatments. At 15-30 cm, higher dose of PE sulfentrazone (720 g/ha) has registered with no total weed population. Total weed density was lower in PE sulfentrazone at 480 g/ha and it was comparable with PE clomazone at 2000 g/ha. This might be due to reduction in seeds bank of weeds due to herbicide application. Similar observations were made by Walia and Brar (2006) in a seed bank study, in soybean.

Table 1. Effect of weed management practices on total weed seed density (no./kg of soil) in soil weedseed bank

Treatment	*Rabi*, 2011-12 (Soil depth)		*Kharif*, 2012 (Soil depth)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
PE Sulfentrazone - 240 g a.i/ha	2.00(2.00)	2.38(3.69)	2.15(2.62)	3.39(9.50)
PE Sulfentrazone - 300 g a.i/ha	1.91(1.66)	1.92(1.70)	1.87(1.50)	2.83(6.00)
PE Sulfentrazone - 360 g a.i/ha	1.65(0.72)	1.85(1.42)	1.73(1.00)	2.23(2.98)
PE Sulfentrazone - 480 g a.i/ha	1.62(0.64)	1.84(1.38)	1.73(1.00)	1.73(1.00)
PE Sulfentrazone - 720 g a.i/ha	1.57(0.48)	1.41(0.00)	1.58(0.49)	1.41(0.00)
PE Clomazone - 750 g a.i/ha	2.76(5.65)	2.90(6.41)	3.19(8.22)	3.41(9.67)
PE Clomazone -1000 g a.i/ha	2.28(3.21)	2.52(4.38)	2.22(2.94)	2.45(4.04)
PE Clomazone - 1250 g a.i/ha	2.00(2.01)	1.83(1.35)	1.79(1.21)	2.12(2.52)
PE Clomazone - 2000 g a.i/ha	1.41(0.00)	1.52(0.32)	1.73(1.00)	1.41(0.00)
POE Imazethapyr - 100 g a.i/ha	3.35(9.21)	2.54(4.44)	2.65(5.02)	2.59(4.72)
PE Pendimethalin - 750 g a.i/ha	3.04(7.23)	2.94(6.64)	2.90(6.41)	2.68(5.17)
HW on 20 and 40 DAS	3.76(12.16)	2.87(6.27)	3.72(11.85)	2.98(6.90)
TWH on 20 and 40 DAS	3.95(13.65)	2.96(6.79)	4.02(14.16)	3.08(7.50)
Unweeded control	4.64(19.59)	3.28(8.76)	4.38(17.23)	3.56(10.74)
CD (P=0.05)	0.21	0.17	0.19	0.22

Figures in parenthesis are original values; Data was subjected to square root transformation; PE = pre-emergence application; POE = post-emergence application; DAS= days after seeding

CONCLUSION

The PE application of sulfentrazone at 480 g/ha effectively controlled the weeds during entire cropping period and reduced the soil weed seed bank.

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Comparative studies on seed germination of okra and radish with application of aqueous extracts of *Pluchea lanceolata*

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Pluchea lanceolata (DC.) C.B. Clarke (Asteraceae) is a rapidly spreading perennial dicot weed in semiarid areas of North-West India(Inderjit 1998). Allelochemicals are released into the environment through leaching from living plant parts, root exudates, volatilization, residue decomposition, microbial activity, and agricultural practices such as plouging of plant residues into the soil (Putnam and Tang 1986, Inderjit and Dakshini 1991). To explore allelopathic potential of *P. lanceolata* on vegetable crops, we examined the effect of aqueous extract of shoots of this plant on seed germination of okra and radish.

METHODOLOGY

The experiment was conducted in the Department of Botany, AMU, Aligarh in the year 2013. The stock aqueous *P. lanceolata* extract was prepared by soaking 100 g of shade dried and finely chopped shoots of*P. lanceolata* in 500 ml distilled water for 48 hours. The extract was strained through four layers of cheese cloth followed by filtration through two layers of Whatman No. 2 filter paper. Various dilutions were obtained by mixing the stock solution and water as given below.

Twenty five thoroughly washed petri dishes lined with absorbent cotton were autoclaved as per standard procedure at temperature 121^0C with a pressure of 15 psi for 20 min. They were allowed to cool overnight. Okra (variety: Pusa A4) and radish seeds (variety: snow white) were surface sterilized with 2% sodium hypochlorite for 15 min(Tomita 1998). Twenty seeds of nearly equal size were placed in each of the petri dish. The control was irrigated with double distilled water. Remaining petri dishes were irrigated with different dilution of *P. lanceolata* extract as outlined in (Table 1). Germination data were recorded at 24 hrs intervals. Emergence of radical was considered as an indicator of germination. Percent germination was calculated as follows.

$$\%\ \text{Germination} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

RESULTS

Seed germination of both the crops was significantly suppressed by all concentration of *P. lanceolata* aqueous extract. Lowest concentration 25% reduced the germination by about 25% in both crops (Table. 2, Fig. 1). A gradual decrease in germination of both crops was observed with increasing concentration of *P. lanceolata* extract. Highest suppression of germination was caused by 100% *P. lanceolata* extract (fig.1). At 25% *P. lanceolata* extract radish showed marginally higher germination. In all remaining treatments okra was found to be more sensitive than the radish. The results were in agreement with that of Inderjit and Dakshini 1991.

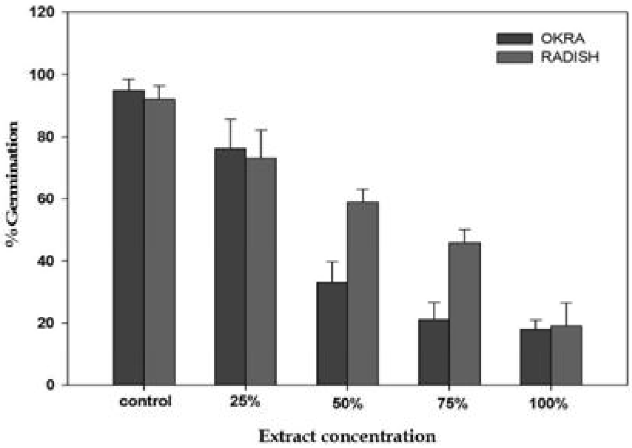

Fig. 1. Effect of *P. lanceolata* extract on the germination of okra and radish seeds

Table 1. Preparation of *P. lanceolata* shoot aqueous extract

Treatment	Dilutions	Stock solution (ml)	Distilled water (ml)
1	Control	00	100.0
2	25%	25.0	75.0
3.	50%	50.0	50.0
4.	75%	75.0	25.0
5.	100%	100.0	00

CONCLUSION

Pluchea lanceolata aqueous extract has suppressive effect on the seed germination of okra and radish. Okra germination was influenced more by the aqueous extract of *P. lanceolata*.

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Biology and seed production of three *Sida* species

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Plants of genus *Sida* are distributed throughout the tropical, subtropical, and warm temperate regions. These plants grow along road-sides, waste-lands, sandy sea coast, garbage areas and railway embankments and also as weeds in upland cultivation (Sivarajan and Pradeep 1996). These plans are of great importance in the Indian traditional systems of medicine and are one of the most widely used raw drug in the production of different ayurvedic formulations.

METHODOLOGY

A field experiment was carried out during *Kharif* season of 2013 at Kerala Agricultural University, Vellanikkara, Thrissur. The location is at an altitude of 22.5 m above MSL and experiences warm humid tropical climate with sandy clay loam soil. Seeds of three *Sida* species, *viz*. *Sida acuta*, *Sidaalnifolia* and *Sida cordifolia* were collected in Vellanikkara during December 2012. Seeds were pre-treated with Conc. H_2SO_4 for 20 min were sown on raised beds of 2 × 2 m and maintained six plants per bed. The plants were raised under rainfed conditions adopting uniform and minimum cultural operations. Observations were recorded from the five plants in all three species.

Table 2. Flowering and fruiting characters of Sida spp.

Characters	*Sida alnifolia*	*Sida acuta*	*Sida cordifolia*
Anthesis (am)	8:00^{b}	7:30^{a}	8:15^{b}
Days for first flowering	142^{c}	120^{a}	131^{b}
Days for the first fruit harvest	160^{c}	137^{a}	149^{b}
Number of fruits per plant	1919.97^{b}	3825.8^{a}	1459.94^{c}
Hundred fruit weight (g)	2.20^{b}	2.40^{b}	5.27^{a}
Fruit yield per plant (g)	42.26^{c}	91.86^{a}	76.96^{b}
Number of seeds per fruit	06	06	09
Number of seeds per plant	11520.53^{b}	23005.78^{a}	10043.84^{b}
Hundred seed weight (g)	0.30^{b}	0.33^{b}	0.48^{a}
Seed yield per plant (g)	34.98^{c}	76.57^{a}	61.52^{b}
Seed yield (t/ha)	0.713^{c}	1.562^{a}	1.255^{b}

(Values having common superscript are not significantly different from each other.)

Table 1. Vegetative characters of *Sida* spp. at different stages of growth

Character	Month	*Sida alnifolia*	*Sida acuta*	*Sida cordifolia*
Plant height (cm)	02	22.79^{b}	26.77^{a}	17.20^{c}
	04	93.20^{a}	83.00^{ab}	74.20^{b}
	08	163.00^{a}	105.90^{b}	97.80^{b}
No. of primary branches	02	12.50^{a}	12.40^{a}	9.20^{b}
	04	45.70^{a}	30.90^{b}	24.70^{c}
	08	71.90^{a}	38.00^{b}	31.50^{c}

(Values having common superscript are not significantly different from each other.)

Table 3. Number of seed rain and seed yield in *Sida* spp.

No. of seed rains weeks	*Sida alnifolia*			*Sida acuta*			*Sida cordifolia*		
	Fruit yield (g)	Seed yield(g)	No. of seeds	Fruit yield (g)	Seed yield(g)	No. of seeds	Fruit yield (g)	Seed yield (g)	No. of seeds
1	-	-	-	2.34	1.95	586	-	-	-
2	-	-	-	3.85	3.21	966	1.60	1.28	209
3	-	-	-	5.97	4.96	1489	5.64	4.51	736
4	-	-	-	8.32	6.94	2084	9.02	7.21	1177
5	3.75	3.11	1016	11.97	9.98	2998	11.74	9.39	1532
6	7.58	6.28	2052	19.95	16.64	4997	14.91	11.92	1946
7	10.77	8.92	2916	16.36	13.64	4097	12.15	9.72	1586
8	8.66	7.17	2346	10.85	9.05	2718	10.36	8.28	1352
9	7.02	5.81	1900	8.06	6.72	2019	6.73	5.38	878
10	4.46	3.69	1207	4.18	3.48	1047	4.79	3.83	625
Total	42.26	34.98	11520	91.86	76.57	23005	76.96	61.52	10043

RESULTS

Sida alnifolia was found to have a vigorous growth as compared to *Sida acuta* and *Sida cordifolia* as indicated by more height and number of primary branches (Table 1).

The seed production potential was highest in *Sida acuta* as evidenced by early flowering and fruiting, extended seed rain (Table 2 and 3), fruit yield and seed yield. *Sida cordifolia* was intermediate in flowering and fruiting whereas *Sida alnifolia* flowered last. In contrast, *Sida cordifolia* had largest fruits and more seeds (09) per fruit whereas only six seeds were recorded in fruits of *Sida alnifolia* and *Sida acuta*. *Sida alnifolia* had the least sized fruits and seeds.

CONCLUSION

Flowering and fruiting in *Sida* species was staggered and started four months after planting. *Sida alnifolia* was most vigorous. The maximum number of schizocarps matured over the season (seed rain)was witnessed in *S. acuta* followed by *S. cordifolia* and *S. alnifolia*. Hot summer stopped further harvests.

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Germination of three *Sida* species under field conditions

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The genus *Sida*, distributed throughout the tropical, subtropical, and warm temperate regions. The plants grow along roadsides, wastelands, sandy sea coast, waste places and railway embankments and also as weed in upland crops. It is of great importance in the Indian traditional systems of medicine and is one of the most widely used raw drug in the production of different Ayurvedic formulations.

METHODOLOGY

An experiment was carried out during February 2013 at Kerala Agricultural University, Vellanikkara, Thrissur. The location is at an altitude of 22.50 m above MSL and experiences warm humid tropical climate. Seeds of three *Sida* species were collected in Vellanikkara during December 2012. One month after collection, hundred seeds each of the three *Sida* species, *viz*. *Sida acuta*, *Sidaalnifolia* and *Sida cordifolia*, were sown in the pots filled with solarized potting media, lightly covering the seeds in four replications. Two sets were maintained. One set of pots were placed under open condition without watering and another set with regular watering. The observation on seed germination was recorded at weekly intervals upto one year and presented month wise.

RESULTS

Under irrigated condition, germination started from February and continued upto 6-9 months. Germination recorded was less than 15% germination in all the three species with highest germination in *Sida alnifolia* (14.50%) (Table 1). The occurrence of polymorphism in species which exhibit seed coat dormancy has been reported (Graaff and Van Staden 1983).

Table 1. Germination percentage of *Sida* spp. under irrigated and rain-fed conditions

	Month	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Total (%)
Sida alnifolia	Irrigated	2.5	1.5	3	4.25	2	0	0.5	0.25	0.5	0	0	0	14.5
	Rain-fed	0	0	0	0	67.5	0	0	0	0	0	0	0	67.5
Sida acuta	Irrigated	1.25	1.75	1.5	0.75	0	0.75	0.75	0.5	0	0	0	0	7.25
	Rainfed	0	0	0	0	74	0	0	0	0	0	0	0	74.0
Sida cordifolia	Irrigated	1.25	1.75	1	0.5	1.5	1.5	1.5	0.25	1.7	0.75	0	0	11.7
	Rainfed	0	0	0	0	42.5	0	0	0	0	0	0	0	42.5

Under rain-fed system, in all the three species, germination started spontaneously on receipt of rain during June and completed within ten days. The percent germination recorded was minimum 42.5 in *Sida cordifolia* and maximum of 74% in *Sida acuta* . This may be because the seeds are dormant at seed fall and require high alternating temperature for germination as reported by Mott (1980). Alternating temperature in soil seed banks of *Sida* results in softening of the thick hard impermeable seed coat permitting imbibition of water and exchange of gases. It is also probable that in nature, exotesta is decomposed by microbial action or ruptured by desiccation due to fluctuating temperatures. Desiccation followed by rain induces the rupture of palisade (endotesta) layer, thus removing the mechanical constraint on the embryos.

Confirming results of this study, 26.0-57.5% hard seeds of three *Sida* species were left after the wet season. The occurrence of 30% hard seeds after the wet season in *Sida acuta* was reported by Mott (1980). In seeds with physical dormancy, opening of a water gap in the seed coat in response to an environmental signal, thereby allowing water to enter. Differences in the lignification of palisade cells produce permeable and impermeable seeds.

CONCLUSIONS

Seeds of *Sida* species are dormant at seed fall. Subjecting the seeds to natural weathering isa simple way of tackling the seed dormancy and improving *Sida* spp. seed germination.

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Weed dynamics in rice-chilli cropping system

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Chilli is one of the most important spices used for its pungency, aroma, flavour and taste. The crop encounters several yield limiting problems during its life cycle, out of which weed is counted as a major one. Successful management of weeds depends on many factors including nature of weeds, time of their emergence and severity of infestation. A study was carried out to enlist the weed flora associated with chilli and understand weed dynamics.

METHODOLOGY

The study was undertaken during *Rabi-Summer* season of 2012-13 and 2013-14 at Instructional cum Research Farm of Assam Agricultural University, Jorhat with ten numbers of treatments replicated thrice in Randomized Block Design. The experimental site was medium textured land with a preceding crop of transplanted rice during *Kharif* season. The chilli variety selected was a local variety "*kharika*" and plot size was 3.2 x 2.7 m. The ten treatments, *viz.* metribuzin at 500 g/ha + garden hoe at 30 and 60 DAP(days after planting); metribuzin at 500 g/ha+ garden hoe at 30, 60 and 80 DAP; metribuzin at 500 g/ha+ garden hoe at 30 ,50 and 80 DAP; quizalofop-p-ethyl at 50 g/ha + garden hoe (GH) 45 and 75 DAP; quizalofop-p-ethyl at 50 g/ha + garden hoe at 60 and 80 DAP; garden hoe at 20, 40, 60 and 80 DAP; garden hoe at 25, 50 and 75 DAP; garden hoe 30, 60 and 80 DAP and weedy check were tested. Observations on associated weed flora and the effect of weed flora on yield of chilli were studied.

RESULTS

During the entire crop season, predominant weed species comprised of two grass species, five broad leaved species and one species belonging to sedge. *Oryza sativa*, the cultivated rice species was one of the major weed species. It was followed by *Cyperus rotundus, Oldenlandia diffusa* and *Polygonumglabrum*. Shaikh (2005) reported, *Eleusine indica*, *Cyperus rotundus*, *Cynodon dactylon, Chenopodim album* as the major weed flora associated with chilli. *Drymaria cordata*, *Centella asiatica*, *Oldenlandia diffusa* and *Polygonum glabrum* were observed to be the new weed species associated with chilli succeeding *Kharif* rice.

The number of weed species varies with the time as well as the treatments. Initially (0-20 days after planting), the densityof *Oldenlandia diffusa* and *Chenopodium album* recorded to be highest quizalofop-p-ethyl at 50 g/ha + garden hoeing at 60, 80 DAP treatment followed by *Oryza sativa* in treatment of metribuzin at 500 g/ha + garden hoeing at 30, 60 and 80 DAP treatment and quizalofop-p-ethyl at 50 g/ha + garden hoeing at 45 and 75 DAP. Subsequently, between 20-40 days after planting, the plots treated with quizalofop-p-ethyl at 50 g/ha + garden hoeing at 60, 80 DAP recorded the

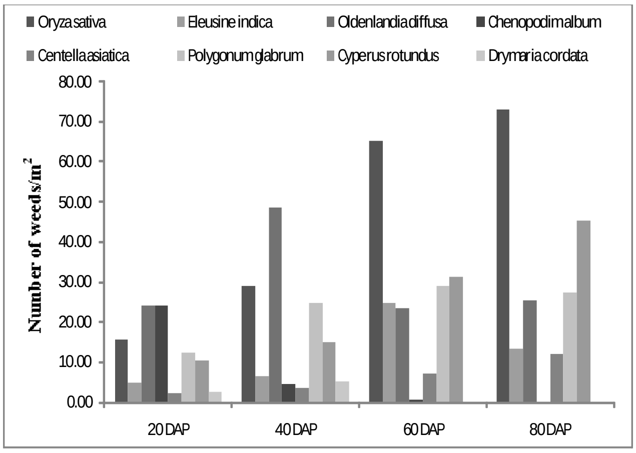

Fig. 1. Weed density in weedy plot

highest density of *Oldenlandia diffusa* followed by *Oryza sativa* in treatment with quizalofop-p-ethyl at 50 g/ha + garden by hoe at 45, 75 DAP and garden hoe 25, 50, 75 DAP and *Cyperus rotundus* in quizalofop-p-ethyl at 50 g/ha + garden hoeing at 60, 80 DAP. From 40 to 60 DAP, *Cyperus rotundus* recorded to be highest in quizalofop-p-ethyl at 50 g/ha + garden hoeing at 60, 80 DAP and *Eleusine indica*in quizalofop-p-ethyl at 50 g/ha + garden hoe at 45, 75 DAP. During 60 to 80 DAP, *Cyperus rotundus* was highest in quizalofop-p-ethyl at 50 g/ha+ garden hoeing at 60, 80 DAP and *Oryza sativa* in quizalofop-p-ethyl at 50 g/ha + garden hoeing at 60, 80 DAP

Density of *Oldenlandia diffusa*, *Eleusine indica*, *Polygonum glabrum* and *Chenopodium album* was found to be varying from 0-80 DAP. At first the density was high and along with time the density was found to be reducing (Figure 1). But the *Oryza sativa* and *Cyperus rotundus* density was found to be increasing consistently from 0-80 DAP. *Centella asiatica* and *Drymaria cordata* are seasonal weeds and the density of these weeds was found to be lower during the whole cropping season.

CONCLUSION

Application of metribuzin along with two to three mechanical weedings gave sustained control of weeds during the entire crop-growing season. The metribuzin treated plots showed the better yield and profitability over the other treatments.

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Mikania-driven forest tends transformation from evergreen to deciduous - a case study in Assam

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Mikania micrantha Kunth ex HBK, the gregarious fast growing invasive vine of Central and South American nativity, posed serious threat to the forest ecosystem of Assam. The study was concentrated in the Dilli reserve forest ($27^0$4'13.91" N to $27^0$8'41.39" N and $95^0$17'25.40" E to$95^0$21'56.07" E) which is the western most part of the Assam valley tropical wet evergreen forest belt under the Eastern Himalayan biodiversity hotspot. The study area was covered 16.7 km^2 area, elevation of 179-197 m above MSL with acidic soil (pH 4.06-4.43) and alluvial formation over tertiary sand stone and shales. The area is situated in the foothill of the Patkai range that is enriched with biodiversity of the undulating hill ranges of Arunachal Pradesh meeting the formation of Assam valley.

METHODOLOGY

Phyto-ecological studies were conducted in two forest sites, *viz*. *Mikania micrantha* infested and un-infested sites during the period from 2013 to 2015 March. Degree of disturbance of *M. micrantha* on forest ecosystem was mainly observed in the outermost edges and road sides where forest canopy was open. Randomly laid quadrats of 10 x 10 m, 5 x 5 m and 1 x 1 m size were used for tree, shrubs and herbs, respectively. Plants having more than 6 feet height were considered as tree species, height of above 2.6 ft. as shrubs and less than that were considered as herbs by following Khan (1961). Dominance spectrum of the species was computed using the methods of Mishra (1968).

RESULTS

Altogether 270 macrophytes were recorded which comprised of 123 numbers of trees, 46 bushy and straggling shrubs and 101 herbaceous species including 19fern and fern alleles. The vegetation in the un-infested area was identified as of evergreen, mixed semi-evergreen and deciduous forest with species richness of 177. *Dipterocarpus retusus* Bl. was the predominant element in this forest having IVI of 34.13 followed by *Vatica lanceaefolia* Bl. (20.27), *Artocarpus chama* Buch-Ham. (15.95) and *Mesua ferrea* L. (15.77) in the upper strata. Family Lauraceae occupied highest basal area (29.8%) in the top crown level (Fig. 1) and Zingiberaceae in the forest floor (41.8%). In contrary, in the *Mikania* infested forest areas top canopy strata was predominated by deciduous species of short leafless period such as *Bombax ceiba* L. (IVI 27.1), *Ficus hispida* L. (IVI 23.3), *Duabanga grandiflora* Roxb.ex DC. (15.7) and *Premna latifolia* Roxb. (15.3); the maximum basal area covered by the family Euphorbiaceae (46.9%) followed by Verbenaceae (19.2%) which included several species typically of secondary forests. Total species recorded in this site was 127, which was 28.2% lower than un-infested counterparts.

The first outbreak of *Mikania* infestation was traced in mid April with the IVI value of 29.5. Gradual increment of its population was recorded in the subsequent months and attained the highest infestation in the later part of August (IVI 57.45). The weed has vigorously invaded the buffer zone of

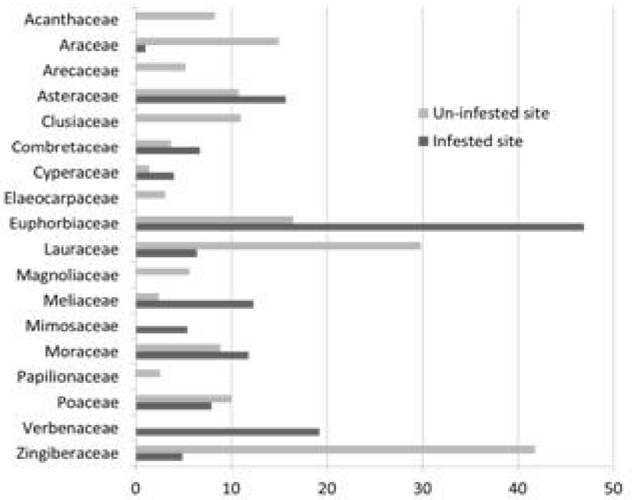

Fig. 1. Basal area (%) of families of un-infested sites and infested sites in Dilli RF, Assam

the studied forest site and affected the species composition rather seriously causing displacement of a number of autochthonous species. It became rampant and covered the canopies of other species and open forest sites by means of proliferation from its horizontal root stock. High level *Mikania* infestation damaged forestry species by smothering them and affected the regeneration of several species. Very few tree species could survive in the infested sites that too mostly of deciduous nature, *viz. Lagerstroemia reginae, Bischofia javanica, Bombax ceiba* and *Hydnocarpus kurzi*, where as, in the dense damp forest floor of un-infested core area possessed 80.9% higher tree seedling-regeneration, including evergreen species like *Artocarpus chama*, *Dipterocarpus retusus*, *Canarium resiniferum,Mesua ferrea,Vatica lanceaefolia, etc.* comparing to *Mikania* infested neighbouring locations.

CONCLUSION

Invasion of *Mikania micrantha* has seriously damaged the forest ecosystem. A case study in Dilli reserve forest revealed alteration of evergreen patches to deciduous forest and displacement of several autochthonous species. Its smothering effect triggered not only the changes of the vegetation component but also the dependent fanatic elements as well as the micro-environmental factors of the ecosystem.

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Assessment of frequency, abundance and density of weed species in rice fields of Kole lands of Kerala, India

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Kole lands are wet-land ecosystems lying 0.5-1 m below main sea level and spread in Thrisuur and Malppuram districts of Kerala state of India. It is a *Ramsar* site since 2002 and considered as the rice granary of central Kerala. Rice cultivation is the main agricultural activity in Kole lands and one of the constraints for rice cultivation in Kole lands is the heavy weed infestation. A survey was conducted in Kole lands during cropping season to develop a database of the weed flora of the ecosystem assessing the predominance of weeds in terms of frequency, abundance and density.

METHODOLOGY

A quantitative weeds survey was carried out in the rice fields of Kole lands during 2012-13 at seedling stage of the rice. Quadrats of 1.0 m^2 was placed at hundred locations of the Kole lands and the number of weed species present in each of the quadrat was recorded. The specimens of different weed species present in the area were collected, preserved and identified using standard procedures. The frequency and abundance of weed species were calculated from the data on the number of quadrats in which the weed species occurred, mean number of individual species in the quadrat and total number of weed species in the quadrat (Mousavi *et al.* 2012)

RESULTS

In this study, 9 weed species belonging to three families were identified as predominant and the maximum number of weed species were of Poaceae family. In Kole lands, 82% of weed species infesting rice were grasses. A preliminary survey conducted during non cropping season on weed flora of Kole wetlands recorded 23 families of dicotyledons and 11 families of monocotyledons and the predominant weed species belonged to Cypreaceae and Poaceae families (Sujana and Peruman 2008). *Fimbristylis miliaceae* and *Echinocloa colona* were the most frequent weeds in rice fields of Kole lands with frequency of 36% followed by *Cyperus rotundus*. *Leptochloa chinensis* and *Cynodon dactylon* had the lowest frequency and were located only in some pockets. The data on species abundance confirmed the predominance of *Fimbristylis miliaceae* and *Echinocloa colona* in rice fields of Kole lands. *Fimbristylis miliaceae* was the most densely populated weeds of Kole lands especially at seed ling stage of the rice. Weed density may be used as a criterion for predicting crop yield loss. Sustainable development and conservation are important for the survival of the Kole wet lands and hence weed management strategies are to be focused on the maintenance of the delicate balance of life that exists within this special ecosystem.

Table 1. Frequency, abundance and relative density of weed species of Kole lands

Weed species	Family	Frequency	Abundance	Relative density (%)
Cyperus rotundus	Cyperaceae	30	10.11	6.10
Oryza rufipogon	Poaceae	26	9.71	5.20
Fimbristylis miliaceae	Poaceae	36	16.21	12.14
Sacciolepis interrupta	Poaceae	14	8.50	2.46
Echinocloa colona	Poaceae	36	10.14	7.60
Ludwigia perennis	Onagraceae	32	9.00	6.00
Leptochloa chinensis	Poaceae	8	4.66	0.76
Echinocloa crus-galli	Poaceae	18	6.25	2.34
Cynodon dactylon	Poaceae	8	4.33	0.72

CONCLUSION

The grassy weeds were found to be the most serious problem in Kole lands. *Fimbristylis miliaceae* and *Echinocloa colona* were the most frequent and densely populated weeds in Kole wetlands of Kerala.

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Creeping thistle (*Cirsium arvense*) - a major threat to ancient Changthang pastoralism

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Creeping thistle (*Cirsium arvense*), also referred to as Canada thistle and California thistle is of Asteraceae family. This herbaceous perennial is one of the most wide-spread and important weed in the world. It is native to South-eastern Europe and the eastern Mediterranean but is now thought to be naturalized worldwide and is generally found in the northern temperate region of North America because its growth is limited by short day length and temperatures that exceed 86^{0}F for an extended period of time. Creeping thistle can thrive in many environments like Changthang region where Changpa nomads living for centuries, supposed to preserve their pasture land but is most commonly found in relatively mesic areas. It is occasionally found in dry habitats, such as sand dunes, but more often occurs in wet areas, such as stream banks, marshy land, along ditches, and lake shores, cultivated fields, pastures, roadsides, and disturbed areas, such as road or fence construction sites, are also areas where the plant can flourish.

METHODOLOGY

A field survey was carried out during 2014-15 at Tsangse, Muglek and Pangong areas of Changthang valley (3999, 4090 and 4116 m) to understand the grassland ecosystem and explore the presence of invasive weed species, dissemination and its further spread under pastoral system. For this purpose, number of locations and nomads were visited and interviewed, respectively and colonies were measured using quadrats (1.0 m^2) randomly located at each of the cardinal points. Observations on density of invasive weedalong with affected flora in general was also recorded.

RESULTS

During the survey made to understand the grassland ecology of Tsangse, Muglek and Pangong parts of Changthang Valley revealed tiny rosette, sedges, and other cohesive group of vegetation such as *Kobresia* spp. *Carex* sp., *Leontopodium pusillum* and *Astragalus strictus*. *Triglochin* spp., *Puccinellia* spp. and *Glaux maritima*. Although these pastures are dominated by one of the smallest Cyperaceae endemic, growing not taller than 2-3 cm, covering more than 90%, and consist of only 8-10 mostly tiny rosette species (*e.g. Thalictrum alpinum, Potentilla saundersiana, Aster flaccidus, Primula walshii, Pedicularis* spp., *Cortiella caespitosa*). The open humic soil is colonized by rosettes (*e.g. Lancea tibetica, Lagotis brachystachya, Potentilla bifurca, Przewalskia tangutica, Persicaria glacialis, Lasiocaryum densiflorum*). During survey, it was also explored to find out any invasive weed species which may under changing climate may pose a threat to steppe of the valley. During the course of search, a major invasive weed: *Cirsium arvense* has been recorded along these tracts in dense patches and along the lake shores. In Changthang pastoral ecosystems, where threat with vegetation like *Cirsium arvense* may affect the economy in long term. Spiny leaves of Canada thistle are unpalatable to livestock; therefore, the forage productivity of pasture and rangeland is reducing. First step after reconstructing a pastoral system, is the management and identification of weedy nature of plants which may create major setback. In addition to this, grazing habits of goats contribute to desertification. On the other side, prolific seed production (1,530-5,300 seeds with approximate viability for 21 years) from weeds like *Cirsium arvense* may pose a major crisis by establishing in future in declining local pasture and there is immediate need to make strategic efforts for identifying and managing weedy nature and invasiveness of plants. Creeping thistle is very intense competitor, absorb quantity of moisture and nutrients. Its massive root system makes easy to access moisture from layers below an arable land. Ethanolic extracts of Canada thistle roots and foliage were similar in their ability to reduce radicle growth of barley, cucumber, green foxtail, and redroot pigweed in petri dish studies (Stachon and Zimdhal 1980) and sunflower and winter wheat (Torma and Bereczki 2004). Density along the Changthang track ranges from 30-50 plants/m^2. As a result of its allelopathic effect, vegetation under Changthang region decline gradually with its establishment at the rate of covering with 10 plants/m^2. It has higher competitiveness against vegetation for nutrient uptake, mainly in water deficit conditions in soil as compared to sufficient soil moisture conditions.

CONCLUSION

Canada thistle, being an aggressive species, in Changthang region needs priority. First and foremost component of the policy is a need to minimize the direct damage to native species and managing invasive nature of this weed species. The best option in grasslands is to enhance growth of native herbaceous species by spring burning, cutting or treating creeping thistle with glyphosate when it is in late bud or early bloom (usually June). It is necessary to prevent shoot growth for at least two years to deplete roots and kill this weed. Competition from tall fescue was more detrimental to *Cirsium arvense*. Control efforts may be more successful when *Cirsium arvense* is under environmental stress. Cutting or applying herbicide to shoots after a very severe winter may add sufficient stress to kill plants. Very young plants are eaten by goats or sheep in the spring, but grazing is the least effective control method. Colonies of this weed are easily identified and may immediately be taken into consideration for further control and action may be initiated from June onwards as this weed flowers from June through August.

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Changes in weed communities of arable field margins in response to recovery efforts and cropping management following the 2011 tsunami disaster in Miyagi, Japan

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Field margins are important components of the agri-environment as they contribute to maintaining agricultural ecosystem functions. The species composition and richness of weed communities in field margins vary considerably, depending on ecological conditions and agricultural management, which may influence weed control and crop production within fields. Weed communities in field margins are strongly affected by the scale of disturbance and the process of field management (Hawes *et al.* 2010). On March 11, 2011, a mega-quake measuring 9.0 on the Richter scale occurred off the Pacific coast of Japan, and subsequently generated a devastating tsunami. As a result, the Sendailow land,which is within 6.0 km from the coast, was inundated with seawater and covered with deposits of rubble and sediment, causing extensive destruction of farmland. Here, we report the changes in field margin weed communities in Miyagi Prefecture, Japan, caused by the 2011 Tohoku-oki tsunami.

METHODOLOGY

This study was carried out in an area *ca.* 5 km from east to west and *ca.* 2 km from north to south near the shoreline in Sendai lowland, Miyagi Prefecture. This area was divided into 5 blocks based on differences in the degree of tsunami damage and recovery processes. A total of 56 survey fields were set up. A vegetation survey was conducted annually in July and September from 2012 to 2014. Species were recorded from an established transect line along field margins. Species richness and frequency as count data were analyzed. The management conditions in the survey fields were also recorded.

RESULTS

In total, 179 vascular plant species were recorded from the 56 surveyed field margins over the 3 years of the study. When cropping was restarted, the species richness did not differ among blocks. In the field margins of Blocks 3 and 5, where weed management was not undertaken immediately after tsunami, there was a tendency for species richness to increase in the current year, relative to other blocks. The species richness in these blocks had decreased by 2014, the third year after tsunami. In Block 5, which is in an area severely damaged by the tsunami, species richness was highest among the five blocks, but rapidly decreased with the start of post-tsunami construction and damage repair. The Bray-Curtis dissimilarity indices from 2012 to 2014 showed that the succession ratesin cultivated fields were only slightly different among blocks, with the highest values being recorded in Block 4 and 5. Non-metric multidimensional scaling analysis revealed that the weed species composition in fields with rice cultivation were similar among different blocks. *Digitaria ciliaris*, *Echinochloa crus-galli*, and *Persicaria longiseta* were dominant species in fields with rice cultivation. The species composition in soybean monoculture or soybean culture in rotation cropping converged uniformly to a point along Axis I of an ordination plot. In Blocks 4 and 5, which were extensively damaged by the tsunami and subsequent recovery practices, the species composition was clearly different from that of other blocks. *Typha latifolia*, *Pharagmites australis*, and *Schoenoplectus trqueter* as marsh species, and *Carex kobomugi* as a coastal species, were particularly notable in Block 5, indicating a specific-species composition influenced by seawater and a long period of flooding.

CONCLUSION

The post-tsunami weed communities' changes were determined by the scale of disturbance in a current year, i.e., the magnitude of damage caused by the tsunami and the management levels of recovery practices, rather than by development depending on temporal processes since the tsunami.

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Caracterization of cadmium and lead potential plant growth promotory rhizobacteria isolated from *Vetiveria zizaniodes* rhizosphere

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Vetiver grass (*Vetiveria zizanioides*) is a weed known for heavy metals accumulation (Singhakant *et al.* 2009). *Vetiveria zizanioides* is popularly known as *Khas Khas*, *Khas* or *Khus* grass in India which prevents the soil erosion as well as land stabilization in warm climates. Vetiver grass (*Vetiveria zizanioides*) is a fast growing grass with a massive and complex root system. Vetiver grass can absorb heavy metal heavy metals such as lead, cadmium, copper (Zhang *et al.* 2014). As the plant grows exclusively downward, it helps to block the runoff of surface water and conserves soil. Hence, it is used to create boundaries for rice paddies, where is used as a bio-tool to rehabilitate heavy metals stressed soil.

METHODOLOGY

Bacterial strains were isolated from rhizospheric soil of *Vetiveria zizaniodes* collected from Panki power plant coordinated 26°28'31"N 80°14'35"E, Kanpur Uttar Pradesh. Isolation and characterization of isolates were done according to the method of Jing *et al.* (2012) and Cappuccino and Sherman (1992), while physico-chemical analysis of the sample was done by following the method of Rahat *et al.* (2014). Further, plant growth promoting traits, were checked in the presence and absence of heavy metals by followings the method.

RESULTS

Seventeen bacterial strains were isolated from rhizosphere of weed (*Vetiveria zizaniodes*) in which 74% of bacteria were resistant towards several Cd (100ppm to 200 ppm) and Pb (500-1000ppm). About 52% of the total isolates solubilized phosphate, 33% of the isolates produced ammonia, 27% produced lipase, 53% produced amylase, 17% chitinase, 40% produced indole-acetic acid and 10% isolates produced HCN. Quantitative assessment for plant growth promotion activity was done and enhanced production of IAA (16.4 g/ml) and (20.8 g/ml) was observed in the presence of 250 g/ml and 500 ìg/ml of tryptophan, respectively. Isolates were also given a better response in phosphate solubilization

Table. 5 blocks set up based on differences in the degree of tsunami damage and recovery process for the field survey

Block		1	2	3	4	5
		Small	Scale of disturbance			Large
Year	Recovery process	Earthquake & tsunami devastated fields				
2011		Cropping	Recovery	Uncontrolled	Weeding	Uncontrolled
2012		Cropping	Cropping	Recovery	Weeding	Weeding
2013		Cropping	Cropping	Cropping	Recovery	Weeding
2014		Cropping	Cropping	Cropping	Cropping	Recovery

Table.1 Physico-chemical analysis of Samples

Parameters	pH	EC (dS/m)	Moisture Content (%) (d/w)	Total Organic Carbon (%)	Total Kjeldhal Nitrogen (%)	Total Available Phosphorous (%)	Cd (µg/g)	Pb (µg/g)
Sample -1	7.06 ±0.05	8.3 ± 0.17	10.23 ± 0.00	0.79 ± 0.01	0.42 ± 0.01	0.16 ± 0.00	40.23 ±0.05	120.37 ± 0.54
Sample – 2	7.96 ±0.05	7.86 ± 0.05	19.44 ± 0.00	1.12 ± 0.00	0.47 ± 0.02	0.19 ± 0.01	41.01 ±0.01	118.66 ± 0.25

Values are means of three replicates ± Standard deviation

by NBRIP media amended with heavy metal. On the basis of different biochemical tests and Bergey's manual, isolates were identified. 60% of isolates were *Pseudomonas* sp. And 35% were *Bacillus* sp.

The strains isolated from the weed plantsin heavy metal contaminated sites were reported to have very good plant growth promoting activities (Wei *et al.* 2005). The isolated strains of this study may enhance the biomass production and tolerance of plants to heavy metals in the contaminated areas. Use of PGPR has steadily increased crop production and offers an attractive way to replace chemical fertilizers, pesticides and supplements.

CONCLUSION

It is concluded that the bacterial strains isolated from rhizosphere of Vetiver plant grown in fly ash of Panki power plant were heavy metal resistant. The isolated bacterial strains showed multiple heavy metal resistance and plant growth-promoting characteristics. The isolates may be useful for plant growth promotion and bacteria-assisted phytoremediation of lead and cadmium-contaminated soils.

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Distribution of *Physalis* species in Uttarakhand and Uttar Pradesh states of India

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Physalis sppis native to Peru, Colombia, and Ecuador (Axel, 2012). A member of the solanaceae family, it is a dicotyledonous, annual herb 0.5 to 1.5 m height with delicate stem and leaves. It bears flowers in summer. Fruits are berry, enclosed within large, ribbed, reticulate veined calyx which is available in autumn. In India, several species and natural hybrids of *Physalis* spp are commonly found in disturbed and uncultivated lands as well as in crop fields. Some farmers also grow it as a commercial crop in the Aligarh, Mathura regions of Uttar Pradesh.

METHODOLOGY

Surveys were conducted in different districts of Uttarakhand and Uttar Pradesh states of India for identifying the locations of *P. minima* occurrence in farmer fields and uncultivated lands. The GPS location and altitudes of surveyed areas were recorded. The soil samples of these locations were collected for nutrients analysis.

RESULTS

The flowering and fruiting season of *Physalis* spp starts from April–May and continues up to the end of November. In the present survey, *Physalis* spp. population was observed mostly in the mustard, soybean, urd bean, radish and tomato cultivated fields. Two locations of Bilaspur-Rampur road [Lalanagla (Bilaspur) and Dibdiba Farm (Rampur)] had heavy infestation of *Physalis* spp. It was observed that mustard, radish, tomato and legume crops cultivated fields exhibited higher infestation of *P. minima* as compared to other synchronous crops.

Fig. 1. Nitrogen, phosphorous and potassium content of soils from different locations

Sl no.	Locations	Nitrogen content (kg/ha)	Potassium content (kg/ha)	Phosphorus content (kg/ha)
1.	Rudrapur	191.92	216.61	73.31
2.	Belpadaw (Ramnagar)	235.83	227.58	50.33
3.	Lalanagla (Bilaspur)	106.62	264.77	33.77
4.	Dibdiba Farm (Rampur)	119.17	146.94	13.43
5.	Nakuda (Almora)	171.85	148.06	38.72
6.	Lalawala bagh (Rampur)	184.39	97.33	40.72
7.	FaridpurFatehganj (Bareily)	103.5	106.2	3.4
8.	Kunwarpur Sissaiya, Sitarganj (US Nagar)	84.7	251.6	15.0
9.	Dandi abhaychand (Bareily)	109.8	76.9	13.6
10.	1.5kmfrom Poolbhatta,Sitarganj(US Nagar)	84.7	168.2	2.9
11.	Madhopur(Bareily)	100.4	61.5	1.3
12.	Nanpur (Moradabad)	147.4	216.4	3.3
13.	Gontiya(Pilibhit)	84.7	60.3	5.4
14.	Badiyakalan (Shajahanpur)	90.9	142.7	1.2
15.	Dhundari (Pilibhit)	100.4	223.1	1.9
16.	Janobi (Bareily)	119.2	119.7	46.2
17.	Ahladpur (Bareily)	65.9	227.9	40.8
18.	Khairabajeda (Shajahanpur)	87.8	226.5	8.0
19.	Madhopur(Bareily)	159	146.2	2.0

Table 2. Description of the locations where *P. minima* occurred

S.no.	Locations	Description of Area
1.	Rudrapur	Uncultivated land
2.	Lalawala bagh (Bilaspur)	Uncultivated land
3.	Lalanagla (Bilaspur)	Poplar, Lobia, Mustard, Radish cultivated fields (Heavily infested)
4.	Belpadaw (Ramnagar)	Soybean cultivated fields (Heavily infested)
5.	Dibdiba Farm (Rampur)	Mustard cultivated fields (Heavily infested)
6.	Poolbhatta (in rice plot)	Rice cultivated fields (Luxurious growth of *P. minima*
7.	Faridpur,Fatehganj Purvi Road	Bajra cultivated fields
8.	Kunwarpur Sissaiya, Sitarganj	Rice cultivated fields
9.	Dandiabhaychand (Bahedi) Bareily	Rice cultivated fields
10.	Bandiyakalan (Shajahanpur)	Rice cultivated fields
11.	Madhopur (Bareily)	Rice and sugarcane cultivated fields (Heavy infestation)
12.	Poolbhatta	Rice cultivated fields
13.	Gontiya (Pilibhit)	Rice cultivated fields
14.	Bandiyakalan(Shajahanpur)	Rice cultivated fields
15.	Dhundari (Pilibhit)	Rice cultivated fields
16	Khairabajeda (Shajahanpur)	Rice cultivated fields
17.	Ahladpur (Bareily)	Rice cultivated fields (Heavily infested)
18.	Janobi ,Bahedi (Bareily)	Rice cultivated fields

CONCLUSION

Physalis species occurs in both plains and hills of Uttarakhand as well as Rampur, Bijnor, Moradabad, Sahajahnpur districts of Uttar Pradesh. The fruit is also available for a brief period of time in the market during March -April. The species needs to be identified accurately.

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Construction of STS markers linked to seed dormancy in hybrid progeny of sesame and its wild ancest

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Sesame (*Sesamum indicum* L.*)*, originated in India and is one of the oldest known oil crops. A wild relative, *Sesamum mulayanum* Nair, which has weedy traits and sometimes contaminates sesame crop fields, is distributed in the Indian subcontinent and is considered the most probable ancestor of cultivated sesame (Bedigian 2003). *S. mulayanum* is distinguished from cultivated sesame by its purple pigmentation on the lower lip of the corolla and its deep seed dormancy. Seed dormancy of this wild sesame is mostly broken by scarification of the seed coat, suggesting coat-enhanced dormancy (Tanesaka 2012). In contrast, extreme loss of seed dormancy under domestication of cultivated sesame sometimes causes pre-harvest sprouting and results in severe economic damage. Genetic markers for seed dormancy are effective tools in breeding programs for obtaining varieties resistant to pre-harvest sprouting. This study aimed to obtain genetic markers linked to seed dormancy.

METHODOLOGY

F_1 hybrids between *S. indicum* Acc. No. 800 (@&) and *S. mulayanum* Acc. No. 0161 (B&) were obtained by artificial crossing. Intact (unscarified) F_1 seeds germinated as easily as seeds from the maternal plant, while F_2 seeds showed deep seed dormancy. Germination of F_3 seeds from each F_2 plant (line) varied among lines, showing continuous variation that ranged from 0 to 100% germination rate (30ºC, 14 days) with most lines in the distribution skewed to deep dormancy. F_3 seeds from lines which showed 0-10% germination (bulk D) and lines which showed 90-100% germination (bulk G) were used for subsequent DNA analysis. Genomic DNA was extracted from both groups of bulked seeds with CTAB isolation buffer and used as template DNA for PCR with 16 random primers (12-mers). PCR products were electrophoresed on a 1.0% agarose gel, resulting in detection of six polymorphic bands, which were heterogenous between the bulks. These bands were extracted from the gel and purified with a QIAquick Gel Extraction Kit (Qiagen). To construct sequence tagged sites (STSs), each purified DNA was sequenced by outsourcing (FASMAC) and new primer sets were designed for each of the six DNAs.

RESULTS

PCR with the six primer sets amplified one or a few DNA fragments. Of the six primer sets, two (bkSimH42-2 and bkSimH42-6) amplified one DNA product only from genomic templates from *S. mulayanum* and bulk D but not from either *S. indicum* or bulk G, suggesting that these DNA products are dominant STS markers linked to the seed dormancy trait carried by wild sesame.

CONCLUSION

Two dominant STS markers linked to seed dormancy were obtained. These markers will be useful for further linkage analysis. These markers will also allow detection of introgression from wild to cultivated sesame, which causes genetic erosion of sesame in field populations.

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Salinity, osmotic and pH stress tolerance in water hyacinth

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Water hyacinth (*Eichhornia crassipes* Mart. Solms) is an important biotic component of aquatic environment with wide range of implications on the ecosystem and its services. As an obnoxious aquatic weed, its invasion is often alarming with heavy economic losses. Though herbicides were proved to facilitate weed management in crops while reducing labour need, their use has potential environmental and toxicological costs raising question about dependence on herbicides. Sustained use of herbicides has resulted in development of herbicide resistance in weeds. Safe herbicide options for aquatic environments are not available for management of weeds in aquatic environment where water has multifarious utilities and safety considerations subsequent to movement of the herbicides with water flow are of paramount concerns.

Natural ecosystems may experience wide range of stresses including salinity, osmotic and pH with seasons and physical manipulation of these for bringing physiological effects on water hyacinth may open up avenues for its probable management under certain situations. Information on stress tolerance by the weed may facilitate prediction of population dynamics of the weed and prediction of its menace under ranges of stress conditions. Present study was aimed to quantify relative effects of different stresses levels on water hyacinth for exploring possibility of employing them for the management of the weed.

METHODOLOGY

Water hyacinth (*Eichhornia crassipes* Mart. Solmns) was collected from aquatic bodies and maintained at the Directorate of Weed Research, Jabalpur, India. Pre-weighed water hyacinth plants were placed in solutions of different levels of NaCl salinity (10-320 mM), pH (1-14) and polyethylene glycol (PEG) 8000 ($Ø_w$0 - -1.09 MPa) and allowed to grow at about >500 µE m^2/s^1 photosynthetic photon flux density (PPFD) at 26-29°C during 2015. The medium contained 10% (v/v) nutrient medium (Pandey 1996). Weed grown in nutrient medium alone served as control. Biomass of the weed and toxicity were monitored. The experiments were replicated thrice.

RESULTS

Sodium chloride salinity at 20 mM inhibited water hyacinth plants. Inhibition was apparent by 5-10 days. At and above 30 mM, the weed was killed in 10-15 days. The salinity toxicity has started with wilting of older leaves from margins extending to petioles and was followed by gradual desiccation and death of above water plant parts. The roots turned flaccid. The treated plants had lower evapo-transpiratory loss of water, showing low water use by the plants. The salinity appeared to have killed the treated plants by affecting roots at first place causing root dysfunction concomitant with decreased evapo-transpiration. Thus failure of water absorption by the roots to sustain evapotranspiration appeared to be the cause of treated plants mortality.

Osmotic stress at and above -0.148 MPa inhibited water hyacinth in 5-10 days and killed at and above -0.511 MPa in 5-10 days. The symptoms of toxicity were same as those of salinity stress. Treated plants were desiccated and died in 5-10 days.

Hydrogen ion concentrations at 1-2 were lethal to water hyacinth, which was killed in 1-5 days. The plants thrived well at pH 3-10 and were killed beyond this range. At extreme range of pH the treated plants showed rapid wilting, bleaching, desiccation and died in 1-5 days.

CONCLUSION

The critical levels of NaCl salinity at or >30 mM, osmotic stress at or >-0.511 MPa and pH beyond 3-10 range on either side of the scale were toxic to water hyacinth.

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Effect of bio-fertilizers on summer moong and *Cyperus rotundus* in relation to planting methods

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Summer moong (greengram), being short duration in nature, can help in increasing the cropping intensity, enhance pulse production and maintain soil fertility owing to its leguminous nature. *Cyperus rotundus* is an important perennial weed which grows in the crop. This study was conducted to evaluate the effect of biofertilizers on summer moong and *Cyperus rotundus* during *Zaid Rabi* season.

METHODOLOGY

The experiment was conducted during *Zaid Rabi* season of 2014 at Punjab Agricultural University, Ludhiana in loamy sand soil in randomized block design with 3 replications. The treatments comprised of 4 biofertilizer, *i.e.* control, *Rhizobium*, plant growth promoting rhizobacteria (PGPR) and consortium inoculation and two planting methods viz., bed and flat sowing. The beds, 67.5 cm wide were made using bed planter and two rows on each bed were sown at row-row spacing of 20 cm whereas in flat sowing row-row spacing was kept 22.5 cm. Moong var. *SML 668* was sown on 25th March, 2014 after application of bio-fertilizers to the seed. Pendimethalin at 0.75 kg/ha was applied uniformly after sowing to control weeds. The observations on seed and biological yield of the crop were recorded at the time of crop harvest, *i.e.* 30th May, 2014, whereas *Cyperus rotundus* density and biomass were recorded 30 days after sowing (DAS).

RESULTS

Application of all biofertilizers increased seed yield over control (Table 1). The seed yield and biological yield with *Rhizobium* and PGPR inoculation were statistically at par, however consortium produced significantly higher seed yield over all the treatments. Methods of planting did not cause significant variation in both of the studied crop parameters as well as density and biomass of *Cyperus rotundus.*

Table 1. Effect of biofertilizers on yield of summer moong and *Cyperus rotundus* density and biomass (g/m^2) under two planting methods

Treatment	Seed yield (q ha^{-1})	Biological yield (q ha^{-1})	*C rotundus* density (no./m^2)	*C rotundus* biomss (g./m^2)
Planting methods				
Flat	20.8	109.3	47.4	46.7
Bed	21.7	110.1	45.7	47.6
LSD (p=0.05)	NS	NS	NS	NS
Biofertilizers				
Control	17.6	87.4	42.0	43.8
Rhizobium inoculation	20.5	110.4	45.7	46.8
PGPR inoculation	21.5	110.5	45.5	46.5
Consortium	25.3	130.4	51.0	51.6
LSD (p=0.05)	3.2	17.0	5.1	4.3

Cyperus rotundus density and biomass under control, *R hizobium* and PGPR treatments were statistically at par, whereas application of consortium increased the *Cyperus rotundus* density and biomass significantly over rest of the treatments. *Cyperus rotundus* density and biomass under consortium was 21.4% and 17.8 % higher over the control, respectively.

CONCLUSION

Application of biofertilizer improved the crop growth and yield of greengram while application of consortium had beneficial effect on *Cyperus rotundus*.

Predominant weed species of *Kharif* groundnut in Rayalaseema region of Andhra Pradesh

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In Andhra Pardesh, it is cultivated in an area of around 13.4 lakh hectares with a production of about 11.1 lakh tones and a productivity of 0.829 t/ha (2012-13) (ZREAC, 2014). In Rayalaseema region of Andhra Pardesh, groundnut is mainly cultivated during *Kharif* under rainfed conditions. The weed flora associated with groundnut is influenced by soil type, moisture availability and management of groundnut. Apart from uncertain rainfall during *Kharif*, weeds significantly reduce the yield due to increased competition for soil moisture between crop and weeds including increased diseases as the weeds of groundnut act as alternate hosts.

METHODOLOGY

As a part of "National Invasive Weed Surveillance Programme", weed survey was carried out for three years during 2008-09 to 2010-11 during both *Kharif* and *Rabi* seasons in different crops of Rayalaseema districts, A.P., in which the predominant crop grown during *Kharif* is groundnut. In each village 10 spots were identified in groundnut cropped area, randomly. The weed species present in the sampled area were identified and recorded in prescribed data sheets. The relative density (RD), relative frequency (RF), relative dominance (RDO) and importance value index (IVI) were calculated for each of the species, using the standard formulae.

RESULTS AND DISCUSSION

The predominant broad leaved weed species were *Chloris barbata*, *Celosia argentia*, *Parthenium hysterophorus*, *Tridax procumbens*, *Digera arvensis*, *Amarnathus viridis* and *Argemone Mexicana*, among the grasses *Cynodon dactylon* and *Dactyloctenium aegyptium* were predominant. One sedge,*Cyperus rotundus* was associated with groundnut in Chittoor (45.03) followed by Kurnool district (38.37) while *Celosia argentia* (58.66) and *Chloris barbata* (31.94) were dominant broad leaved weeds in Kadapa district.

Among the broad leaved weeds in rainfed groundnut, the highest IVI was obtained with *Celosia argentia* (58.66), *Chloris barbata* (31.94), *Digera arvensis* (27.96), *Tridax procumbens* (20.27) and *Parthenium hysterophorus* (20.14) in Kadapa. The highest IVI were with *Celosia argentia* (28.48) followed by *Parthenium hysterophorus* (23.20) in Anantapur. *Parthenium hysterophorus* was the predominant weed species in Kurnool district with IVI value of 23.54 followed by *Argemone mexicana* (19.23) and *Amaranthus viridis* (18.01) probably due to black soils preference of these weeds. In Chittoor, *Celosia argentia* (16.11) was the predominant weed followed by *Digera arvensis* (15.34) associated with groundnut. *Celosia argentia* was the predominant weed in light soils (or) alfisols of Anantapur and Chittoor. The only sedge associated with Kharif groundnut was the *Cyperus rotundus* with IVI of 48.01, 47.35, 44.15 and 25.86 in Kadapa, Kurnool, Chittoor and Anantapur districts respectively.

Name of the weed and district	RD	RF	RDO	IVI
Chloris barbata				
Kurnool	5.80	5.59	1.75	13.14
Anantapur	4.76	4.80	1.16	10.72
Kadapa	12.45	12.39	7.10	31.94
Chittoor	4.08	4.33	2.99	11.40
Cynodon dactylon				
Kurnool	14.41	16.08	7.78	38.27
Anantapur	10.27	9.95	4.46	24.67
Kadapa	-	-	-	-
Chittoor	19.24	14.64	11.14	45.03
Dactyloctenium aegyptium				
Kurnool	5.29	5.64	10.47	21.39
Anantapur	2.89	3.40	4.60	10.88
Kadapa	1.73	1.99	4.40	8.16
Chittoor	9.27	9.45	7.28	26.00
Celosia argentia				
Kurnool	4.18	4.97	6.77	15.92
Anantapur	8.40	9.14	10.94	28.48
Kadapa	15.19	12.76	30.72	58.66
Chittoor	3.38	3.91	8.83	16.11
Parthenium hysterophorus				
Kurnool	7.25	6.64	9.65	23.54
Anantapur	7.38	7.91	7.91	23.20
Kadapa	4.50	5.44	10.20	20.14
Chittoor	3.07	4.06	6.68	13.81
Tridax procumbens				
Kurnool	2.13	2.49	2.10	6.72
Anantapur	4.17	4.53	3.31	12.01
Kadapa	6.40	6.50	7.38	20.27
Chittoor	3.12	3.31	3.45	9.87
Digera arvensis				
Kurnool	2.81	3.12	0.97	6.90
Anantapur	1.87	1.88	0.52	4.27
Kadapa	10.29	9.24	8.43	27.96
Chittoor	4.15	4.27	6.92	15.34
Amaranthus viridis				
Kurnool	6.22	2.83	8.96	18.01
Anantapur	0.64	1.10	0.74	2.48
Kadapa	3.76	5.23	4.85	13.84
Chittoor	1.21	1.96	2.01	5.18
Argemone Mexicana				
Kurnool	4.52	3.49	11.22	19.23
Anantapur	2.83	3.41	5.66	11.91
Kadapa	4.05	4.09	3.74	11.88
Chittoor	2.58	1.58	3.07	7.23
Cyperus rotundus				
Kurnool	18.07	18.22	11.06	47.35
Anantapur	10.48	10.22	5.16	25.86
Kadapa	16.94	14.89	16.18	48.01
Chittoor	15.35	14.74	14.06	44.15

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Phytoremediation of cadmium by potential weed species and PGPR

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Heavy metals are some of the most dangerous substances in the environment due to their persistence and harmfulness to living organisms in which cadmium (Cd) is one of the major contaminants of soils, which induces oxidative stress in plants. This metal ion is extremely toxic to plants and animals. Weeds have been pointed out as a suitable plants for soil remediation (Hussein *et al.* 2012). The present study was aimed at identification of the potential weed species for cadmium phytoremediation.

METHODOLOGY

Cassia tora was used for pot experiments in green house. Seeds were inoculated with and without plant growth-promoting rhizobacteria (PGPR) strain. Cd concentration maintained in pots was 10, 20 and 50 ppm followed by control in triplicate. Results were compared with the metal tolerant PGPR inoculated pot. PGPR; isolated and characterized (Positive in IAA production, siderophore production and phosphate solubilization activity) from rhizosphere of weed grown in agricultural field. *Cassia tora* seedlings treated with or without PGPR in different concentration of Cd amended soil. Phytoremediation potential was evaluated in terms of the total accumulation factor and translocation factor.

RESULTS

Bacterial treated plant resulted in better plant growth, plant biomass and higher Cd content than control plants. The detectable content of Cd (by AAS) accumulated by *Cassia tora* inoculated with PGPR was, 3.5, 4.05 and 4.92 ppm and without PGPR was, 1.35, 2.05 and 2.33 ppm for 10, 20 and 50 ppm respectively. Biomass of root /shoot of *Cassia tora*, significantly increased in PGPR inoculated pots. Themetal distribution profile in different plant tissue (Root and shoot) of *Cassia tora* is shown in (Fig. 1). Interestingly *Cassia tora* accumulated metal (Cd) mostly in their root and shoot parts in the order of root > shoot. The accumulation of Cd in the roots and shoots of *Cassi tora* plant was dependent on increased concentration of Cd in the soil and duration with and without PGPR inoculation.

The Cd accumulation in the roots is higher and faster in 10 ppm Cd treated plant than 20 and 50 ppm Cd treated pants. This can be attributed the toxicity of Cd for plant, Results also supported by Bang *et al.* (2015) and Akpinar *et al.* (2015). In addition the growths of *Cassia tora* plant were increased in inoculated with PGPR in presence of cadmium. The application of individual PGPR strain as well as consortium gave significant accumulation value against control under Cd stress.

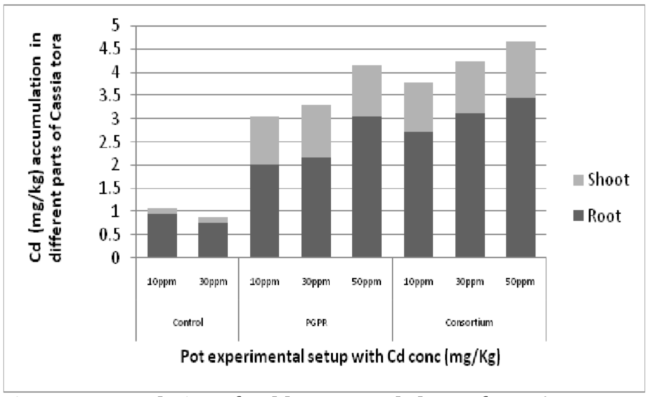

Fig. 1. Accumulation of Cd by root and shoot of *Cassia tora*

CONCLUSION

Phytoremediation assisted with potential PGPR appears a very promising technology for the removal of metal pollutants from the environment and may be, at present, approaching commercialization. Although research on phytoremediation using weeds has just begun and there are many issues which need to be resolved, this remediation technique is expected to become a valuable technology for the alleviation of heavy metal contaminated soil in the near future.

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Enhanced cadmium accumulation in *Arundo donax* by EDTA

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Due to industrial development and population expansion, heavy metal pollution in soil and water environment is becoming increasingly serious in India. Cadmium is one of the most important pollutants to consider in terms of food chain contamination. Continuous use of cadmium containing waters for irrigation is bound to result its entry in the food chain. Studies indicated that use of phosphate fertilizers is also the route of Cd addition to soils. Cd content is typically in the range of 3-50 ppm and even higher in the range of 10-500 ppm (Mar and Okazaki 2012) in rock phosphate used as raw material for phosphatic fertilizers. Unless there is a specific de-cadmiation treatment, Cd is accumulated in sewage sediment, waste water irrigated soil and retains in the rock phosphate. Less bio-availability of Cd at the contaminated sites affect the bioremediation process. Recently, EDTA is reported as one of the surfactant for enhancement of bioremediation.The removal and phytostabilisation of cadmium at contaminated source is easier than from areas where these get accumulated by adsorption. The use of fast growing weedy plant producing efficient biomass such as *Arundo donax* L. is highly desirable for phyto-remediation of cadmium from contaminated soil and waters. *Arundo* is cultivable throughout India locally called as *natkhat* and is also grown in Asian countries (Papazoglou *et al.* 2005).

METHODOLOGY

A pot experiment was set up in the net house of Directorate of Weed Science, Jabalpur with an objective to elucidate the growth response of *A. donax* irrigated with different spiked levels (0, 100, 200, 400, 800 and 1200 ppm) of cadmium ($Cd(NO_3)_2.4H_2O$). Selected rhizome of *Arundo* was planted in a 2 kgcapacity pot filled with sand (2mm size). During growing periods, one stem per pot was kept. The Cd containing aqueous solution was prepared by dissolving cadmium nitrate salt (Cd(NO3)2.4H2O) in the tap water. Various Cd treatments were given in six times to experimental plants. Cd treatments included 0 (control), 100, 200, 400, 800 and 1200 mg/L with ethylene diamine tetra-acetic acid (EDTA) concentrations applied at 0, 3 and 6 ppm.A completely randomized experimental design was applied using 3 repetitions for each of the 18 treatments.

RESULTS

The results indicated that the *Arundo* tolerated Cd upto 400 ppm without showing any adverse effect in terms of plant height, number of tillers and leaf area. The plant accumulated cadmium from spiked medium to shoot and root with bioconcentration factor (BC) of 1.44 and 1.96 respectively at 200ppm Cd exposure (Table. 1). EDTA significantly enhanced 12.8% dry weight of shoot and enhanced 2-3 times cadmium accumulation in root as compared to control (No EDTA). At elevated cadmium concentration (400 ppm), the BC factor of 7.74 in root and 0.89 in shoot was recorded under EDTA application of 3 ppm. Except root length no adverse effect of EDTA was observed on plant growth.

Table 1. Cadmium accumulation in different plant parts and its bio-concentration factor and shoot/ root ratio of *Arundo donax*

Treatment	Cd (mg/kg DW)		Bio concentration factor		shoot/ root ratio
Cd (mg/L)	shoot	root	shoot	root	
100	249.9	340.1	2.406	1.059	0.735
200	285.6	1626.5	1.444	1.960	0.175
400	292.2	2319.1	0.633	1.941	0.126
800	320.7	3481.1	0.416	2.471	0.092
1200	398.5	2485.7	0.311	1.855	0.160
LSD (P=0.05)	56.18	475.0	-	-	-

CONCLUSION

A. donax irrigated with increased concentrations of cadmium containing spiked water showed tolerance at 400 ppm Cd. EDTA application enhances the biomass of the plant, and Cd accumulation in different part of *Arundo*. The bioconcentration (BC) of shoot was higher than > 1 when exposed upto 200 ppm of Cd has implications for phytoextraction of Cd contaminated sludge. At elevated cadmium concentration (400 ppm), the higher BC factor for root and shoot with EDTA application has relevance for increasing bioavailability and subsequently the bio-absorption of cadmium from sedimentary rocks as a source of fertilizer in which Cd lies in the range of 10-500 ppm. The results suggested considering environmental risk of chemical compound, optimum level of EDTA (3 ppm) could be considered as surfactant for giant reed remediation system. However, next focus should be on the testing effects of organic chelating compound or to explore the potential of plant growth promoting rhizobacteria associated with *Arundo* for substitution of EDTA.

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Effect of irrigation scheduling and weed control measures on growth and yield of transplanted rice

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Major rice area is under rainfed and excessive irrigation in irrigated area is causing soil salinity due to imbalance use of fertilizer nutrient. As water is one of the crucial input of agriculture, efficient utilization and sustainable use of irrigation water is advocated through reducing the losses of water from paddy field, percolation from the soil surface and by evapo-transpiration from plant surface. The proper use of available irrigation water may play an important role in minimizing present large gap between yield achieved and yield achievable. Weed management is an other important factor in getting maximum harvest of rice with optimal use of water. Chemical weeding is considered a better option for timely control of weeds in rice and several herbicides are available in the market, whose efficacy need to be judged. Hence, this study was undertaken.

METHODOLOGY

The experiment was conducted at Agronomy Research Farm of N. D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P) during *Kharif*, 2009 and 2010. The experiment was laid out in split plot design with 4 replications consisting of 3 irrigation schedules; T_1- 7 cm irrigation at 1 day after disappearance of ponded water (DADPW), T_2- 7 cm irrigation at 3 DADPW, T_3- 7 cm irrigation at 5 DADPW in main plots and 5 weed control measures. W_1- One hand weeding, W_2- Butachlor at 1.50 kg/ha at 3 days after transplanting (DAT), W_3- oxadiargyl at 0.1 kg/ha at 3 DAT , W_4- anilophos at 0.5 kg/ha at 3 DAT and W_5- Weedy check in sub plots. Nursery was sown on 21/6/09 and 15/06/2010 using seed rate of 25 kg/ha. Transplanting of two rice seedling of 22 days age was done per hill at a spacing of 20 x 10 cm. Soil of experimental field was silt loam with pH 8.2 having low organic carbon (0.28%) available nitrogen (160.45 kg/ha) and phosphorous (18.5 kg/ha) and high potassium (280 kg/ha). The climate was sub tropical. The dose of fertilizers (120 kg N, 60 kg P_2O_5 and 40 kg K_2O per ha)was applied uniformly . Half dose of nitrogen and total dose of phosphorous and potash was applied as basal application before puddling. Remaining half dose of nitrogen was applied as top dressing in two equal doses each at tillering and panicle initiation stage. Irrigation treatments based on day after disappearance of pounded water was started just after transplanting with 7 cm while weed control measures were given as per treatments. The values of weed density were transformed using "^x+1 transformation.

RESULTS

Irrigation schedule 7 cm at 1 DADPW (I_1) produced maximum rice grain yield (5.20 t/ha) which was at par with irrigation schedule 7 cm at 3 DADPW (I_2) and significantly superior over irrigation schedule 7 cm at 5 DADPW (I_3), which recorded lowest yield (3.31 t/ha) Water use efficiency (WUE) was also highest (62.86 kg/ha/cm) under I_1 irrigation schedule followed by I_2 and I_3 irrigation schedule in which it was 57.62 and 48.21 kg/ha/cm) respectively. I_1 treatment recorded the minimum weed density of 3.27 and 5.61 no./m^2 at 20 and 60 DAT which was significantly lower than other irrigation treatments. Application of oxadiargyl at 0.1 kg/ha at 3 DAT was found most effective for weed control as it recorded the lowest weed density, 2.75 and 3.70 no./m^2 at 20 and 60 DAP with maximum rice yield of 4.87 t/ha which was significantly superior over other weed control measures. It also gave the highest WUE (64.3 kg/ha/cm) in comparison to other treatments. Moisture regime (7 cm at 1 DADPW) created the favorable environment for plant growth, better weed control and uptake of nutrients by the plants and there by better yield of rice.

Table. Grain yield and WUE of rice under different treatments

Treatment	Grain yield (kg/ha)	Straw Yield (kg/ha)	Weed density (no. /m^2)		WUE (kg/ha.cm)
			20 DAP	60DAP	
A- Irrigation schedule					
I_1 – 7cm irrigation at 1 DADPW	5205	8364	10.76(3.27)	41.44(5.61)	62.86
I_2 – 7cm irrigation at 3 DADPW	4368	6814.08	13.0 (3.61)	45.00 (5.95)	57.62
I_3 – 7cm irrigation at 5 DADPW	3317	4975.50	14.64 (3.86)	49.92 (6.4)	48.21
SEm ±	60	75	0.1	0.11	-
C.D. (P=0.05)	207	218	0.29	0.32	-
B- Weed control treatments					
W_1- One weeding at 25 DAT	4196	6671.61	21.20 (5.95)	27.33 (6.20)	55.35
W_2 – Butachlor @ 1.5 kg ai/ha 3 DAT	4461	6914.55	7.40 (3.70)	19.35 (5.35)	58.85
W_3 – Oxadiargyl@ 0.1 kg /ha at 3 DAT	4877	7803.20	6.66 (2.75)	12.46 (3.70)	64.34
W_4 – Anilophos@0.5 kg/ha at 3 DAT	4505	7162.90	7.03 (2.82)	17.80 (4.30)	59.43
W_5 – Weed check	3444	5372.64	21.76 (4.76)	150.5(12.3)	45.43
SEm ±	73	70	0.15	0.21	-
C.D. (P=0.05)	209	205	0.43	0.63	-

(Interaction – NS. Figures in parenthesis are transformed values of weed density.)

CONCLUSION

Irrigation schedule 7cm irrigation at 1 DADPW with application of oxadiargyl (0.1 kg/ha at 3 DAT) were most effective in managing weeds and attain higher yield of transplanted rice.

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Morpho-physiological and molecular variations in *Physalis* species collected from different locations

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Physalis peruviana, a small herbaceous annual/ perennial weed plant is a member of solanaceae family. It is similar to cherry tomato and grows in warm temperate and subtropical regions of the world. It is mainly known by several names like cape goose berry, winter cheery, golden berry in many parts of the world, and by Rasbhari in India, where it grows around wastelands, houses, roadsides and in crop fields as a weed. It produces an edible fruits enclosed in bladder like persistent calyx. Mature fruits are collected and sold by farmers in local market. *Physalis peruviana* is mainly known for its fruits medicinal and nutritional values. Different products processed from the fruit of *P. peruviana* include: jams, raisins and chocolate-covered candies and juices. The ripened fruits are eaten fresh because of their taste. The fruit of *P. peruviana* is highly nutritious, having high levels of vitamins A, B and C and is recommended as a alternative source for vitamin A to malnourished children (Puente *et al.* 2011). Hence in view of weedy characteristics as well as high nutritional contents of its fruit, a study was carried out to at Directorate of Weed Research, Jabalpur (M.P.), India assess the variation in its useful traits. The main aim of the study was to quantify the nutritional potential of *Physalis peruviana* and its weedy counterpart *Physalis minima* potential utilisation to alleviate malnutrition problems in India and elsewhere.

METHODOLOGY

Extensive surveys were conducted for collection of seeds of *Physalis* species. Samples were collected from the different locations across the agro-climatic zones. A total collection of 50 *Physalis* species was made. Twenty one collections of *Physalis peruviana* and *Physalis minima* were grown under field conditions for assessing variation among different accessions. Physiological parameters were recorded at 60 days after transplanting. Flower structural character / orientation of different accessions were recorded along with observations on fruit shape, size and yield of individual plants to evaluate their yield potential. Molecular diversity analysis was done using RAPD.

RESULTS

Flowers are the key to identify any plant species. Huge variation was noticed in flower colours/shape/pigmentation and orientation of petals. Variations in different flower parts and their reproductive parts (androecium and gynoecium) were also evident in different accessions.

Vast variation in morphological and physiological traits as well as yield attributes was noticed. Number of fruits/plant, and fruits size/colour and shape also varied in different accessions. Considerable variation was evident in rate of gas exchange parameters with huge variation in fruits shape, size and yields (Table 1). Molecular diversity analysis revealed variations in different accessions within and across the species.

Table 1. Photosynthesis, transpiration, fruit shape, size and yield of different accessions of *Physalis* spp.

Accessions	Photosynthesis (µmoles/m2/s1)	Transpiration (mmoles/m2/s1)	Fruit Shape	Fruit Length Calyx (mm)	Fruit Length (mm)	Fruit yield (g/plant)
DWR-NGP	16.6±1.4	1.24±0.16	Round	60	28	735±46.9
DWR-MOD	17.9±1.6	1.34±0.54	Round	41	25	598±55.3
DWR-PUN (L)	17.7±1.0	1.47±0.15	Long	60	37	784±99.6
DWR-NSK (S)	20.7±1.0	1.46±0.06	Round	35	25	582±91.8
DWR-LKO	20.4±2.0	1.31±0.37	Round	45	33	701±31.0
DWR-JBP (L)	20.2±1.3	1.21±0.19	Long	57	43	887±58.9
DWR-VAR (XL)	20.5±1.4	1.24±0.15	Round	60	35	368±13.7
DWR-JAI	21.6±1.1	1.41±0.22	Long	61	30	488±33.6
DWR-JOD	21.6±1.2	1.59±0.24	Round	60	32	633±51.2
DWR-MUM	23.1±1.4	1.60±0.25	Round	35	27	433±41.4
DWR-NSK (B)	23.0±1.6	1.47±0.12	Round	43	30	687±14.5
DWR-GOA	16.2±1.7	1.22±0.31	Long	66	35	569±54.1
DWR-KOL	18.9±1.3	1.23±0.55	Round	50	29	771±51.1
DWR-NGP (S)	20.3±1.4	1.24±0.43	Round	50	35	850±34.5
DWR-JBP(R)	22.6±1.2	1.48±0.27	Long	55	40	670±79.4
DWR-AGR (B)	20.7±1.7	1.30±0.39	Long	67	36	626±62.9
DWR-PUN(R)	23.7±0.9	1.39±0.13	Round	34	31	442±29.4
DWR-AGR (B)	21.4±1.5	1.03±0.26	Round	60	35	462±30.5
DWR-SJP	22.5±1.8	1.28±0.18	Round	45	30	638±66.1
DWR-SAO	21.5±1.5	1.17±0.14	Long	61	44	1058±87.8
DWR-DEL	24.3±1.1	1.52±0.16	Round	40	30	316±67.9
Physalis minima	21.46±1.1	4.1±0.1	Round	30	20	158±18.5

Data given are the mean of at least three or more individual plants

CONCLUSION

This is first diversity assessment of *Physalis peruviana*, based on morpho-physiological parameters in Indian subcontinent. The evolution of morphological and physiological variation is a consequence of adaptive evolution. Understanding their variability patterns and interactions with environments to determine morphological variation in flower and fruits are key to establish novel strategies to improve/incorporate useful traits related to the productivity and fruit quality of *Physalis peruviana.*

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Competitive effect of *Isachne globosa* on growth and yield of wet-seeded rice

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Weeds are the major biotic stress in rice production and are universal pest in agriculture. Weed management is the key factor towards achieving higher rice productivity. (Rao *et al.* 2007). In Sri Lanka that 30-40% of rice yields are generally lost due to weed competition (Abeysekera 2001). Degree of loss due to weeds could be varied, depending on type of weed species, density, duration of crop weed interference, rice cultivar and cultural practices. Weeds grow quickly in direct-seeded areas compared with weeds growth in wetland transplanted rice cultivation. *Isachne globosa* is one of the major noxious weed associated with the rice yield reduction, across all agro ecological zones of Sri Lanka. Mere presence of *I. globosa* in rice field may not be economical to control and decision on herbicide spraying depends on the density of weeds. Limited scientific studies have conducted to find out the competitiveness of *I. globosa* and its effect on growth and yield of rice. Hence, the objective of this study was to determine the competitive effect of different densities of *I. globosa* on growth and yield of rice.

METHODOLOGY

A pot experiment was conducted at Rice Research and Development Institute, Batalagoda, Sri Lanka during major and minor seasons 2013/2014. The pots were filled with red yellow podsolic soil having pH of 5.95. Complete Randomized design (CRD) is followed with three replicates. The treatments consisted of seven different densities of *I. globosa* with a control. 90 days duration rice variety Bg-300, was used and pre-germinated seeds were sown with the space of 7.5 cm. *I. globosa* stems were planted surrounding the rice seedlings maintaining equal distance while maintaining the desired weed density. All the other agronomic and plant protection practices were adopted according to the department of agriculture (DOA) recommendations. Plant growth parameters were measured at two weeks interval and 56 days old weeds were uprooted to measure the biomass.At maturityyield and yield components were recorded. The data were analyzed using the statistical package Minitab15. One way ANOVA, two way ANOVA and regression analysis were performed.

RESULTS

Plant Growth Characters: Height of rice plants showed significant (P=0.000) reduction with increase weed densities at 4 weeks after sowing (WAS). The least value was observed with 151 weeds/m^2 . Number of leaves and tillers were significantly (P=0.000) affected by weed competition. Weed density of above 43 plants/m^2 has significantly affected the growth parameters, which were significantly (p=0.001) affected with interaction effect of weed density and the duration. The biomass of weeds showed a significant (p=0.000) increase with increased weed competition.

Table 1. Yield and yield components of rice under different weed densities

	Yield and yield components					
Weed density (weeds/ m^2)	No. of panicles /m^2	Grains/ panicle	Filled grain %	1000 grain weight (*10^{-3}kg)	Grain yield (*10^{-3} kg/m^2)	% yield loss over control
0	624.33a	115.3a	94.32a	25.008a	1214.5a	0.00a
22	484.39ab	89.27ab	92.34ab	24.315a	999.7ab	17.69ab
43	419.81abc	80.07b	91.67ab	20.777ab	879.9bc	27.555bc
65	387.51abc	78.17b	90.44ab	20.971ab	821.5bc	32.358bc
86	312.16bc	69.57b	88.20ab	19.725b	798.8bc	34.228bc
108	312.16bc	68.93b	87.69ab	18.714b	777.5bc	35.983bc
129	236.81c	65.53b	84.70ab	18.72b	762.3bc	37.233bc
151	226.05c	66.27b	85.19b	17.513b	661.0c	45.573c

Within a column, any two means followed by same letter is not significantly different at 5% probability level.

Yield Component: The interspecific competiton with weeds at varying weed densities significantly (P=0.000)affected the panicles/m^2 of rice and the number of effective tillers (Table 1). Grain yield of Bg-300 rice was significantly (0.000) and negatively affected by varying densities of *I. lobosa*. Increased weed density resulted in the decreased rice yield due to interspecies competition. Weed density of *I. globosa* from 22 - 151 plants /m^2 reduces rice yield from 17.69 - 45.57% respectively.

CONCLUSION

Rice growth parameters, yield and yield parameters were significantly reduced at density of 22 plants/m^2 and reduction rate increases with increasing *I. globosa* densities.

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Weed identification and herbarium preparation of winter weed flora of Lucknow

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Weeds causes major lose to the crops production and to avoid these losses, timely weeds management is required. Successful weed management requires identifying and understanding biological characteristics of associated weed species. Accurate identification of emerging weeds seedlingsis critical for selecting an appropriate post emergence herbicide, while identifying mature weedsgives indication on species that populate a particular field during the following season. According to Blackwelder (1967) "identification enables us to retrieve the appropriate facts from the system (classification) to be associated with some specimen at hand". Herbarium preparation is an important part of taxonomy. It is simply a dried and pressed collection of plants arranged in an accepted sequence of classification (Lawrence 1951). Winter weed floras of Lucknow were collected and taxonomic description were prepared for accurate identification of weed species.

METHODOLOGY

A minimum of three specimens were collected for each of the weed species from NBRI campus, Botanical Garden, CISH and IISR field during winter season, when flora was in flowering or fruiting along with important information. Out of three specimens, one was used for writing taxonomic description with the help of dissecting microscope and other two were dried for herbarium specimenspreparation. The correct identification of weed species was done with the help of taxonomic description andbotanical keys (indented and bracketed keys) given in different floras like Flora of Dudhwa National Park, Flora of upper gangetic plain and of the adjacent siwalik and subhimalyan tract, and Flora of Madhya Pradesh. Photographs were taken for different plant parts of each the weed species and plates were prepared. Dried specimens were poisoned by dipping in the saturated solution of mercuric chloride in ethyl alcohol to avoid damage through insect and fungus. Properly dried specimens were mounted on herbarium sheet.

RESULTS

Description was prepared for 30 plant species belonging to 17 families and 28 genuses (Table-1). The families to which weed species belonged are:. Acanthaceae (1sp.), Asteraceae (7 spp.), Amaranthaceae (1 spp.), Brassicaceae (3 spp.), Caryophyllaceae (2 spp.), Chenopodiaceae (2 spp.), Convolvulaceae (1spp.), Euphorbiaceae (1spp.), Fabaceae (3 spp.), Malvaceae (2 spp.), Oxalidaceae (1 spp.), Papeveraceae (1 spp .), Polygonaceae (1 spp.), Phrymaceae (1 spp.), Primulaceae (1 spp.), solanaceae (1 spp.) and Xanthorrhoeaceae (1 spp.). A bar diagram was prepared using the families and number of species. Herbarium specimens, prepared for 30 weeds, were deposited in the NBRI national herbarium with collection number provided in Table-1. Highest number of weed species was of Asteraceae followed by the Fabaceae and Brassicaceae. The family Asteraceae is the 2nd largest family with more than 23,000 currently accepted species and includes only herbaceous plants. Hence this family has more weeds than other families.

Table 1. Scientific names, families, collected locality and collection numbers of different weed species

S. No.	Scientific Name	Family	Locality	Collection number
1	*Andrographis paniculata (*Burm. f.) Nees.	Acanthaceae	NBRI C	254245
2	*Vernonia cineria* (L.) Less	Asteraceae	CISH Field	254228
3	*Gnaphalium uliginosum* C. B. Clarke	Asteraceae	NBRI BG	254230
4	*Tridax procumbens* (L.) L.	Asteraceae	CISH Field	254233
5	*Launea procumbens* (Roxb.) Ramayya & Rajagopala	Asteraceae	CISH Field	254247
6	*Sonchus arvensis* L.	Asteraceae	CISH Field	254254
7	*Eclipta prostrata* (L.) L.	Asteraceae	NBRI C	254249
8	*Ageratum houstonianum* Mill.	Asteraceae	CISH Field	254260
9	*Amaranthus viridis* L.	Amaranthaceae	CISH Field	254248
10	*Coronopus didymus* (L.) Sm.	Brassicaceae	CISH Field	254241
11	*Sisymbrium irio* L.	Brassicaceae	CISH Field	254244
12	*Lepidium sativum* L.	Brassicaceae	CISH Field	254243
13	*Stellaria media* (L.) Vill.	Caryophyllaceae	NBRI BG	254231
14	*Spergula arvensis* L.	Caryophyllaceae	CISH Field	254242
15	*Chenopodium album* L.	Chenopodiaceae	CISH Field	254237
16	*Chenopodium murale L.*	Chenopodiaceae	CISH Field	254236
17	*Convolvulus arvensis* L.	Convolvulaceae	CISH Field	254246
18	*Euphorbia hirta* L.	Euphorbiaceae	CISH Field	254252
19	*Vicia sativa* L.	Fabaceae	CISH Field	254239
20	*Vicia hirsuta* (L.) Gray	Fabaceae	CISH Field	254240
21	*Melilotus indica* (L.) All.	Fabaceae	CISH Field	254235
22	*Abutilon indicum* (L.) Sweet	Malvaceae	CISH Field	254253
23	*Sida cordifolia* L.	Malvaceae	CISH Field	254250
24	*Oxalis corniculata* L.	Oxalidaceae	NBRI, B.G.	254229
25	*Fumaria officinalis* L.	Papaveraceae	CISH Field	254234
26	*Polygonum plebeium* R.Br.	Polygonaceae	IISR Field	254251
27	*Mazus pumilus* (Burm.f.) Steenis	Phrymaceae	CISH Field	254232
28	*Anagallis arvensis* L.	Primulaceae	CISH Field	254233
29	*Solanum nigrum* L.	Solanaceae	CISH Field	254227
30	*Asphodelus tenuifolius* Cav.	Xanthorrhoeaceae	CISH Field	254255

NBRI C= National Botanical Research Institute Campus; NBRI BG= National Botanical Research Institute Botanical Garden; CISH= Central Institute of Subtropical Horticulture; IISR= Indian Institute of Sugarcane Research.

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Web-based expert module for decision making on weed management in crops and cropping systems

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Weeds grow with crops and in other terrestrial and aquatic ecosystems. Controlling the large spectrum of weed species in cropped and non-cropped areas is becoming a difficult task. Although herbicides are available, selection of a suitable herbicide for the control of a specific weed or a complex weeds community is difficult for the farmers and advisors. Emergence of Information and Communication Technologies (ICT) has opened new avenues in knowledge management that could play important roles in meeting the prevailing challenges related to sharing, exchanging and disseminating knowledge and technologies. Expert system can be defined as a tool for information generation from knowledge. Information is either found in various forms or generated from data and/or knowledge like text, images, video, audio etc. Web-based expert module for weed management in crops and cropping systems developed by Directorate of Weed Research, Jabalpur (M.P.) provides ICT-based advisories on weed management in crops and cropping systems. The objective of this module is to provide state-wise and crop-wise weed control recommendations.

METHODOLOGY

The first step in building an expert system is knowledge acquisition (Spangler *et al.* 2003). Methodology is mainly based on the principle of knowledge level which means developing a knowledge model at the human level problem solving approach. This expert module/system for weed management in crop and cropping system provides advice on the basis of state-wise and crop-wise available information on major dominant weeds, and their control by chemical and mechanical methods. With the help of scientists of All India Coordinated Research Project on Weed Management (AICRP-WM), data were collected on soil type and meteorological parameters of the location; herbicide available, crop/cropping system, dominant weeds and crop-wise and state-wise recommendations of weed control in prescribed format (Varshney *et al.* 2011). Major weeds, their characteristics and other related information were gathered through field surveys and from literature (Naidu 2012). The information about weeds' scientific names, common names, family and morphological features of stem, leaves, flowers, fruits and seeds along with weed images were documented. To enable use of this system easily by end user, the user-friendly interface was developed with graphical user interface (GUI), which allows the user to communicate with the system in a more natural way by permitting the use of simple selection drop down. User is allowed to view, query and advance.

RESULTS

Expert systems developed for making weed management decisions provides advice on the basis of information on weeds and crop/cropping system including chemical and mechanical weed control. Expert system combines the experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops. It is menu-driven system on the opening screen. The user can select either the information, recommendations of a particular state in India (state) or advance query. It is a simple search mechanism which allows the user to search for a particular state, and then user selects crop/cropping system, crop and dominated weeds along with photographs. If the user wants more details of a particular weed, then just click the hyperlink, a popup display will appear with complete details/morphological information of that particular weed (Naidu *el al.* 2014). All the images have been stored in digitized form. The knowledge base contains information about 337 weeds, consisting of 60 attributes clustered into 10 parameters. In query hyperlink, user can select the option button for search information based on the crop-wise, herbicide-wise and state-wise recommendation for management of weeds in crops and cropping systems.

CONCLUSION

By recognizing the problems in using the traditional system for technical information transfer, expert system has been developed to overcome the problems addressed. Online expert system is capable to transfer location-specific technology among farmers efficiently too. The expert system developed at the ICAR-Directorate of Weed Research, Jabalpur helps researchers, farmers, extension workers and students to search state-wise and crop-wise weed problems, morphological characteristics of weed species and recommendations for their management.

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Effect of crop and weed leaf age and position on leaf optical properties

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Leaf optical properties influence the amount and the quality of light reflected, absorbed and/or transmitted through plant leaves, which in turn could alter the red:far-red light (R/FR) ratio (a signal of potential competition) in plant canopies. R/FR ratio triggers a series of morphological and physiological responses in plants (Page *et al.* 2010). Low R/FR ratio induces shade-avoidance response in plants which includes enhanced elongation growth and alteration of carbon allocation pattern (Liu *et al.* 2009). From a plant-plant interaction perspective, entire leaf area of a plant is considered qualitatively similar and is used as one of the indicators of the plant's ability to compete. Little information is available on how leaf age and leaf position on the stem influence leaf optical properties and whether species (weed as well as crop) differ in this regard. The objective of this study was to investigate effects of age and position on optical properties (reflectance, transmittance, and absorptance) for red and far-red lights in common lamb's-quarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.) and tomato (*Lycopersicon esculentum* L.) leaves.

METHODOLOGY

Common lamb's-quarters, redroot pigweed, and tomato (cv. Gold Nugget Cherry) plants were grown in 10 cm diameter plastic pots in a potting mix (70% peat moss and 30% perlite, West Creek Farms, Canada). Tomato seeds were sown 5 days prior to pigweed and lamb's-quarters in order to synchronize seedling emergence for the three species. Plants were grown under controlled environment in a growth chamber. Reflectance, transmittance and absorptance of leaves, while still attached to the stem, at red (660 nm) and far red (730 nm) wavelengths were measured using a CI-710 Miniature Leaf Spectrometer (CID Inc., U.S.A.).The 3, 5, 7, 9 and 11th true leaves in lamb's-quarters and pigweed, and 1, 3, 5 and 7th true leaves in tomato were chosen to study the effect of leaf position on optical properties. To study effect of leaf age on optical properties, periodical observation was taken on the third true leaf. A completely randomized design with 6 replicates for each species was used and the experiment was repeated.

RESULTS

Leaves at higher position generally reflected and transmitted less radiation at 660 and 730 nm wavelengths in lamb's-quarters and pigweed. Reflectance at 730 nm was not affected. In tomato, reflectance did not change with leaf position at either 660 or 730 nm. Interestingly, species differed in this regard. The magnitude of the position effect was the greatest in pigweed, which also reflected and transmitted more radiation at 660 nm wavelength. With the exception of R/FR ratio of the reflected light in tomato, R/FR ratios of the reflected and transmitted lights were significantly influenced by leaf position. R/FR ratio and the magnitude of change were the greatest in pigweed compared to other species. Leaf age also influenced leaf optical properties and species differed in this regard. For example, reflectance and transmittance at 660 nm decreased with leaf age in lamb's-quarters but increased in pigweed; there was no consistent effect of age in tomato. Some differences in optical properties at 730 nm were also observed in these species.

CONCLUSION

The observed effects of leaf age and position on leaf optical properties and species-specific differences suggest that the same area of leaves of different species may influence R/FR ratio in a plant canopy differently, inducing different magnitudes of shade-avoidance response in plants. The leaf area index (leaf area per unit ground area) alone therefore should not be used to assess the potential plant competition. Effects of leaf age and position on leaf optical properties, and species-specific differences must be considered.

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Evaluation of bioefficacy of herbicides in linseed

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Linseed (*Linum usitatissimum* L.) is mostly grown under conserved moisture and limited nutrient conditions with poor management practices. However, its cultivation is extending to irrigated areas due to higher yield potential and market oilseed prices. Among the different constraints, weed management is one of the serious problem in linseed, if left uncontrolled due to its poor competitive ability. As linseed is slow in early growth, uncontrolled weeds compete with young flax seedlings, reduce availability of water and nutrients to the crop resulting in substantial yield reduction. Hand weeding, which is usually preferred, adds to the cost of cultivation due to higher labour wages. Moreover, non-availability of labour during peak period is also a major constraint in realizing higher yields of linseed. Hence, chemical weed control became an effective and cheaper alternative to manage weeds in flax production. Thus, an experiment was conducted to manage weeds using herbicides and to make cultivation of linseed economically viable and remunerative.

METHODOLOGY

A field experiment was conducted under protective irrigation to evaluate the bioefficacy of herbicides in managing weeds of linseed on black clay soil. Study was conducted at Main Agricultural Research Station, UAS, Raichur, Karnataka during post-rainy season of 2014-15 in randomized block design with 10 treatments in three replications. Treatments details are furnished in Table 1.

RESULTS

Among the different herbicide treatments, pendimethalin + imazethapyr at 1.0 kg/ha as pre-emergence application (PRE) recorded significantly lower weed biomass upto harvest and higher seed yield (852 kg/ha) compared to isoproturon at 1.0 kg/ha and imazethapyr at 75 g/ha. A lower weed persistence index (WPI) and higher herbicide efficiency index (HEI) values are indicative of efficient weed management. Lower WPI was recorded with clodinafop at 60 g/ha and hand higher HEI was recorded with pendimethalin + imazethapyr at 1.0 kg/ha. The latter treatment also recoded higher net returns while BC ratio was higher with former treatment and both treatments were on par, confirming findings of Chandrakar *et al.* (2014).

Table 1. Weed biomass, seed yield and economics of linseed as influenced by weed control treatments

Treatment	Weed biomass at harvest (g /0.25 m^2)	WPI	HEI	Seed yield (kg/ha)	Net returns (Rs/ ha)	BC ratio
T_1 : Weedy check (control)	2.07*	1.00	0.00	459	12817	2.26
T_2 : Hand weeding at 25 DAS and 45 DAS (farmers' practice)	1.27	0.61	0.81	904	29061	2.80
T_3: Weed-free**	1.14	0.55	0.92	925	29810	2.81
T_4 : Pendimethalin 1.0 kg/ha (PRE)	1.90	0.91	0.45	779	26732	3.19
T_5 : Pendimethalin + Imazethapyr 0.75 kg/ha (PRE)	1.84	0.89	0.47	791	27583	3.31
T_6 : Pendimethalin + imazethapyr at 1.0 kg/ha (PRE)	1.80	0.87	0.53	852	30105	3.41
T_7 : Isoproturon 1.0 kg/ha at 2-3 leaf stage of weeds	1.76	0.85	0.48	764	26477	3.26
T_8 : Clodinafop 60 g/ha at 2-3 leaf stage of weeds	1.74	0.84	0.51	805	29436	3.72
T_9 : Imazethapyr 75 g/ha at 2-3 leaf stage of weeds	1.84	0.89	0.42	741	25610	3.24
T_{10} : Imazethapyr 100 g/ ha at 2-3 leaf stage of weeds	1.79	0.86	0.48	783	27051	3.24
LSD (P=0.05)	0.12	0.08	0.11	86	4340	0.36

* Weed biomass (x) data were transformed to log (x+2) **: HW at 25 DAS + IC at 35 DAS + HW at 45 DAS, WPI: Weed Persistence Index, HEI: Herbicide Efficiency Index, HW = Hand weeding; IC=inter cultivation; DAS = days after seeding.

CONCLUSION

It is concluded that pre-emergence application pendimethalin + imazethapyr at 1.0 kg/ha would result in higher seed yield which were comparable to weed free and net returns. Next best herbicide was clodinafop 15 WP at 60 g/ha as POE.

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Energy utilization and nutrient removal in rice in agri-horticulture ecosystem

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Madhya Pradesh is known forrice cultivation but average rice yield of the state is quite low. In the monsoon season, weeds are the efficient competitors depriving the crop of the major requirements of nutrients, moisture, solar energy and space and create stress for the crop and reduce the yield (Mani 1975, Rao *et al*. 2007). Agri-horticulture is an alternate land use system that integrates the cultivation of arable and horticultural crops and it occupies a prime position in the farming system research due to higher value. The ability to tap water from deeper soil layers and to drought tolerance are major advantages of guavas' inclusion in agri-horticulture system. Weeds management is critical cultural operation in rice cultivation for good harvest in rice-guava agri-horticulture ecosystem.

METHODOLOGY

The study was initiated to know the energy and nutrients utilization in rice cultivated in 15 years old guava plantation, planted at a distance of 5 X 5 m^2. The study was carried out at the Forestry Research Farm, Imalia, Jaw aharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The soil of the experimental field was clay in texture and almost neutral in reaction. The available nitrogen, phosphorus and potash in the soil were 262 (low), 24 (medium) and 253 (medium) kg/ha, respectively. The rice (Kranti) was drilled in the inter spaces between the trees of Guava (Lucknow-49) orchard. Different weed control treatments along with weedy check were tested in a Randomized Block Design replicated thrice. The spraying of herbicides was done by mixing the required quantity of herbicides in 600 liters/ha water using knapsack sprayer with flat fan nozzle. The NPK contents in plant and weed samples was analyzed at harvest by standard methods. The energy utilized by crop and weeds was determined by using reported energy content of 4.32 K Cal/gram for conversion of dry weight into energy content of weed dry weight and crop straw.

RESULTS

The result revealed that *Echinochloa crusgalli*, *Cyperus iria* and *Commelina benghalensis* had the highest weed biomass. The significant reduction in biomass of weed species was recorded with the post-emergence application of 2,4-D and Butachlor. The maximum NPK removal was observed by *Echinochloa crusgalli*, *Cyperus iria* and *Commelina benghalensis* in all the treatment combinations. In hand weeded plot, weeds removed 1.503, 0.419, 5.097 NPK kg/ha, while maximum nutrients removal was in weedy check (19.414, 5.913, 78.279 NPK Kg/ha). In guava-rice ecosystem, the energy utilization by weeds was maximum in weedy check (94.03 lakh k cal/ha) and minimum with 2,4-D (6.77 lakh k cal/ha) treatment. The energy utilization by rice was higher with the application of fenoxaprop-p-ethyl + 2,4-D (138.78 lakh k cal/ha) and minimum under weedy check (92.11 lakh k cal/ha). The energy utilized by the rice seed was maximum (64.54 lakh kcal/ha) when fenoxaprop-p-ethyl was combined with 2,4-D. The lowest energy utilization by rice seed was observed in weedy check (33.12 lakh kcal/ha).

CONCLUSION

Post-emergence application of fenoxaprop-p-ethyl + 2,4-D (100 + 500 g/ha) found more productive (3.22 t biomass and 2.01 t yield/ha) and energy efficient (138.78, 64.54 lakh kcal/ha) under guava-rice agri-horticulture ecosystem.

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Impact on ecofriendly methods of defluoridation from drinking water using plant parts

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In India hardly 12% of the population get clean drinking water while rest of the population quench their thirst from such water which serve as the inoculant of large number of water borne diseases. The magnitude and dimension of drinking water contamination have assumed condition of severe concern as it poses a grave danger and serious threat to the humanity. Out of different chemical contaminants, the higher concentration of fluoride in drinking water is one of the major cause of human ailments. Due to higher fluoride concentration in the drinking water, fluorosis is caused. In different parts of Bhagalpur especially Jagdispur this disease has attained alarming condition .Both dental and skeletal fluorosis are very common in the inhabitants of Kolakhurd (Jagdispur). The removal of fluoride from potable water assumes significance and has been given priority by chemists, environmentalists and public health and engineers.

According to World Health Organization (WHO), 1984 the maximum acceptable fluoride concentration in drinking water should be 1.5 mg/l. Major de-fluoridation devices and methods have been referred with advantages and limitations. The adsorption process is the cheapest, simplest, easily available and accessible process for defluoridation particularly for developing countries like India. Recently considerable attention has been paid to develop better and suitable adsorbents for de-fluoridation purposes. Plant materials are reported to accumulate fluoride and hence their application as de-fluoridation agents has been suggested. Examples of such biosorbents are leaves and seeds of Tulsi (*Ocimumsanctum*), fruits and seeds of Amla (*Emblica officinalis*), leaves and seeds of Neem (A*zadirachta indica*). The works related to use of plant parts as de-fluoridation agents are fragmentary and no systematic attempt has been done in different parts of the world.

METHODOLOGY

The piece of investigation was carried out to assess the Water Quality Index (WQI) of higher fluoride concentration in drinking water on the basis of monthly variation and physico –chemical analysis along the Kolakhurd, Jagdishpur at Bhagalpur district of Bihar,India.

The quality of water was measured by testing various physico-chemical parameters such as pH, temperature, Total Hardness (TH), bicarbonate (HCO_3^-), carbonate (CO_3^-), phosphate(PO_4^-), nitrate (NO_3^-), chloride and fluoride.

RESULTS

On the basis of these results WQI of drinking water were evaluated.WQI is calculated from the point of view of suitability of water resources for human consumption.

The results indicated that most of the studied physico-chemical parameters were within the WHO limits (1998) for drinking water in some samples.

CONCLUSION

Plant parts of Tulsi (*Ocimum sanctum*), Amla (*Emblica officinalis*) and Neem (*Azadirachta indica*) can be used as de-flouridation agents in drinking water.

Germination ecology of bladder ketmia (*Hibiscus trionum* L.)

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Bladder ketmia (*Hibiscus trionum* L.) is considered an emerging weed problem in many regions of the world in several crops, including cotton, maize, and soybean. It has been referred to as a serious emerging weed problem in Australia. In a survey conducted from Hillston to Emerald, bladder ketmia was found to be the most troublesome and widespread weed, infesting about 85% of the cotton fields surveyed. It is closely related to cotton plants in terms of phenological and physiological traits, which makes it difficult to control after cotton emergence. Herbicides are widely used to control weeds. However, concerns about the development of resistance in weeds, environmental safety, and the availability of new broad-spectrum herbicides have increased interest in improving integrated weed management (IWM) strategies.

The development of effective IWM programs, however, depends on a detailed understanding of seed biology. Greater understanding of the factors affecting weed seed germination and weed seedling emergence would help the development of more effective cultural management practices through either suppressing or encouraging germination at times when seedlings can be readily controlled. A better understanding of germination of bladder ketmia could facilitate the development of more effective weed management options, as well as a characterisation of the potential infestation range of this weed. Research is in progress to determine the effects of temperature, light, salt and water stress, and seed burial depth on the germination and emergence of bladder ketmia.

Italian ryegrass: germination, biology, and interference with corn

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Italian ryegrass [*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot] is an annual/biennial grass that can germinate, emerge, and establish over a range of environmental conditions. It establishes in the fall, overwinters, and grows vigorously in early spring in United States Of America (U.S.A.). Annual ryegrass (*Lolium* spp.) is typically used as a pasture crop or cover crop alongroadsides, rights-of-way, and industrial areas in the U.S.A. Italian ryegrass has established along roadsidesdue to its ability to hybridize with cultivated annual ryegrass species, escape cultivation, and possessing a networkof broad and shallow fibrous root system. Italian ryegrass has become an economically important weed affecting small grain and vegetable crops.

Control of Italian ryegrass has traditionally been realized by herbicides. Relentless selection pressurefrom herbicides has resulted in the evolution of resistance in Italian ryegrass to several herbicide mechanisms ofaction across varied cropping systems in many countries (Heap 2015), thereby, making it's management difficult. Historically, glyphosate was frequently used forcontrolling Italian ryegrass and other weed flora in orchards and vineyards. In agronomic cropping areas across the U.S.A., including Mississippi, glyphosate was used as a pre-plant, post-directed, and/or post-harvest treatment, prior to the commercialization of glyphosate resistant (GR) crops inthe mid-1990s. With widespread adoption of the GR crops, multiple in-season post-emergence applications ofglyphosate have become a common practice. This added selection pressure from glyphosate resulted in Italianryegrass populations evolving resistance to glyphosate. Glyphosate-resistant Italian ryegrasspopulations could jeopardize pre-plant burndownoptions in reduced-tillage crop production systems.Corn is an economically important crop in several states in the U.S.A. including Mississippi. It is the first of the spring planted crops. Hence it isprone to competition from established weeds such as Italian ryegrass, especially, GR populations.

The first evidence of evolved GR Italian ryegrassin agronomic crops was reported from Washington County, Mississippi in 2005 when two populations, R1 and R2, exhibited a 3-fold resistance to glyphosate compared to a susceptible population, S. Resistance levels in Italian ryegrass in Mississippi and surrounding states have most likely increased since 2005. Studies on germination and emergence indicated that germinationof both R1 and S populations of Italian ryegrass was highest at 13°C anddecreased when temperature increased to 20 or 27 °C under both light anddark conditions. Light stimulated germination (57%) compared to darkness (41%) at 13°C, but light had no effect on germination at 20 and 27 °C. Seedling emergence was highest from seed placed on the soil surface. Seedlingemergence was less than 7.0% from seed planted at a 0.5 cm depth and noseedlings emerged from seed planted below 2.5 cm for both R1 and S populations. Both populations germinated under a broad range of environmental conditions, however, the R1 population had higher germination compared to the Spopulation.

A field study was conducted in 2012 and 2013 to assess competition between corn and Italian ryegrass (R1 and S populations). Corn height was greater in 2012 than in 2013 at comparablestages of the growing season, due to a cooler and wetter growing season in 2013. Averaged across weed densities, corn density at early and late season and yield were higher inthe S than in the R1 population, but Italian ryegrass biomass was similar for both populations.Also, corn density at early and late season, andyield were inversely proportional to Italian ryegrass density. Overall, Italian ryegrass significantlyreduced corn density and yield and reduction was greater with the R1 than the Spopulation.

Studies are underway to determine inter population competition and whole-plant level physiological differences between the R1 and S populations. Also, studies are planned to investigate allelopathic effects of Italian ryegrass by determining the effect shoot and root residues as well as root exudates of Italian ryegrass at various growth stages on emergence and growth of selected crops and weeds; and identifying phytotoxic compounds produced by Italian ryegrass by systematically performing bioassay-directed isolation and subsequent identification of active biochemical with MS and NMR spectroscopy.

In conclusion, Italian ryegrass, especially, GR populations pose a direct (competition for sunlight, nutrients, and moisture) and indirect (allelopathic) threat to many crops such as corn, cotton, peanut, rice, soybean, and wheat and should be controlled at a relatively young stage to minimize crop yield losses.

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Spread, invasion and implications for management of *Mikania micrantha* and *Merremia boisiana* in the Hainan island

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Mikania micrantha has been spreading rapidly in Hainan since its first discovery in 2003. Frequent and various types of disturbances can break *Mikania* plants into small pieces and spread these fragments. Greenhouse experiments showed that single-node stolon fragments have a high regeneration capacity (67.5%). The regeneration rate and subsequent growth are positively associated with internode length, stolon thickness and the presence of leaves. The time needed for emergence averaged 8 days, ranging from 4-28 days. These results indicate that manual or mechanical control should not avoid the generation of small clonal fragments of *Mikania*, and repeated control with short time intervals (*e.g.* 1 month, when most of the fragments have regenerated but when the regenerated plants are small) is necessary in order to prevent reinvasion from the stolon fragments.

Merremia boisiana is an evergreen woody vine originating from South Asia that has caused significant harm to many forests in recent decades in Hainan. *Merremia* typically invades disturbed forests, but has now expanded to natural forests in the Wuzhi Mountain, where there is tourism-associated disturbance. Surveys found that mature plants and emerged seedlings of *Merremia* were mainly distributed within 20 m from the tourist path, but a few reached more than 40 m into the forest interior. Larger seedlings were closer to the forest edge, compared with mature plants and emerged seedlings. A transplant experiment further indicated that emerged seedlings could not survive in the forest interior, but a proportion of them could survive on the forest edge. These findings suggest that while natural forests can probably resist seedling establishment of *Merremia* in the forest understory, *Merremia* seedlings may establish in disturbed sites near the tourist path and then expand to the forest interior through stolon elongation and climbing growth.

Characterization and phytochemical analysis of *Cyperus rotundus* and *Cyperus stoloniferus*

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The genus Cyperus belongs to the family Cyperaceae, which includes about 3000 species. Out of these about 220 species were identified as weeds. *Cyperus rotundus* is one among them. It is distributed throughout the world in both temperate and tropical regions. It grows naturally in paddy fields, farmlands, wastelands, sandy soil, damp and marshy places. There are number of compounds which have been extracted from plants for medicinal purposes.In recent years, *C. rotundus* has been given a special recognition in Ayurveda owing its therapeutic benefits to cure various diseases. The past studies has proved that this plant has many pharmacological activities such as anti- inflammatory, antibiotic, antidiarrhoeal, anti-Candida, antimutagenic, antimicrobial, antioxidant, cytotoxic and analgesic activities. This is a multipurpose plant, widely used around the world as medicine to treat stomach infections, wounds, boils and blisters and it contains alkaloids, flavonoids, tannins, starch, glycosides and sesquiterpenoids. In present study, essential oil was extracted from the tubers which contains Rotundene, D- Limonene, Myrtenol, Caryophyllene oxide, aromadendrene and many other compounds. *Cyperus stoloniferus* shows similar medicinal properties as *Cyperus rotundus*. Essential oil was extracted from the stolons of *Cyperus stoloniferus* also. It contains Patchoulene, Trans-Sesquisabinene hydrate, Longipinocarveol, Spathulenol and many other compounds.

Mapping of the infestation of *Parthenium* along the selected National and State Highways of Imphal valley, Manipur

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Parthenium hysterophorus L. is an invasive alien species; hazardous to human health, animal, plant and environment (Sushilkumar, 2012). In Manipur too, it is now seen growing gregariously in wasteland, national and state highways, roadside and is spreading like a wild fire. Due to its prolific cover and hazardous properties to environment and no previous report on the density and frequency of *Parthenium* infestation from Imphal valley of Manipur, the present study was undertaken with the objective to assess the density and frequency of Parthenium and to map the Parthenium infested region along the selected National and State highways.

METHODOLOGY

Field surveys along the roadside of selected national highways (NH-39, NH-150 and NH-53) and state Highway (Mayai Lambi) in Imphal valley, Manipur were carried out during 2012-2013 to record the distribution and invasion of Parthenium using 1x1 m^2 quadrat method from both sides of the road. Density/m^2 and frequency of the *Parthenium* weed and other weed species were recorded. The locations of *Parthenium* growing sites were taken twice using GPS device along the selected highways during July–August, 2012 and July-August, 2013. The mapping of *Parthenium* growing site was done using Mapinfo professional software.

RESULTS

The survey data and the map of study sites revealed that among the highways, the highest density of *Parthenium hysterophorus* was recorded at Mayai lambi state highway (21.48 /m^2) followed by national highway No. 39 (Imphal - Dimapur road) (9.56/ m^2), national highway No. 53 (Imphal–Churachandpur road) (9/m^2) and national highway No.150 (Imphal – Jiri road) (6.4/ m^2) respectively. The mean density across the highways depicts the *Parthenium hysterophorus* (11.61/ m^2) as the premier component of the flora infesting the Imphal valley followed by *Cynodon dactylon* (11.28/m^2), *Cassia tora* (5.38/m^2), *Xanthium strumarium* (4.43/m^2), while *Lantana camera* (0.57/m^2) and *Chromolaena adorata* (0.69/ m^2) had the lowest density among the species infesting the study sites. The gap between the two *Parthenium* spotted sites during the first survey was found with the presence of *Parthenium* in the second time survey.

The domination and rapid spread of *P. hysterophorus* along the highways could be attributed to its invasive capacity, allelopathic properties, high growth rate, short growth cycle and large number of seed production. Since *Parthenium* weed introduction into the Imphal valley in late 1990s, it has expanded at alarming rate in all directions. It was observed that *Parthenium* weed population was high at state highway (i.e Mayai Lambi) and spreading fast than the other sites which may be attributed to high soil fertility as Nambul river is flowing along the side of Mayai Lambi state highway. The river also helps in spreading the seed of *Parthenium*.

Table 1. Density/m^2 of *Parthenium hysterophorus* L. and other weed species in 3 National highways and 1 State highway of Imphal valley, Manipur

Weed species	SH (Mayai Lambi)	NH-39	NH-150	NH-53	Means
Parthenium hysterophorus L.	21.48	9.56	6.4	9	11.61
Urena lobota L.	1.96	1.64	0.76	0.84	1.30
Chenopodium album L.	1.28	1.48	0	0.84	1.20
Alternanthera philoxeroides (Mart.)	1.44	1.08	0.76	1.08	1.09
Cynodon dactylon (L.) Pers.	13.48	14.56	7.44	9.64	11.28
Casssia sericea Sw.	1.76	1	0.36	0.76	0.97
Rumex maritimus L.	1.96	1.36	0.88	1.24	1.36
Ageratum conyzoides L.	1.84	1.48	0.64	1.32	1.32
Polygonum orientale L.	1.88	1.84	0.28	0.84	1.21
Riccinus cumminis L.	2.36	1.24	0	1.48	1.27
Mimosa pudica L.	1.44	0.96	0.56	0.68	0.91
Xanthium strumarium L.	4.76	5.44	3.48	4.04	4.43
Amaranthus spinosus L.	1.72	2.04	0.44	0.92	1.28
Chromolaena adorata (L.) King & Robinson	1.16	0.88	0	0.72	0.69
Cassia tora L.	6.45	6.55	3.95	4.55	5.38
Lantana camara L.	1.08	0.68	0	0.52	0.57
Ipomoea carnea Jacq.	2.24	1.64	0.28	1.28	1.36

CONCLUSION

It is concluded that *Parthenium* weed has attained the status of most frequently and densely occurring weed in Imphal valley and expected to continue its dissemination. It will replace the precious native flora and will pose strong threats to the biodiversity of Manipur if it is not controlled at an earliest. Therefore, an appropriate *Parthenium* weed management strategy is necessary to be taken up to stop the potential spread and threats to biodiversity and economy of Manipur at large.

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Weed diversity in sweet corn

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Sweet corn (*Zea mays saccharata* Sturt.) in Indonesia, became one of commodities which potential to be developed (Sudarsana, 2000, Ebtan *et al*. 2013). However, the sweet corn is highly sensitive to weeds competition with a result decrease achieved 56% (Kurniadie *at al.* 2011). The diversity of species, the growth and reproduction of weeds were affected by various kinds of factors, one of them were different elevation of place. The different kinds of elevation affected a domination of growing kinds of weed. Therefore, Aim of this study is to find out weeds diversity in sweet corn Cultivated fields at different elevation in Brebes Regency.

METHODOLOGY

The research conducted by observation directly in the field sweet corn. The data then analyzed by destructive method namely expounds or describes the result according to circumstances found in the field. The observation is made using analysis its vegetation by a method of quadrate. Density parameter that observed is absolute, summed dominance ratio (SDR), the weeds species diversity index (H) and Coefficient community (C).

RESULTS

The present weeds analysis in three areas encountered 24 weeds species, (A) at the elevation of < 20 meters above sea level, 24 weeds species the dominant weeds *Portulaca oleracea* (SDR 20, 4%). (B) at the elevation 20-50 meters above sea level, 19 weeds species the dominant weeds *Cynodon dactylon* (SDR 21, 2%), and (C) at the elevation 69-100 m above sea level, 15 kind of weeds species the dominant *Cynodon dactylon* (SDR 26,1%), were predominant.

The result of the coefficient community for the area of A and B was 70, 78 %, then the area between A and B having the difference weeds community. The smaller coefficient community appears between area of B and C of 65, 37% and followed by a coefficient community area between A and C of 61, 91%. This result showed the difference weeds community. The differences caused by differences sweet corn plant aged 2 - 6 weeks after cropping so raises the difference broad canopy or headline plants that can affect micro climate around plants as a weeds growing place and weed control performed by farmer. In each of the regions studied differences in elevations of the fields, caused weeds deversity. In experimented region, the species diversity (H') value at the elevation of < 20 m above sea level was 2,7, at the elevation 20 – 50 meters above sea level was 2,6 and at the elevation 69-100 m above level, it was 2, 3.

Tabel 1. Species Diversity Index (H'), Coefficient Community (C), (SDR) and weeds species in Brebes Regency

Elevation of place	H	C	SDR	Weeds species
A (of < 20 m above sea level)	2,7	A : B = 70,8 %	20,4%	*Portulaca oleracea*
B (at 20 – 50 m above sea)	2,6	A : C = 61,9 %	21,2%	*Cynodon dactylon*
C (elevation 69-100 meters above sea)	2,3	B : C = 65,4 %	26,1%	*Cynodon dactylon*

CONCLUSION

Difference in elevatios of the fields in the Brebes Regency has caused in weeds associated with sweet corn fields. Weed diversity that was in the observation affected by various factors, among others is intensity of light; soil moisture, soil pH, soil fertility level, pattern cropping, and weed control performed by farmer.

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Effect of different nitrogen levels and weeding intervals on yield ad yield components of maize

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Maize (*Zea mays* L.) is the third most important cereal crop in Pakistan after wheat and rice. Grain yield in maize is highly reduced due to weeds competition. In crop productivity, nitrogen also plays a vital role and its deficiency is among the most yields reducing factor (Shah *et al*. 2003). As the nitrogen use efficiency was reported to be affected by time of weed control in maize crop, a field experiment was conducted to quantify the effect of different nitrogen levels and weeding intervals on the production of maize.

METHODOLOGY

The trail was conducted in summer 2014 at the Farm of Agricultural University Peshawar-Pakistan. Different nitrogen levels viz., N0=0, N_1=100, N_2=150, and N_3=200 kg/ha were applied to main plot while different weeding intervals i.e. weeding at: W_1= 15 days after sowing (DAS), W_2=30 DAS, W_3=45 DAS, W_4=60 DAS, W_5=75 DAS, W_6= weed control throughout season and W_7= weed infested throughout season were allotted to sub plots.

RESULTS

The weed density was significantly affected by different nitrogen levels and weeding intervals. However, their interaction was non-significant. The maximum weed density (148.7/m^2) was recorded with 200 kg/ha nitrogen and minimum weed density (93.29 /m^2) was recorded with zero nitrogen (Jalali *et al*. 2012)

Among the weeding intervals high weed density (186.8 / m^2) was recorded when weeds were left un-managed throughout the growing season (Maqbool *et al.* (2006)). Grain yield was significantly affected by nitrogen levels and weeding intervals. Highest grain yield (6.26 t/ha) was noticed in 200 kg/ha nitrogen level plots while the lowest grain yield (4.22 t/ha) was recorded with zero nitrogen (Hammad *et al.* 2011).

Among the weeding intervals, highest grain yield (5.06 t/ha) was noticed with weed free and lowest grain yield (3.33 t/ha) was observed in weedy situation (Table 1). The interaction between nitrogen levels and weeding intervals showed that grain yield was affected quadraticly at all nitrogen levels across various weeding regimes.

Table 1. Weed density and maize agronomic parameters as affected by different nitrogen levels and weeding intervals

Nitrogen Levels (N) Kg/ha	Weed Density/m^2	Number of grains/cob	Plant height (cm)	Biological Yield (t/ha)	Grain yield (t/ha)
Zero Nitrogen	93.2b	298.8c	190.5c	7.16d	4.21d
100	140.1a	311.8b	212.3b	7.54c	5.02c
150	148.2a	314.8b	211.5b	9.16b	5.54b
200	148.7a	326.2a	220.7a	10.18a	6.26a
LSD (p=0.05)	20.68	3.60	7.92	216.06	24.76
Weeding timing (W)					
Weed free throughout	0.00	371.5a	216.0a	9.27a	5.06a
Weeding at 15 DAS	129.7d	354.6b	208.6a	9.03b	4.57b
Weeding at 30 DAS	129.8d	325.5c	209.5a	8.72c	4.09c
Weeding at 45 DAS	144.4c	321.7c	214.4a	8.44d	3.57d
Weeding at 60 DAS	165.9b	296.7d	211.1a	8.05e	3.41e
Weeding at 75 DAS	171.5b	264.6e	209.5a	8.05e	3.34e
Weed Infested	186.8a	255.5f	192.4b	8.04e	3.33e
LSD(P=0.05)	10.90	6.68	12.15	41.19	138.13
Interaction (N x W)	NS	NS	NS	*	*

Means of the same category followed by different letters are significantly different at Pd"0.05 level using LSD test; DAS=Days after seeding; NS = Non Significant, * = Significant at Pd"0.05

CONCLUSION

It is concluded that weeds in maize crop must be managed before 30 DAS and nitrogen should be applied at 200 kg/ha at the agro-ecological conditions of Peshawar.

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Effect of nitrogen application on biomass and ecophysiology of *Phalaris minor* and *Rumex dentatus* in wheat field of Indo-Gangetic plains

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Weeds are one of the major problems associated with high yielding varieties of wheat, because high yielding wheat varieties require high fertilization and irrigation which further, favored the weeds to compete and outgrow the crop. Nitrogen (N) is considered as the most widely limiting factor for plant growth. Thus, it is important to have insight on how different weeds respond to N fertilization under competition. Functional traits may be useful predictors of the weeds response to N availability because they may represent speciûc functional adaptations to various environmental and differences in these traits between species are likely to reflect differential plant strategies of competition. *Phalaris minor* Retz. (PHME) and *Rumex dentatus* L. (RUDE) are of major concern in irrigated wheat under rice–wheat system in India. Currently, information is limited on functional growth traits and biomass partitioning of *R. dentatus* and *P. minor* under competitive field environment. The objective of this study was to understand adaptation strategies of *P. minor* and *R. dentatus* in relation to functional traits and biomass partitioning under varying levels of fertilizer N in field condition.

Table 2. Effects of nitrogen (N) application on biomass of *Phallaris minor, Rumex dentatus* and wheat at different growth stages

	Time	N0 (0 kg/ha)	N120 (120 kg/ha)
P. minor	4 week	5.27 ± 0.87	19.51 ± 2.73
	8 week	38.36 ± 5.26	99.77± 8.57
	12 week	26.55 ± 5.26	245.25 ± 25.62
R. dentatus	4 week	3.15 ± 0.53	12.22 ± 0.84
	8 week	31.40 ± 3.85	81.83 ± 9.54
	12 week	26.1 ± 4.14	133.22 ± 12.02
Wheat	4 week	59.8 ±7.76	117 ± 14
	8 week	461 ± 45	901 ± 70
	12 week	696 ± 108	1481 ± 145

METHODOLOGY

The experiment was carried out in two consecutive growing seasons from November 2008 to March 2009 and November 2009 to March 2010 at the research farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. For the field experiment six plots (5 × 3 m) were selected. Each plot was separated from the other by strips of 1m. Three of the six plots (N_2) received fertilizer application of NPK (120: 60: 80 kg/ha) as per the regional practice in wheat field. Rest of the three plots (N_0) received only regular doses of P and K without the nitrogen input. Sowing of wheat was done on 16 November and 22 November during first and second year of the study, respectively. Weeds were allowed to grow in wheat plots without physical and chemical control. Weeds emerged at around 15 days after sowing (DAS). Three weeks after emergence, weed seedlings were thinned to 30 plants per m^2 (i.e. total of 60 weed plants) and 60 wheat plants were retained while the additional plants were removed. Gas exchange measurements (between 0800 and 1100 hours local time) were made on *R. dentatus* (RUDE) and *P. minor* (PHMI) at 60 DAS of wheat. This experiment is done only once in a growing period. Detailed experimental procedures were given in Singh and Singh (2012).

For biomass partitioning estimation, plants were harvested at the interval of 4 weeks from the date of sowing of wheat (4, 8 and 12 weeks, respectively). Leaf area was determined using leaf area meter (SYSTRONICS, Leaf area meter-211) the leaves and other plant parts were oven dried at 70æ%C for 48 h to obtain the dry mass. Specific leaf area (SLA) (cm^2/g) was calculated as area per unit mass and leaf mass per unit area (LMA) was calculated as 1/SLA. Dried leaf material was used to determine the organic N concentration according to Kjeldahl method (Jackson 1958). Photosynthetic energy use efficiency (PEUE) was calculated as the ratio of A_{area} to leaf construction cost (LCC_{area}) (Nagel *et al*, 2005). Details of procedure are given in Singh and Singh (2012).

Table 1. Effects of nitrogen (N) application on physiological parameters of *Phallaris minor, Rumex dentatus*

Treatment	2008-2009				2009-2010			
	P. minor		*R. dentatus*		*P. minor*		*R. dentatus*	
	N_0	N_2	N_0	N_2	N_0	N_2	N_0	N_2
Photosynthetic rate (A_{area}) µmol/m^2/s	12.98 ± 0.039	23.48 ± 1.09	13.53 ± 0.35	27.43 ± 0.75	13.45 ± 0.86	26.35 ± 1.56	12.69 ± 0.55	28.61 ± 0.87
Water use efficiency (WUE)	3.03 ± 0.14	5.50 ± 0.45	1.63 ± 0.04	2.06 ± 0.06	3.32 ± 0.15	4.86 ± 0.08	1.49 ± 0.05	2.10 ± 0.04
Photosynthetic nitrogen use efficiency (PNUE)	116.34 ± 3.48	203.57 ± 9.43	199.42 ± 5.13	363.70 ± 10.00	120.50 ± 7.74	228.48 ± 13.51	187.11 ± 8.11	379.23 ± 11.60
Photosynthetic energy use efficiency (PEUE)	0.28 ± 0.01	0.65 ± 0.03	0.32 ± 0.01	1.18 ± 0.03	0.29 ± 0.02	0.73 ± 0.04	0.35 ± 0.01	1.26 ± 0.04

RESULTS

A significant effect of species and treatment was observed on photosynthetic rate ($F_{1, 40}$ = 5.76, p< 0.05; $F_{1, 40}$ = 452, p < 0.001), water use efficiency; WUE ($F_{1, 40}$ = 340, p < 0.001; $F_{1, 40}$ = 98, p < 0.001), photosynthetic nitrogen use efficiency; PNUE ($F_{1, 40}$ = 319, p < 0.001; $F_{1, 40}$ = 455, p < 0.001) and photosynthetic energy use efficiency; PEUE ($F_{1, 40}$ = 220, p < 0.001; $F_{1, 40}$ = 1000, p < 0.001) while effect of year was significant only on PEUE. Effect of N was more pronounced on RUDE as compared to PHMI (Table 2). In PHMI A_{area} exhibited 80% and 95% increase in first year and second year, respectively, over No treatment. While in RUDE, 102% and 125% increase of A_{area} was observed in first year second year, respectively, over control. RUDE had high A_{area}, PNUE and PEUE as compared to PHMI (Table 2), while WUE was maximum in PHMI. Further, high N increased the WUE and decreased A_{area} of both weeds. Resource use efficiency parameters such as PEUE and PNUE was higher in RUDE than PHMI with substantial differences among N_0 and N_2 treatments (Table 1). PEUE has been used to assess the ratio of energetic gains to cost, reflecting the specific energy use strategy of plants. Increased PEUE of 133% and 152% in PHMI and 269%, and 266% in RUDE, respectively was recorded due to N application (Table 2). High PEUE exhibited by both weeds in N_2 treatment indicated that these species can assimilate significantly more carbon per unit energy invested in leaf biomass accumulation which in turn influences their competitive ability and this is supported by their high biomass recorded in N_2 treatment. Substantial differences in PNUE were found between both weeds; RUDE exhibited higher PNUE than PHMI in both treatments. Many leaf attributes might be responsible for variation in PNUE, a low PNUE found to be associated with a high leaf mass per unit leaf area (LMA). Thus, high LMA (low SLA) in PHMI as compared to RUDE might be responsible for low PNUE in this species.

A significant effect of species, nutrient and time was found on biomass ($F_{1, 120}$ = 10.54, $p < 0.05$; $F_{1, 120}$ = 312, $p < 0.001$; $F_{2, 120}$ = 1000, $p < 0.001$) and various partitioning parameters. However, treatment effect was non-significant SWR. PHMI had greater biomass as compared to RUDE; however response to N was more with RUDE (Table 2). With the increase in soil N, the root fraction decreased whereas the stem and leaf fraction increased. Weed species deficient in N, improve their ability to obtain N from soil by altering their carbon partitioning to favor root elongation. PHMI showed very little change in partitioning in response to fertilization as compared to RUDE. Biomass partitioning to reproductive parts increased by N supply in both PHMI and RUDE.

Overall, LWR and RWR was greater in RUDE while SWR and IFR was greater in PHMI this showed the different strategy followed by these weeds. RUDE dominated crop fields by readily exhausting the nutrients through long and extensive root system, in addition high leaf ratio provides high assimilation rates required for rapid growth. While PHMI by allocating more biomass in its stem became able to grow taller than wheat and other weeds and gets the benefit of light, which is generally considered the limiting resource in nutrient-rich environments, which helps in increasing photosynthetic rate and ultimately seed production.

CONCLUSION

Overall it appeared that RUDE is physiologically better competitor than PHMI. It exhibited high SLA, LMR, photosynthetic and resource use efficiency parameter (PNUE and PEUE) than PHMI.). These ecophysiological traits are tightly related to resource capture and use efficiency (Shen et al 2011). In addition, added N benefitted RUDE more as compared to PHMI. Thus, it is concluded that in near future RUDE might be more dangerous than PHMI in our area. Therefore, more attention should be paid toward the control and management of RUDE.

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Theme 2

Weed management options in crops and cropping systems

Management of weeds in direct-seeded rice

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Rice (*Oryza sativa* L.) is the major staple food of more than half of the population of the world. The direct-seeding of rice is an attractive and sustainable alternative to traditional transplanting as it avoids the puddling and transplanting operations. Direct dry seeding also offers advantages such as faster and easier planting, reduced labour, earlier crop maturity by 7-10 days, more efficient water use and higher tolerance of water deficit, less methane emission and often higher profit. A major impediment in the successful cultivation of direct-seeded rice (DSR) in tropical countries is heavy infestation of weeds which emerge simultaneously with the crop. Thus, weeds are the main biological constraints to the production of DSR (Rao *et al.* 2007, Chauhan and Johnson 2010), which may cause 60-80% reduction in grain yield of rice (Paradkar *et al.* 1997). Hence, present study was carried out to evaluate the efficacy of different chemical and mechanical weed control methods and its economics in direct-seeded rice.

METHODOLOGY

A field experiment was carried out during *Kharif* 2012, 2013 and 2014 for three years at Agricultural Research Station, Vadgaon Maval, Pune, Maharashtra. The experiment consisted of ten treatments comprising of unweeded check, weed free and weed control methods, *viz*. pre emergence application (PE) of pendimethalin (1.0 kg/ha), oxyflourfen (0.150 t/ha), metsulfuron methyl + chlorimuron ethyl (0.004 t/ha, 25 DAS), pendimethalin (1.0 t/ha) *fb* metsulfuron methyl + chlorimuron ethyl (0.004 t/ha, 25 DAS), oxyflourfen (0.150 t/ha) *fb* metsulfuron methyl + chlorimuron ethyl (0.004 t/ha, 25 DAS), pendimethalin (1.0 t/ha) *fb* 1 hoeing (25-30 DAS) *fb* 1 HW (40-45 DAS), oxyflourfen (0.150 t /ha) *fb* 1 hoeing (25-30 DAS) *fb* 1 HW (40-45 DAS), metsulfuron methyl + chlorimuron ethyl 10% WP (0.004 t/ha, 25 DAS) *fb* 1 HW (40-45 DAS). The experiment was laid out in randomized block design with three replications. The rice variety Phule Samruddhi was sown at 22.5 cm distance. The crop was raised with recommended package of practices.

Table 1. Weed biomass, rice yield and economics as influenced by different weed control treatments

Treatment	Weed biomass (g/m^2)	Weed control efficiency (%)	Weed Index	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (`./ha)	B:C ratio
Pendimethalin PE 1.0 kg/ha	158.77	38.04	42.0	3.29	3.76	16129	1.3
Oxyflourfen PE 0.150 kg/ha	139.56	45.29	39.1	3.46	3.96	19206	1.4
Metsulfuron Methyl + Chlorimuron Ethyl POE 0.004 kg/ha	139.88	45.28	34.8	3.72	4.24	24595	1.6
Pendimethalin PE 1.0 kg/ha + POE application of Metsulfuron Methyl + Chlorimuron Ethyl 0.004 kg/ha	54.31	78.84	13.5	4.91	5.63	45211	2.0
Oxyflourfen PE 0.150 kg/ha+POE application of Metsulfuron Methyl + Chlorimuron Ethyl 0.004 kg/ha	22.77	91.08	2.9	5.53	6.38	57063	2.3
Pendimethalin PE 1.0 kg /ha + One hoeing (25 to 30 DAS) + one hand weeding (40 to 45 DAS)	123.32	51.84	27.8	4.10	4.67	27616	1.6
Oxyflourfen PE 0.150 kg /ha + One hoeing (25 to 30 DAS) + One hand weeding (40 to 45 DAS)	106.40	58.15	23.8	4.34	4.95	32070	1.7
POE application of Metsulfuron Methyl + Chlorimuron Ethyl 0.004 kg/ha + one hand weeding (40 to 45 DAS)	112.79	55.63	27.5	4.14	4.73	30421	1.6
Unweeded check	256.65	0.00	69.4	1.76	1.98	-10817	0.8
Weed free	0.00	100.0	0.00	5.71	6.55	54390	2.0
LSD (P=0.05)	20.79	7.64	-	6.02	6.77	11157	-

RESULTS

The dominant weed flora was *Echinochloa colona* and *Cynodon dactylon* among grasses; *Cyperus iria* and *Cyperus defformis* among sedges while dicots like *Eclipta alba*, *Portulaca oleracea*, *Celosia argentea* and *Ludwigia parviflora* in all three years. The pooled data showed that the significantly lowest weed biomass and weed index with highest weed control efficiency were recorded in the weed free treatment (Table). The second best treatment was oxyflourfen 0.150 t/ha PE and post emergence application (POE) of metsulfuron methyl + chlorimuron ethyl 0.004 kg/ha having lowest weight of weed biomass (22.77 g/m^2) with higher weed control efficiency (91.08%) and lower weed index (2.96). The highest weed biomass was recorded in unweeded check. Similar result were close conformity of Singh *et al* (2010)

Significantly highest grain and straw yield of paddy (5.709 t/ha and 6.553 t/ha respectively) were obtained in the weed free treatment (Table) which was at par with oxyflourfen 0.150 t/ha PE and metsulfuron methyl + chlorimuron ethyl 0.004 kg /ha POE.

Significantly highest net returns (Rs. 57063 /ha) and B:C ratio (2.3) obtained with oxyflourfen 0.150 t/ha PE and metsulfuron methyl + chlorimuron ethyl 0.004 t/ha POE, which was at par with the weed free treatment (Rs. 54390 /ha). Thus, for effective management of weeds in dry-direct-seeded rice, the pre emergence application of oxyflourfen 0.150 kg/ha followed by post emergence application of metsulfuron methyl + chlorimuron ethyl 0.004 t/ha at 25 days after sowing in 500 liters of water is recommended.

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An overview of rice crop weed management in Andaman and Nicobar Islands

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Rice (*Oryza sativa*) is the most important and extensively grown staple crop of Andaman and Nicobar Islands (with 3 districts) under rain fed situation (lowland and upland) including in coastal saline and acidic soils during *Kharif* season. The rice crop that was grown exclusively in South Andaman (90% of total acreage) in pre-Tsunami times (before 26th December, 2004), has moved to North and Middle Andaman District (>97% of total area and produ ction in 2012-13). Rice crop productivity in the islands is limited by various biotic and abiotic stresses and among abiotic stresses; weeds are the most important one. The weeds menace in assumes prominence for two reasons i.e. (1) the high (300 cm) and continuous rainfall (up to 7 days) during crop life cycle allows growth of several flushes of weeds and (2) the use of herbicides is minimal owing to various socio-economic and technological constraints and the manual weeding operations have limited effecicency.

METHODOLOGY

The paper summarizes the rice weed management knowledge accumulated from studies made at ICAR-CIARI, Port Blair and the extension work (field demonstrations, trainings etc.) carried out through KVK, South Andaman (CIARI) in farmer's field. The constraints of weed management and future strategy for increased use of new potent herbicide in rice are also narrated.

RESULTS

Both native and introduced species form the weed flora of rice in the Islands. Sevreal weeds have entered the islands through the imported food grains from main land and some plants introduced for ornamental purposes later became weeds. Water cabbage {*Limnocharis flava* (L.) Buchenau}, pickerel (oval leaf pond) weed {*Monochoria vaginalis* (Burm. F.) Presl.}, alligator weed {*Alternanthera philoxiroides* (Mart.) Griseb}, water hyacinth {*Eichhornia crassipes* (Mart.) Solms}, short pipe-wort {*Eriocaulon truncatum* Buch.-Ham. ex Mart.) etc. are some aquatic weeds of prominence in rice fields. These aquatic weeds together with common Poaceae, Cyperaceae and other broadleaved weeds are inflicting serious yield losses in rice crop. In saline rice soils, *Scirpus littoralis* and *Acrostichum aureum* weeds are widely seen. The presence of wild rice (*Oryza indandamanica)* in Andaman also a concern, as a weed of rice crop not only from the point of yield loss but also from loss of quality.

Earliest studies on weed flora of rice started in 1986 have resulted in enlisting of 40 weed species that rose to an alarming 130 by 1991. The yield loss too varied with method of rice cultivation from 18.1% (estimated in 1989-90, 2.2 t in unweeded against 2.77 t/ha in one hand weeding) from research farm studies to 25.3% in on farm trials (OFT) of KVK (2012) in transplanted rice crop. The weed induced losses were found to be highest (62%) in direct wet seeded rice at research farm studies (2002) owing to simultaneous crop–weed competition from a wide and several flushes of weeds.

Though all available management options are tested and established their utility in offsetting the weed induced rice yield losses, the use of herbicides failed to reach island farmers fields probably due to their restricted or non-availability and to some extent due to lack of technical knowhow about herbicide use.

Land preparation (puddling in transplanted crop and ploughing in upland rice) with indigenous plough (3-6 passes) is the most commonly followed practice by farmers that has contributed to the weed management in rice till last decade. In recent times, small tractors and power tillers have entered the farming and contributed to quick and effective land preparation (Din *et al.* 2004) and thus to rice crop weed management. Studies have indicated that rice transplanting in levelled and bunded field was found to reduce the weed density by 30% over unlevelled and unbunded one (95 weeds /m^2). Transplanting of 60 day old seedlings of long duration tall rice (C-14-8) and its harvesting for fodder prior to grain harvest was also found effective in giving an edge to rice crop over weeds. The utility of conoweeders in weed management in rice transplanted in wide rows (system of rice intensification) has been demonstrated to farmers. Manual weeding is commonly followed in rice; however, its effectiveness is limited owing to its untimely and continuous rains. Lack of man power for weeding is also makes farmers to neglect weeding. Brown manuring (OFT) and azolla culture in paddy fields was found to contribute to not only weed management but also to rice crop nutrition. Among herbicides, butachlor is widely tested in transplanted rice at both research and farmer's fields and its use was seen among some progressive farmers. In wet seeded rice, the effectiveness of pretilachlor$^+$ integrated with hand weeding (45 DAS) on weed management was established, but not adopted by farmers.

CONSTRAINTS

Rice is only crop that can be grown during rainy season in the islands and due to low or no profits, farmers are reluctant to use external inputs. Pesticide use is minimal in the islands and among the pesticides, herbicides are applied rarely by farmers. The fluctuating field water levels due to continuous rains makes timely application of herbicide difficult, even applied, their loss through various means limits their effectiveness. All herbicides have to come from mainland India, whose import into islands is very difficult. Except butachlor, no other product is available in the market for farmers. The Governments desire to develop Islands as organic hub also limits the herbicides availability. Lack of technical knowhow: about dose, time of application, nozzles; fear of damage to farm ponds (fish), livestock and other crops with herbicide use are the other reasons for low or no use of herbicides.

CONCLUSION

Concerted efforts of all are required to make rice cultivation profitable. In this direction effective weed management plays an important role. Making available new potent herbicide and their technical knowhow about their use among farmers of North and Middle Andaman District of islands with inorganic mode of production may make rice cultivation profitable by offsetting weed induced losses effectively.

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Efficacy of combination of penoxsulam and cyhalofop-butyl on weed management in wet-seeded rice

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Rice is normally infested with a broad spectrum of weeds belonging to grasses, broad leaved weeds and sedges. The relative proportion of the weeds varies with the soil and environmental condition and method of rice cultivation. Cyhalofop butyl is an efficient herbicide for the selective control of grass weeds in rice (Saini *et al.* 2013). Being inefficient against sedges and broad leaved weeds, Cyhalofop butyl has to be followed up by a herbicide like 2, 4-D, Almix, etc. for total control of the weeds. Penoxsulam is very effective on sedges and broad leaved weeds (Singh *et al.*, 2009), and is is not as good as Cyhalofop butyl against major grass weeds. Hence a combination of these two herbicides was tested for better management of weeds in wet direct-seeded rice (WSR).

METHODOLOGY

A trial was taken up with ten treatments laid out in RBD with three replications in the *Kole* lands of Thrissur, Kerala during two crop seasons in 2012-13 and 2013-14 in WSR var. Jyothi. The treatments comprised of four doses (105, 120, 135 and 150 g/ha) of a readymix of Penoxsulam 1.02% w/w (10% w/v) and Cyhalofop butyl 5.1% w/w (5.0% w/v), compared with Penoxsulam 24% SC at 25 g/ha, Cyhalofop butyl at 80 g/ha, Bispyribac sodium at 20 g/ha, and Oxyfluorfen 23.5% EC at 150 g/ha followed by hand weeding at 30 days after seeding (DAS). An untreated check and handweeded check were also included for comparison. Observations were taken on major weeds density and biomass at 30 and 60 DAS.

RESULTS

All the herbicide treatments resulted in significant reduction in weeds density compared to unweeded control a 30 and 60 DAS. Among them, Penoxsulam + Cyhalofop butyl at 135 g and 150 g/ha resulted in very good control of all types of weeds resulting in less weed density and biomass and was on par with hand weeding. Individually, the herbicides (cyhalofop-butyl, penoxsulam and bispyribac- sodium) were efficient only on a section of weeds while ineffective against others. But the combination of Penoxsulam and cyhalofop-butyl has managed effectively the broad spectrum of weeds. The weed control efficiency (WCE) was highest in hand weeded control. Among the herbicides, 90% or more WCE was recorded by the treatments: Oxyfluorfen followed by hand weeding and the combination of Penoxsulam + Cyhalofop butyl at 150 g/ha, at 30 and 60 DAS in both years.

Penoxsulam + cyhalofop-butyl at 150 g/ha improved the height and tiller production of rice and resulted in higher rice grain yield than the unweeded control. Highest grain yield of 5.01 t/ha in 2012-13 and of 4.25 t/ha in 2013-14 were recorded in the hand weeded treatment, closely followed by Penoxsulam + Cyhalofop butyl at 150 g/ha (5.49 and 4.12 t/ha respectively). Straw yields also recorded the same trend.

CONCLUSION

A combination of penoxsulam + cyhalofop-butyl at 150 g/ha performed better than other herbicides resulting in superior control of all types of weeds, and higher grain and straw yields of WSR.

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Herbicide combinations for control of complex weed flora in wet-seeded rice in lateritic belt of West Bengal

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Rice (*Oryza sativa* L.) is one of the most important food crop (Singh and Khush 2000) of more than one third of the human population of the world including those of India.. In India rice is grown by manually transplanting rice seedlings in puddled soil. Recently, Indian farmers are opting direct-seeding of rice because of labour and water scarcity. In direct wet-seeded rice (WSR), weeds are one of the major biological constraint as the weeds and rice seedlings emerge simultaneously (Rao *et al.* 2007). In WSR, weedscause yield loss of 40-100% (Choubey *et al.* 2001). Herbicides are used to manage weeds in WSR but the use of a single herbicides alone does not manage weeds effectively in a sustainable manner. Hence, the present study was carried out to identify herbicides and their mixtures to control mixed weed flora in wet-seeded rice.

METHODOLOGY

The field trial was laid out in RBD with 10 treatments and replicated thrice in Agricultural Farm of Visva-Bharati during *Kharif*, 2014. The herbicidal treatments were bispyribac sodium alone and in combination or supplemented with pendimethalin, oxadiargyl, pyrazosulfuron and chlorimuron + metsulfuron. Three mechanical weeding and three hand weeding (weed free) were also included. The rice (var. *IR-36*) was drum seeded on 26th July, 2014 and harvested on 12th November 2014. Data on weed growth, yield performance and economics were recorded.

RESULTS

Pre-emergence application of pendimethalin followed by bispyribac, pyrazosulfuron fb bispyribac and tank mix of bispyribac and Chlorimuron + metsulfuron successfully controlled grass weeds, while. pre-emergence application of pyrazosulfuron *fb* bispyribac followed by pendimethalin fb bispyribac and tank mix of bispyribac + (Chlorimuron + metsulfuron), were most effective against broad leaved weeds Post-emergence application of bispyribac + (chlorimuron + metsulfuron) controlled sedge weeds very effectively. Sedge weeds were most predominant in in the associated weed community and as post-emergence application of bispyribac + (Chlorimuron + metsulfuron) controlled sedges very effectively, the total weed density was least in this treatment.

Table 1. Effect of treatments on weed density (no/m^2) and biomass in wet-seeded rice at 60 DAS

Treatment	Weed density (no./m^2)		Weed biomass (g/m^2)	
Bispyribac-Na 25 g/ha	10.8	(115.3)	3.0	(8.7)
Pendimethalin *fb* bispyribac 1000 *fb* 25 g/ha	8.7	(75.3)	2.5	(6.0)
Oxadiargyl *fb* bispyribac 100 *fb* 25 g/ha	6.3	(39.7)	2.4	(5.4)
Pyrazosulfuron *fb* bispyribac 20 *fb* 25 g/ha	4.9	(24.0)	2.1	(4.0)
Pendimethalin *fb* bispyribac*fb* manual weeding 1000 *fb* 25 g/ha	7.1	(50.3)	2.2	(4.5)
Pendimethalin *fb* manual weeding 1000 g/ha *fb* 25-30 DAS	8.9	(78.3)	2.9	(7.7)
Bispyribac + (chlorimuron + metsulfuron) 20 + 4 g/ha	3.8	(14.3)	1.3	(1.2)
Three mechanical weedings (cono / rotary weeder) (Rice spacing 25 cm) 20, 40, 60 DAS	5.0	(25.0)	1.7	(2.3)
Weed free (HW at 20, 40 and 60 DAS)	0.7	(0.0)	0.7	(0.0)
Weedy check	16.3	(267.0)	8.5	(71.5)
LSD (P=0.05)		0.68		0.16

Table 2. Effect of treatments on wet-seeded rice yield and economics

Treatment	Grain yield (t/ha)	Gross return (`/ha)	Net return (`/ha)	B:C ratio
Bispyribac-Na 25 g/ha	4.423	61927	36327	2.42
Pendimethalin *fb* bispyribac 1000 *fb* 25 g/ha	4.826	67559	40609	2.50
Oxadiargyl *fb* bispyribac 100 *fb* 25 g/ha	4.829	67611	41411	2.58
Pyrazosulfuron *fb* bispyribac 20 *fb* 25 g/ha	4.836	67699	41399	2.57
Pendimethalin *fb* bispyribac*fb* manual weeding 1000 *fb* 25 g/ha	4.854	67956	39806	2.41
Pendimethalin *fb* manual weeding 1000 g/ha *fb* 25-30 DAS	4.808	67312	41662	2.62
Bispyribac + (chlorimuron + metsulfuron) 20 + 4 g/ha	4.853	67942	42682	2.69
Three mechanical weedings (cono / rotary weeder) (Rice spacing 25 cm) 20, 40, 60 DAS	4.869	68161	42061	2.61
Weed free (HW at 20, 40 and 60 DAS)	4.895	68525	39425	2.35
Weedy check	3.070	42980	19880	1.86
LSD **(P=0.05)**	0.488	6828.2	6828.2	0.26

The highest rice grain yield (4.895 t/ha) was recorded under three hand weeding (weed free) and this was statistically at par with all other weed control treatments tested. Post- emergence application of bispyribac + (chlorimuron + metsulfuron) showed slight toxicity on direct seeded rice but rice recovered within a short period of time. Post-emergence application of bispyribac + chlorimuron gave the highest net return (Rs. 42682 /ha) and B:C ratio (2.69). Weed free check and three mechanical weeding gave comparatively higher gross return but net return and B:C ratios were lower as that of bispyribac + chlorimuron. All the herbicidal treatments were at par in recording B:C ratios.

CONCLUSION

The post-emergence application of bispyribac + chlorimuron (20 + 4 g/ha) was found most effective for controlling weeds, improving grain yield and profitability of wet- seeded rice.

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Chemical management of weeds in direct dry-seeded rice

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More than half of the world's population depends on rice (*Oryza sativa L.*) for their daily sustenance (Chauhan and Johnson 2011). Heavy infestation of weeds is one of the major constraints for successful cultivation of direct dry-seeded rice (DSR) DSR is becoming popular among farmers as an alternative to transplanting due to the expansion in the irrigated area, the declining water table, introduction of early maturing rice cultivars, availability of selective herbicides for weed management together with increasing cost and declining profitability of transplanted rice production (Rao et al. 2007). Eventhough several have been used for controlling weeds in DSR, the efficacy of a particular herbicide may be unsatisfactory because of its specificity in managing specific weed species. For instance, grassy weeds in DSR may be managed by the application of Pendimethalin, pretilachlor and butachlor resulting in improvement in rice yield by 7-19% over the control. Hence, this study was conducted to identify ready mix/tank mix herbicide that effectively controls both the grassy and non-grassy weeds with single application.

METHODOLOGY

The field experiments were conducted during *Kharif* 2010 and 2011 at Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *Kharif* 2010 and 2011 to find out the appropriate combination of herbicides in direct dry-seeded rice to control the complex weed flora and enhance the rice yield. There were of twelve treatments, *viz.* pyrozosulfuron 25 g/ha, pretilachlor 750 g/ha, cyhalofop butyl 90 g/ha, fenoxaprop 60 g/ha, cyhalofop butyl + readymix of chlorimuron ethyl + metsulfuron methyl 90 + 20 g/ha, phenoxaprop + readymix of chlorimuron + metsulfuron 60 + 20 g/ha, azimsulfuron 35 g/ha, bispyribac-Na 25 g/ha, fenoxaprop + ethoxysulfuron 60 + 15 g/ha, oxyflurofen + 2,4-D Na salt 300 + 500 g/ha, two hand weedings at 20 and 40 days after seeding (DAS) and weedy check were laid out in randomized block design with three replications. The soil of experimental site was silty clay loam in texture, medium in organic carbon (0.66%), available phosphorus (27.5 kg/ha) and potassium (243.5 kg/ha) with pH 7.3. Rice variety "*Sarjoo 52*" was sown at row spacing of 20 cm on June 09, 2010 and June 12, 2011 following the recommended package of practices of the area. The observation on density and dry matter weight of weeds was taken at 60 DAS. Quadrate was placed at four randomly selected spots in each plot for observation of weed and crop plants. The weeds were recorded species wise and total biomass was weighed after drying the weed sample at 70^{0}C for 72 hrs.

Table 1. Weed density, weed dry weight, weed control efficiency and yield of direct dry seeded rice as influenced by different treatments

Treatment	Dose (g/ha)	Application stage (DAS)	Total weed density (no./m^2)		Total weed dry weight (g/m^2)		Weed Control Efficiency (%)		Grain yield (kg/ha)	
			2010	2011	2010	2011	2010	2011	2010	2011
Pyrazosulfuron (10% WP)	25	4	13.7 (74.7)	14.8 (110.7)	17.2 (296.27)	27.4 (350.7)	35.6	34.1	442	744
Pretilachlor (50% EC)	750	4	12.7 (66.6)	10.6 (186.6)	15.7 (247.73)	19.0 (359.9)	46.2	32.4	438	630
Cyhalofop butyl (10%EC)	90	30	10.6 (143.3)	10.7 (253.3)	12.0 (142.27)	18.6 (339.9)	69.1	36.1	1416	1331
Fenoxaprop(10% WP)	60	30	7.6 (79.3)	10 (224.0)	10.9 (188.0)	13.9 (134.1)	74.1	74.8	2766	2142
Cyhalofop butyl + (chlorimuron +metsulfuron)	90+20	30	16.8 (70.9)	7.7 (50.6)	11.5 (130.67)	14.8 (276.4)	71.6	48.1	1536	1420
Fenoxaprop + (chlorimuron +metsulfuron)	60+20	30	10.3 (93.3)	5.7 (29.3)	8.2 (66.8)	10.6 (54.9)	85.5	89.7	3401	3559
Azimsulfuron (50%WP)	35	20	9.4 (73.4)	5.7 (65.3)	8.2 (66.4)	12.5 (216.0)	86.9	59.4	2083	2086
Bispyribac sodium (10% EC)	25	20	7.2 (40.0)	8.7 (116.0)	8.2 (65.33)	11.9 (112.7)	85.8	78.8	3175	2831
Fenoxaprop+ Ethoxysulfuron	60+15	30	6.7 (29.4)	5.1 (17.3)	6.0 (35.2)	9.3 (67.5)	92.3	87.3	3187	3813
Oxyflurofen +2,4-D Na salt	300+500	4 *fb* 30	11.5 (125.3)	8.3 (78.6)	13.0 (186.47)	14.8 (331.1)	59.5	37.8	1208	820
Two hand weeding 20&40 DAS			7.3 (29.3)	9.6 (68.0)	5.1 (25.47)	12.2 (75.1)	94.5	85.9	3263	3005
Weedy check			15 (91.9)	12.7 (74.6)	21.5 (460.4)	17.7 (532.3)	0.0	0.0	416	288
LSD (P=0.05)			3.1	7.5	1.2	10.6			654	730

RESULTS

The major weed flora in the experimental field consisted of grasses; *Echinochloa colona* (36.3 and 51.9%), *Echinochloa crus-galli* (5.8 and 7.1%), *Panicum maximum* (14.5 and 7.1%), *Leptochloa chinensis* (1.2 and 5.36%), sedge; *Cyperus rotundus* (31.8 and 23.2%) during 2010 and 2011 respectively. The post-emergence application of fenoxaprop + ethoxysulfuron 60 + 15 g/ha had better control over grassy, non-grassy and sedges as compared to other treatments, resulting in lowest total weed biomass. The highest weed control efficiency (92.3 and 87.3%) was recorded with two hand weeding at 20 and 40 DAS followed by fenoxaprop + ethoxysulfuron 60 + 15 g/ha at 60 DAS during 2010-2011 over the weedy check. The highest rice grain yield was obtained with fenoxaprop + ethoxysulfuron 60 + 15 g/ha resulted in 86.9 and 92.4% higher grain yield than weedy check during both the years.

CONCUSION

It is concluded that post-emergence application of fenoxaprop + ethoxysulfuron 60 + 15 g/ha was found most effective in weed management and realizing higher yield of direct dry-seeded rice .

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Herbicide combination for managing complex weed flora in transplanted rice

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In transplanted lowland rice, high weed infestation is a major constraint which causes severe reduction in the grain yield. Impact of weed competition usually starts early in growing season (Rao 2010). About 60% of the weeds emerge during 7-30 days after transplanting (DAT) and strongly compete with rice up to maximum tillering stage (Saha and Rao 2010). Hence, weed free environment during early crop growth stage should be ensured for higher rice productivity. Pre-emergence herbicides control the weeds as theyt germinate but are ineffective to late emerging weeds. Besides, application of single herbicide alone may not control all kinds of weeds such as grass, broad leaf weeds and sedges and may increase the resurgence of certain weeds. Hence, a field experiment was carried out in transplanted rice with the objective to study the effect of herbicides combination against complex weed flora, yield and economics of transplanted rice.

METHODOLOGY

Field experiments were conducted in Tamil Nadu Agricultural University, Coimbatore during *Kharif*, 2012 and 2013 with twelve treatments in a randomized block design replicated thrice. The treatment consisted of pre emergence (PE) pretilachlor 1000 g/ha alone and 750 g/ha followed by (*fb*) post emergence application (POE) of ethoxysulfuron 18.75 g/ ha or chlorimuron + metsulfuron (ready mix) 4 g/ha POE and ready mix of pretilachlor (6%) + bensulfuron (0.6%) 6.6% GR 660 g/ha PE, pyrazosulfuron ethyl 20 g/ha PE alone and fb manual weeding, early POE (EPOE) bispyribac sodium 25 g/ha alone and with tank mix of either ethoxysulfuron 18.75 g/ha or chlorimuron + metsulfuron (ready mix) 4 g/ha, POE penoxulam 22.5 g/ha, hand weeding at 25 and 45 DAT and unweeded check.

Table 1. Weed management treatments on total weed density (TWD), weed dry weight (TWDW), weed control efficiency (WCE) at 60 DAT, yield, and net return in transplanted rice

Treatment	TWD (No./m^2)	TWDW (/m^2)	WCE (%)	Grain yield (kg/ha)	Net return (`/ha)
EPOE - bispyribac sodium 25 g/ha	4.42 (17.50)	6.03 (34.41)	70.70	4708	30,269
PE - pretilachlor 1000 g/ha	4.65 (19.67)	5.76 (31.22)	72.15	4569	29,548
POE - penoxulam 22.5 g/ha	4.36 (17.00)	7.27 (50.86)	59.60	4437	27,803
PE - pyrazosulfuron ethyl 20 g/ha	5.31 (26.16)	9.84 (94.77)	25.35	4333	26,855
EPOE - bispyribac 25 g/ha + ethoxysulfuron18.75 g/ha	3.81 (12.50)	5.21 (25.10)	78.20	4783	30,203
EPOE - bispyribac 20 g/ha + (chlorimuron + metsulfuron) 4 g/ha	3.32 (9.00)	4.26 (16.12)	87.00	4703	30,170
PE + POE - pretilachlor 750 g/ha fb ethoxysulfuron 18.75 g/ha	4.00 (14.00)	3.56 (10.68)	91.10	5702	41,654
PE + POE - pretilachlor 750 g/ha fb (chlorimuron + metsulfuron) 4 g/ha	1.91 (1.67)	2.20 (2.84)	97.15	6038	47,001
PE - pyrazosulfuron ethyl at 20 g/ha fb hand weeding	4.75 (21.50)	6.14 (35.67)	67.40	4690	27,839
PE - Pretilachlor (6%) + bensulfuron (0.6%) 6.6% GR 660 g/ha	4.38 (17.16)	7.34 (51.90)	59.10	4690	30,165
Hand weeding at 25 and 45 DAT	2.77 (5.67)	3.15 (7.90)	93.35	5859	37,093
Unweeded check	7.71 (57.49)	10.96 (118.18)	-	3222	14,423
SEd	0.27	0.42	-	174	-
LSD (P=0.05)	0.52	0.84	-	342	-

Figures in parenthesis are means of original values; Data subjected to square root transformation

RESULTS

The pooled analysis of data of *Kharif*, 2012 and 13 revealed that pretilachlor 750 g/ha PE *fb* chlorimuron + metsulfuron 4 g/ha POE recorded considerably lesser total weed density (1.67 no./m^2), weed biomass (2.84 g/m^2) and higher weed control efficiency of 97% at 60 DAT. Similar observations were made by Mukherjee and Maity (2011). Grain yield was significantly higher (6038 kg/ha) in pretilachlor 750 g/ha PE *fb* chlorimuron + metsulfuron 4 g/ha POE. Similarly, higher net return (Rs. 47,001 /ha) was registered in pretilachlor 750 g/ha PE *fb* chlorimuron + metsulfuron 4 g/ha POE.

CONCLUSION

Pre emergence application of pretilachlor 750 g/ha at 3 DAT + post emergence application of chlorimuron and metsulfuron 4 g/ha at 25 DAT for broad spectrum weed control, higher grain yield and net returns in transplanted rice.

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Efficacy of bensulfuron-methyl + pretilachlor on weeds of transplanted rice in humid tropics of Kerala

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Rice is a socially important crop grown in a vast array of ecological niches of Kerala. But the area under rice has been declining over the years due to the escalating cost of production which is weaning away rice farmers from cultivation. Labour requirement of the crop is very high and it constitutes more than 70% of the total cost of cultivation. A major portion of the labour is used for hand weeding. Shortage of labour affects timely operations. It is also estimated that delay in weeding by one day decreases the yield by about 200-250 kg/ha and hence timely and effective weed control is one of the key requirement for successful rice production. Very few pre-emergent herbicides are recommended for transplanted rice and continuous use of same herbicides may lead to the development of resistance among weeds. Thus it is essential to identify alternative effective pre –emergent herbicides for transplanted rice. Hence the present investigation was undertaken.

METHODOLOGY

Field experiments were conducted in the sandy loam soil at Regional Agricultural Research Station, Pattambi, Kerala during 2009-11 under All India Co-ordinated Rice Improvement Programme. The experiment was laid out in Randomised Block Design with seven treatments. Rice variety Jyothi was transplanted. Fertilisers were applied at 90-45-45 NPK kg/ha. Treatments included pre-plant application of glyphosate 15 days before planting, application of pre-emergent herbicides butachlor or bensulfuron methyl + pretilachlor at 0.06 + 0.6 kg/ha at 0-5 days after transplanting (DAT), sequential combination of pre-plant and pre-emergent herbicides, two hand weeding (20 and 40 DAT) and unweeded check. Observations on weed biomass at flowering stage and rice yield were recorded and subjected to statistical analysis. Based on the results, the pre-emergent herbicides were put under farm trials and tested over hand weeding during 2013-14 in 16 locations in four districts of Kerala for confirmation.

Table 1. Efficacy of herbicides on weed flora and yield of transplanted rice

Treatment	Yield (t/ha)	Weed biomass (g/m^2)	Weed control efficiency (%)	Net profit (`/ha)	B:C ratio
Bensulfuronmethyl + pretilachlor	5.58	9.22	84.57	58743	1.41
Butachlor	4.95	15.54	74.01	46706	1.11
Hand Weeding twice	5.41	7.41	87.60	40434	0.71
Unweeded control	3.42	59.79	-	23238	0.61
LSD (P=0.05)	0.220	7.705	-	-	-

RESULTS

Three year trials at RARS, Pattambi showed that weedy condition resulted in 64% reduction in rice grain yield. Rice grain yield with all weed management treatments were comparable except pre-plant glyphosate application. Weed biomass in the unweeded plot (53.44 g/m^2) was reduced to 12.81 and 8.28 g/m^2 with butachlor and bensulfuron methyl + pretilachlor treatments, respectively. The herbicides were as effective as hand weeding in controlling weeds (13.37 g/m^2) indicating the efficacy of pre-emergent herbicides.

Farm trials also confirmed the results (table 1). The highest rice yield (5.58 t/ha) and weed control efficiency (84.5%) was recorded with bensulfuron methyl+pretilachlor and the lowest in unweeded check (3.42 t/ha). Bensulfuron methyl + pretilachlor use caused 12.7% increase in yield when compared to currently recommended butachlor. As it was effective up to 40 DAT, second hand weeding was not required unlike in the case of butachlor. The weeds controlled include all major grasses, sedges and broad leaf weeds (*Echinochloa spp*, *Cyperus* sp., *Fimbristylis* spp., *Eichornea* sp., *Alternanthera* sp., *Aeschynomene* sp., *Monochoria* sp., *Ludwigia* sp., *Sphenoclea* sp.). The treatment gave an additional net returns of Rs 12037/ha over butachlor and provided the highest profitable B:C ratio.

CONCLUSION

Broadcasting of bensulfuron methyl + pretilachlor at 0.06 + 0.6 kg/ha at 0-5 days after transplanting can be recommended as an effective weed management practice for transplanted rice crop in Kerala.

Integrated effect of different planting geometry and weed management practices on weeds, growth and yield of direct-seeded (aerobic) rice

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Food security, among other things, also depends on the ability to increase food production with decreasing water availability. Rice, as a submerged crop, is a prime target for water conservation. Moreover, about 90% of the world's rice is grown and produced in Asia (FAO 2009). Rapidly depleting water resources threaten the sustainability of irrigated rice and hence, food security. Thus, a shift toward aerobic rice systems can play a key role in increasing rice production globally. Singh and Singh (2006) emphasized that both pre- and post-emergence herbicides, if properly used are quite effective in suppressing weeds in DSR. Thus research is needed on the effects of efficacy of different herbicides along with optimum planting geometry as an integrated approach in direct seeding which could reduce crop establishment cost, hence the present investigation was undertaken.

METHODOLOGY

A field experiment was conducted during the *Kharif* 2013 at the Crop Research Centre of GBPUAT, Pantnagar (Uttrakhand), India. The experiment was laid out in a factorial randomized complete block design with three different planting geometry (continuous drilling at 20cm, 20cm x 10 cm, 25 cm x 25 cm) as first factor and four weed control treatments (pendimethalin 1.0 kg/ ha as pre-emergence *fb* hand weeding 30 DAS; bispyribac-Na, 25 g/ha as post-emergence *fb* hand weeding at 45 DAS; Pendimethalin 1.0 kg/ha *fb* bispyribac-Na 25 g/ha *fb* 1 hand weeding at 45 DAS and weedy check) as second factor. "*Pant dhan-12*" was sown manually by line sowing. Fertilizers were applied uniformly through NPK mixture (12:32:16) and rest through urea, respectively. Data on weed growth, yield performance and economics were recorded.

RESULTS

The dominant weeds in the experiment were *Echinochloa crussgalli, Echinochloa colona, Leptochloa chinensis, Caesulia axillaris, Ammania spp., Cyperus spp.* The planting geometry of continuous drilling at 20 cm and weed control practice, pendimethalin (1.0 kg/ha) + bispyribac-Na (25 g/ha) + one hand weeding at 45 DAS significantly reduced the weed density (35.5 and 8.6/m^2) and biomass (59 and 24.7 g/m^2) compared with other treatments (Table1). There was a clear response of narrow plant spacing (continuous drilling at 20 cm) in suppressing weed growth. Weed control efficiency was lower in the wider (25 cm x 25 cm) spacing (63.5%) than the narrow (continuous drilling at 20 cm) spacing (68.3%) and among weed control treatments, same results were obtained for the treatment, pendimethalin (1.0 kg/ha) fb bispyribac-Na (25 g/ha) *fb* hand weeding at 45 DAS (87.4%). Narrow spacing (continuous drilling at 20 cm) along with pendimethalin (1.0 kg/ha) *fb* bispyribac-Na (25g/ha) *fb* 1hand weeding at 45 DAS, had higher grain yield (3.47 and 4.79 t/ha) and straw yield (6.78 and 7.97 t/ha), compared to other treatments (Table 1). Singh and Singh (2006) also reported higher grain yield with high WCE in which treatment. Similarly, Combination of herbicides along with hand weeding and narrow spacing resulted in higher net returns (40,576 and 40,633 '/ha) and B:C ratio (1.7 and 1.8), respectively.

Table1. Weed growth, yield and economics of rice as influenced by different treatments

Treatment	Weed density (no /m^2)	Weed dry weight (g/m^2)	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (x 10^3 Rs /ha)	B:C ratio
Planting geometry (cm)							
Continous drilling at 20cm	5.5 (35.5)*	6.8 (59.0)	68.3	3.47	6.78	40,576	1.7
20 x 10	5.8 (42.8)	7.6 (65.5)	66.5	3.41	6.37	38,215	1.6
25 x 25	5.9 (43.2)	7.9 (70.0)	63.8	2.90	4.60	32,048	1.5
LSD (P=0.05)	0.2	0.2	NS	0.40	1.05	-	-
Weed control practices							
Pendimethalin + 1HW at 30 DAS	5.4 (29.0)	6.3 (39.8)	82.2	3.62	6.52	30,498	1.4
Bispyribac sodium +1HW at 45 DAS	4.0 (15.6)	5.5 (30.7)	86.2	3.77	6.53	32,135	1.5
Pendimethalin+ bispyribac sodium +1HW at 45 DAS	3.0 (8.6)	5.0 (24.7)	87.4	4.79	7.97	40,633	1.8
Weedy	10.4 (108.8)	12.8 (164.3)	0	0.86	2.64	2,073	0.11
LSD (P=0.05)	0.2	0.3	6.4	0.46	1.22	-	-

*Original values are given in parenthesis; HW: Hand weeding; DAS: Days after sowing

CONCLUSION

Combination of planting geometry and different weed control measures *i.e.* continous drilling at 20 cm with pendimethalin (1.0 kg/ ha) *fb* bispyribac-Na (25 g/ha) *fb* hand weeding at 45 DAS proved to be effective and a profitable alternative to the existing recommendation of sole application of herbicide with hand weeding in direct seeded rice.

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Effect of post-emergence herbicide on yield and yield contributing character of transplanted rice in north Konkan region

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Cultivation of rice by transplanting in puddled soil is the major practice followed in Konkan region. Weed infestation is the major problem associated with the cultivation of rice under the different ecosystems (Rao *et al.* 2007). In transplanted rice (TPR), weeds not only reduce the grain yield up to 45% but also impair rice grain quality. The share of weed management cost is higher than any other operations in TPR. Though many pre-emergence herbicides are available for controlling weeds, the need for post-emergence herbicide is often realized to combat the weeds emerged during later stages of crop growth. Moreover, due to increasing problem of labour availability for rice cultivation, use of post-emergence herbicide has greater potential for effective weed management and higher rice yield. In this context, present study was carried out to evaluate bispyribac-sodium efficacy in managing weeds of transplanted rice.

METHODOLOGY

A field experiments were conducted at Agricultural research station Palghar, Dr Balasaheb Sawant Konkan krishi vidyapeeth Dapoli (MS) to evaluate herbicide bispyribac-sodium on weed control efficiency, growth and, yield of TPR during Kharif 2010 and 2011. A total of seven treatments were evaluated in a randomized block design with four replications. The treatments consisted of pre-emergence application (PE) of butachlor 1500 g/ha at 0-5 days after transplanting (DAT), post-emergence application (POE) of bispyribac-sodium at 25, 35, 50 g/ha applied at 20 DAT, weed free, two hand weeding and weedy check. The soil of the experimental field was clay loam with a pH of 7.5 and having NPK status of low, medium and high respectively. The rice variety *'Karjat-3'* were tested with recommended package of practices. The data on weed growth, yield performance and economics was collected using standard methods.

RESULTS

Basically, grassy weeds were predominant followed by broad leaved weeds and sedges .Among the grassy weeds *Echinoclola colona* and among the broad leaf weed *Mimosa pudica* were dominant. The total weed density and biomass decreased with increase in doses of bispyribac-sodium but not significantly. The lowest total weed density and biomass was observed by weed free plots, which was statistically on par with application of all the doses of bispyribac-sodium during both the years. The highest weed density and biomass was observed in unweeded control plot. Reduction in weed density and biomass due to application of bispyribac-sodium at 15 and 25 DAT in transplanted rice were reported by Yadav *et al.* (2009).

Among the weed control treatments, application of bispyribac-sodium at 50 g/ha recorded highest weed control efficiency of 98.1 and 98.5%, which was followed by the same herbicide with lower doses of 35 g/ha (97.5 and 97.8%) and 25 g/ha (96.5 and 97.1%), respectively, during both the years. Weed index which indicate the reduction in grain yield was minimum under bispyribac-sodium applied plots. POE of bispyribac-sodium at all the doses reduced the grain yield very marginally indicating the superiority inweed control. Higher weed control efficiency with lower weed index in bispyribac-sodium applied plots were due to effective weed control as evident from lower weed densityand biomass than other treatments as reported by Yun *et al.* (2005)

Table 1. Effect of post emergence application of herbicide on yield contributing character of rice under the Konkan condition

Treatment	Total weed density at 45 DAT (no./m²)		Total weed Biomass (kg/ha)		Weed control efficiency (%)		Weed index		Grain yield (t/ha)		Net profit (Rs/ha)		B:C ratio	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Butachlor 1500 g/ha	4.75	33.00	356	307	92.1	91.3	11.23	13.70	6.34	5.89	38.74	34.72	2.81	2.43
Bispyribac-sodium 25 g/ha	1.50	12.00	159	105	96.5	97.1	4.21	4.64	6.84	6.51	42.45	40.40	2.89	2.61
Bispyribac-sodium 35 g/ha	1.25	7.67	112	76	97.5	97.8	3.57	2.99	6.88	6.62	42.09	40.23	2.81	2.54
Bispyribac-sodium 50 g/ha	0.75	5.32	87	53	98.1	98.5	1.75	0.35	7.01	6.70	42.25	40.33	2.73	2.51
Weed-free	0	0	0	0	100.0	100.0	-	-	7.14	6.83	40.32	37.77	2.47	2.24
Two hand weedings	3.75	16.67	289	128	93.6	96.4	6.30	5.57	6.69	6.45	38.55	36.47	2.54	2.30
Unweeded check	63.75	110.68	4511	3541	-	-	44.78	51.28	3.94	3.33	15.48	10.26	1.78	1.45
LSD (P=0.05)	0.28	12.00	3.89	81.60	-	-	-	-	1.94	1.78	-	-	-	-

Significantly higher rice yield was associated with bspyribac-sodium application. Weed free has registered highest grain yield of 7.14 and 6.93 t/ha during 2010 and 2011, respectively which was at par with all the doses of bispyribac-sodium. POE of bispyribac-sodium at 25 g/ha recorded grain yield of 6.84 and 6.51 t/ha during 2010 and 2011, respectively which was at par with higher doses of bispyribac-sodium and significantly superior than butachlor application. The effect of all the three doses of bispyribac-sodium on grain yield was significantly higher than butachlor application and unweeded control. The per cent yield increment due to application of bispyribac-sodium at the rate of 25 g/ha were 7.9, 2.2 and 73.5 during 2010 and 0.8, 9.4 and 95.7% during 2011 than hand weeding twice, butachlor application and unweeded control, respectively. There was 44.8 and 51.3% yield reduction due to uncontrolled weeds in unweeded check over weed free check during 2011 and 2012, respectively.. The results of effective weed control along with higher grain yield by bispyribac-sodium against mixed weed flora in transplanted rice are in confirmity with Yadav *et al.* (2009)

The economic analysis of weed management practices revealed Post- emergence application of bispyribac-sodium at 25 g/ha registered highest net profit of 42,452 and 40,400 /ha during 2010 and 2011, respectively followed bybispyribac-sodium at 50 g/ha (42,086 and 40,330 /ha). Higher benefit-cost ratio was also associated with bispyribac-sodium at 25 g/ha (2.89 and 2.61) which was followed by bispyribac-sodium at 35 g/ha (2.81 and 2.54).

CONCLUSION

Application of post-emergence herbicide bispyribac-sodium at the rate of 25 g/ha on 20 DAT is suitable for attaining higher productivity by effectively managing weeds in transplanted rice.

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Effect of method of sowing and weed control on the performance direct-seeded rice in *Konkan* region

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The alternate methods of rice establishment are inevitable for handling the problem of labour shortage and make the rice cultivation more remunerative (Rao et al., 2007). Weeds are very serious problem in rice of *Konkan* region. Hence studies on sowing methods and weed management are essential. Hence, a field study was undertaken at Agronomy Farm, College of Agriculture, Dapoli during *Kharif*, 2013 to quantify the effect of methods of rice sowing and weed control on weeds, yield and economics of direct-seeded rice in *Konkan* region.

METHODOLOGY

The field experiment was laid out in split plot design with three sowing methods: broadcast-seeding, drill-seeding and drum-seeding as main plots and seven weed control measures as sub plots. Three replicates were maintained.

The soil of the experimental plot was sandy clay loam in texture, slightly acidic in pH, medium in organic carbon content, medium in available nitrogen, low in available phosphorus and high in available potassium. The weed growth, yield performance and economics data was taken following standard methods.

RESULTS

The beneficial effect of drill-seeding method of rice establishment in enhancing the growth characters i.e. plant height, leaves, number of tillers, and dry matter production was reflected in higher rice yield and yield attributing characters.

Different methods of sowing showed significant influence on various yield attributes. Number of panicle m^{-2}, maximum panicle length, maximum number of filled grains, weight of filled grains panicle^{-1}, and 1000 grain weight was found to be maximum with drill-seeding followed by drum-seeding. The increased yield attributes might be due to increased growth and development parameters which ultimately resulted in increased rice grain and straw yield as reported by Roy (2009)

Density of monocots and broad leaved weeds (BLW) (number 0.25 /m^2) was significantly influenced by different methods of sowing. At 30, 60, 75 DAS and at harvest, density of monocot and BLW was significantly lower with drill-seeding, followed by drum- seeding. Broadcast-seeding recorded significantly higher density of monocot and BLW.

Table 1. Effect of methods of rice seeding and weed control on yield contributing parameters, grain and straw yield, weed index and economics of rice

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Weed density (Monocot)	Weed density (BLW)	WCE (%)	Cost of cultivation (Rs/ha)	B: C ratio
Seeding methods							
S_1: Broadcast-seeding	29.94	38.45	4.95 (2.06)	9.81 (2.84)	46.20	40428.42	1.09
S_2: Drill-seeding	37.43	48.32	2.86 (1.73)	3.71 (1.87)	63.42	43514.53	1.29
S_3: Drum-seeding	35.88	46.57	3.38 (1.88)	4.90 (2.08)	58.68	43420.08	1.24
LSD (P=0.05)	4.05	7.64	(0.29)	(0.73)		2103.82	-
Weed control methods							
W_1 : Unweeded check	20.74	26.88	10.22 (3.15)	19.00(4.23)	0	36389.89	0.85
W_2 : Weed free (H.W. at 20, 40, 60 DAS)	41.97	54.26	0.33 (0.88)	0.44 (0.92)	98.95	50182.44	1.26
W_3 : PE *Oxadiargyl* @ 120 g ha^{-1}	31.86	40.27	4.22 (2.16)	6.56 (2.53)	45.52	38936.70	1.22
W_4 : PoE *Bispyribac sodium* @ 25 g ha^{-1}	33.48	42.85	4.33 (2.11)	5.89 (2.41)	51.82	40760.62	1.23
W_5 : PE *Oxadiargyl* @ 120 g ha^{-1} + One hoeing (40 DAS)	35.20	45.76	2.67 (1.77)	3.89 (2.01)	53.17	42579.96	1.24
W_6 : PoE *Bispyribac sodium* @ 25 g ha^{-1} + One hoeing (40 DAS)	36.62	48.05	3.00 (1.83)	4.33 (2.06)	59.33	43286.72	1.28
W_7 : PE *Oxadiargyl* @ 120 g ha^{-1} + PoE *Bispyribac sodium* @ 25 g ha^{-1}	41.05	53.07	1.33 (1.32)	2.89 (1.70)	83.92	45044.07	1.37
LSD (P=0.05)	4.08	7.26	(0.46)	(0.49)		2305.94	
Interaction effects							
S.Em. ±	2.70	4.90	(0.27)	(0.37)		1495.42	-
LSD (P=0.05)	-	-	-	-		-	-

The increased weed density in broadcasting was due to uneven distribution of crop in field which lead to increased field space for better weeds growth. These results confirm findings of Kumar *et al.* (2012).

The biomass of monocot weeds (g/m^2) was significantly influenced by different sowing methods under study. Three rice seeding methods did not differ with respect to monocots biomass at 30 DAS. At 60, 75 and at harvest the broadcast-seeding recorded maximum weed biomass of monocots than other seeding methods. Drill-seeding and drum- seeding significantly reduced weed biomass of monocots and were at par with each other. The biomass of BLW (g/m^2) was significantly influenced by sowing methods. At 30, 60, 75 DAS and at harvest the broadcast-seeding recorded maximum weed biomass of BLW other two seeding methods. Drill-seeding and drum-seeding significantly reduced weed biomass of BLW and were at par with each other confirming the results reported by Kumar *et al.* (2012).

The data further indicated that the treatment drill-seeding recorded the highest weed control efficiency followed by drum-seeding. The lowest weed control efficiency was recorded by the broadcast-seeding, confirming the findings of Walia *et al.* (2012). The drill-seeding of rice gave the highest net returns (Rs. 12940.17 /ha) and B:C ratio (1.29) followed by the drum-seeding (Rs. 10742.18 /ha) and B:C ratio (1.24).

CONCLUSION

It may be concluded that direct-seeded rice sown by drill-seeding method with hand weeding thrice (20, 40 and 60 DAS) results in higher rice yield and net returns. However, under the scarcity of labourers, application of pre (*Oxadiargyl* @120 g ha^{-1}) and post emergence (*Bispyribac sodium* @25 g ha^{-1}) herbicide for drill-seeded rice is advisable as it gave higher net returns, B: C ratio and better weed control.

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Effect of weed control on growth and yield of upland drilled rice under the lateritic condition of Konkan

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In case of direct seeded rice, there is unchecked weeds competition since the establishment and the reduction in yield was up to 80%. Effective weed control thus is a pre-requisite for high grain yield in direct seeded rice. Herbicides alone cannot completely check weeds. With the integrated weed management package in direct seeded rice, the rice yields ranged from 4.8 to 6 tonnes per hectare as against 4.2-5.8 tonnes per hectare obtained under the farmers conventional methods. With this view the trial was formulated to study integrated weed control methods in upland drilled rice.

METHODOLOGY

The field experiment was conducted during the *Kharif* season at Department of Agronomy, Dr. BSKKV, Dapoli. The soil was lateritic sandy clay loam in texture, slightly acidic in reaction (pH 6.12), medium in available N (310.17 Kg/ha), P_2O_5 (20.18 Kg/ha) and moderately high in K_2O (241.12 Kg/ha). The experiment was laid out in Randomized Block design with three replications. There were eleven treatments comprising of growing smother crop, *viz*. cowpea, mechanical methods like hand hoeing, hand weeding, use of herbicides, combination of these methods and unwedded control. The crop was sown in 3rd week of June and harvested in 3rd week of October. A fertilizer dose of 100:50:50 kg NPK /ha was applied to all the treatment plots. Complete dose of P, K and 40% of N was applied as a basal dose and remaining dose of N was splitted into two and applied at 30 and 70 DAS. The data were recorded on growth parameters; yield attributes and yield of rice, dry matter production of weeds and were analysed statistically.

RESULTS

The data recorded on growth parameters, *viz*. plant height (cm), number of tillers/m^2. and dry matter production (g/m^2) are given in Table 1. It was observed that different weed control treatments differed significantly in respect of plant height, number of tillers per sqm. and dry matter production. Recommended weed control practice *i.e.* oxadiargyl + hand weeding (T_{10}) recorded significantly taller plants, more number of tillers per sqm and dry matter production than the remaining treatments. It was followed by cowpea (intercrop) + butachlor followed by incorporation of cowpea + oxadiargy 30-35 DAS (T_4). The favourable conditions in terms of more nutrients, space and sunshine available under the recommended weed control practice i.e. oxydiargyl + hand weeding resulted into better growth of the crop due to efficient weed control. Similar results were obtained by Bhoje (2002).

From the data recorded on yield attributes of rice (Table 1), it was clear that recommended practice i.e. oxadiargyl + hand weeding (T_{10}) recorded significantly more number of panicles per square meter and weight of panicle than the remaining treatments except cowpea (intercrop) + butachlor + incorporation of cowpea 30-35 DAS + oxadiargyl (T_4) and butachlor + hand weeding (T_5) which were at par with the former treatments. The availability of more amount of source due to efficient weed control in the rice crop grown under the recommended weed control practice oxadiargyl + hand weeding (T_{10}) resulted into production of higher sink in terms of number of panicles per sq.m and weight of panicle, than the other treatments tried. In case of grain and straw yield also the recommended weed control practice oxydiargyl + hand weeding (T_{10}) was observed to be superior over the remaining treatments. These results corroborate the findings of Gogoi *et al.* (2002).

The treatment of oxadiargyl + hand weeding (T_{10}) recorded significantly the lowest total dry weight of weeds at harvest. It was followed by cowpea (intercrop) + butachlor + incorporation of cowpea 30-35 DAS + oxadiargyl (T_4) which was at par with butachlor + hand weeding (T_5) and recorded significantly less total dry weight of weeds than the remaining treatments. Highest weed control efficiency (82.57%) was recorded due to the recommended practice of weed control i.e.

Table 1. Effect of weed control treatments on growth and yield attributes, yield of rice, dry weight of weeds and weed control efficiency

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Dry Wt of weeds (q/ha)	WCE (%)
Cowpea (intercrop) harvested at 30-35 DAS + hoeing	13.50	21.62	26.49	36.71
Cowpea (intercrop) harvested at 30-35 DAS + oxadiargyl 0.1 kg/ha	22.12	27.66	18.00	56.99
Cowpea (intercrop) + butachlor 1.0 kg/ha P.E. (5-7 DAS) + incorporation of cowpea 30-35 DAS	28.72	38.68	14.32	65.79
Cowpea (intercrop) + butachlor 1.0 kg/ha P.E. (5-7 DAS) + incorporation of cowpea 30-35 DAS + oxadiargyl 0.1 kg/ha	32.85	48.52	12.55	70.01
Butachlor 1.0 kg/ha P.E. (5-7 DAS) + hand weeding at 40-45 DAS	29.41	41.11	12.78	69.46
Cyhalofop butyl 0.09 kg a.i./ha (5-7 DAS) + hoeing 40-45 DAS	23.18	32.39	15.21	63.66
Hoeing at 20-25 DAS and 40-45 DAS	17.76	25.13	23.58	43.66
Farmer's practice-hand weeding 20-25 DAS and 40-45 DAS	14.20	23.62	24.04	42.57
Hoeing 20-25 DAS and hand weeding 50-60 DAS	15.33	23.41	24.44	41.61
Recommended practice- oxadiargyl 0.1 kg/ha (5-6 DAS) + hand weeding 20-25 DAS	38.12	51.08	7.42	82.27
Unweeded control	9.52	15.08	41.86	–
LSD (P=0.05)	2.42	3.64	3.64	--

oxadiargyl + hand weeding (T_{10}) followed by $T_4 > T_5 > T_3 > T_6 > T_2 > T_7 > T_8 > T_9 > T_1$ in the descending order.

CONCLUSION

It may be concluded that performance of rice was not influenced by introducing cowpea, as an intercrop in direct seeded upland rice for 30-35 days. It was also ineffective in controlling the weeds. For effective weed control and higher yields as well as higher net returns from the direct seeded *Kharif* upland rice, oxadiargyl 0.1 kg/ha should be sprayed 5-6 days after sowing of the crop and it should be followed by hand weeding 20-25 days after sowing.

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Weed management by live mulches, cover crops and herbicides in direct-seeded rice

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Living mulches are usually not grown for harvest or direct profit but, instead, to provide ecological benefits including protecting soils from erosion, improving soil fertility, providing traffic lanes, suppressing weeds and reducing pest populations (Hartwig and Ammon 2002). Live mulching can reduce the weed population without any adverse effect on crop. *Sesbania* co-culture reduced broadleaf and grassy weed density by 76-83% and 20-33% respectively, and total weed biomass by 37-80 % compared with a sole rice crop (Singh *et al.* 2007). Keeping above facts in view the present investigation was carried out to the performance of live mulches, cover crops and herbicides in direct seeded rice.

METHODOLOGY

An experiment was conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi during *Kharif* season of 2014 to study the weed management by live mulches, cover crops and herbicides in direct seeded rice. The experiment comprised of nine treatments as given in the table no.1 replicated thrice in Randomized Block Design. Rice variety '*MTU-7029*' was sown by zero till drill on June 25, 2014 with 18 cm row spacing. A uniform dose of fertilizers at 120 kg N, 60 kg P_2O_5 and 60 kg K_2O /ha were applied through urea, di-ammonium phosphate and muriate of potash. Data on weed growth and yield were recorded as per the standard procedure. Duncan Multiple Range Test (DMRT) was used for comparing treatment mean.

RESULTS

At 60 DAS, *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS significantly reduced weed density and dry weight as compared to different weed management treatments except Sunhemp cover crop *fb* Sunhemp coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS which was at par. However, at harvest, the same treatment had significantly less weed density and dry weight as compared to the rest of the treatments. At 60 DAS, bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS had statistically comparable weed density and dry weight as compared to *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS and Sunhemp cover crop *fb* Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS . *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS recorded significantly higher grain and straw yields which was found at par to with rest of the weed management treatment except two hand weeding treatment.

CONCLUSION

It may be concluded that *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS maximally reduced weed density and weed dry weight as compared to rest of the weed management treatments which also resulted in maximum grain yield except two hand weeding.

Table 1. Effect of different treatments on weed density, weed dry weight, grain and straw yields in direct seeded rice

Treatment	Weed density (No. /m²)		Weed dry weight(g/m²)		Grain yield (t/ha)	Straw yield (t/ha)
	60 DAS	At harvest	60 DAS	At harvest		
Sesbania cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS	9.19e (12.00)	28.87h (117.33)	7.54e (6.88)	21.28h (66.16)	5.20b	9.94b
Sunhemp cover crop *fb* Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS	18.17bc (45.33)	36.13c (185.33)	12.59b (21.99)	26.77c (108.73)	4.84b	10.26b
Sesbania cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS	15.91cd (33.33)	34.34e (167.47)	11.33bc (17.22)	25.47e (98.16)	4.89b	8.95b
Sunhemp cover crop *fb* Sunhemp coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS	10.40e (16.00)	30.84g (135.20)	8.29ed (9.20)	23.01g (79.82)	5.05b	9.16b
Sesbania coculture *fb* 2, 4 -D 0.5 kg/ha at 30 DAS	19.50b (52.00)	36.72b (191.47)	13.56b (26.05)	27.19b (112.25)	48.44b	10.31b
Sunhemp coculture *fb* 2, 4- D 0.5 kg/ha at 30 DAS	13.70d (25.33)	31.63f (142.00)	10.17cd (13.76)	23.55f (83.57)	4.94b	9.63b
Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS	17.76bc (42.67)	34.89d (173.07)	12.49b (22.90)	25.85d (101.26)	4.68b	9.79b
Hand Weeding at 15 and 35 DAS	4.95f (0.00)	20.66i (57.87)	4.95f (0.53)	15.38i (32.39)	6.45a	12.99a
Weedy	31.87a (142.67)	51.57a (384.67)	46.60a (360.70)	37.93a (224.66)	1.04c	2.00c
CV (%)	10.6	0.39	6.36	0.35	0.78	.95

Values in parentheses are original. Data were analyzed after square root transformation.

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Integrated weed management in direct-seeded rice

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Weed problem in direct seeded rice can be managed by implementing integrated weed management. Chemical control proved to be a viable strategy with higher economic returns (Khaliq *et al*. 2011). Ehsanullah *et al.* (2012) observed that the post emergence application of bispyribac-sodium was the most effective in reducing the total weed density and dry weight over the weedy, followed by penoxsulam. However, weeds in direct seeded rice cannot be managed by herbicide alone because of various flushes of weeds during the initial stage of crop growth. Therefore, the present study was undertaken to assess the efficacy of various herbicides along with manual weeding to find out the best integrated weed management practices in direct seeded rice.

METHODOLOGY

A field investigation was carried out at Agricultural Research Farm, Banaras Hindu University, Varanasi during *Kharif* season of 2014 to study integrated weed management in direct seeded rice. The experiment comprised of ten treatments as per the Table 1 replicated thrice in randomized block design. Rice variety '*MTU-7029*' was sown by zero till drill on June 25, 2014 with 18 cm row spacing. A uniform dose of fertilizers at 120 kg N, 60 kg P_2O_5 and 60 kg K_2O /ha was applied through urea, di-ammonium phosphate and muriate of potash. Data on weed growth and yield were recorded as per standard procedures. Duncan Multiple Range Test (DMRT) was used for comparing treatment means.

RESULTS

At 60 days stage, penoxsulam 35 g/ha at 10 DAS + 1 HW at 35 DAS recorded significantly lesser weed density and dry weight over rest of the integrated weed management treatments and it was at par with penoxsulam, 35 g/ha at 20 DAS + 1 HW at 35 DAS. At 60 DAS, bispyribac Na, 12.5 g/ha + (chlorimuron ethyl + metsulfuron methyl) 2 g/ha at 10 DAS + 1 HW at 35 DAS and bispyribac Na, 12.5 g/ha + azimsulfuron, 15 g/ha at 10 DAS + 1 HW at 35 DAS had statistically comparable weed dry weight. At harvest, bispyribac Na, 12.5 g/ha + azimsulfuron, 15 g/ha at 20 DAS + 1 HW at 35 DAS was at par with bispyribac Na, 12.5 g/ha + (chlorimuron ethyl + metsulfuron methyl) 2 g/ha at 10 DAS + 1 HW at 35 DAS. At 60 days stage, bispyribac Na, 12.5 g/ha + azimsulfuron, 15 g/ha at 10 DAS + 1 HW at 35 DAS, bispyribac Na, 12.5 g/ha + azimsulfuron, 15 g/ha at 20 DAS + 1 HW at 35 DAS, bispyribac Na, 12.5 g/ha + (chlorimuron ethyl + metsulfuron methyl) 2 g/ha at 10 DAS + 1 HW at 35 DAS and bispyribac Na, 12.5 g/ha + (chlorimuron ethyl + metsulfuron methyl) 2 g/ha at 20 DAS + 1 HW at 35 DAS had statistically comparable weed density. Among the different integrated weed management practices penoxsulam,35 g/ha at 10 DAS + 1 HW at 35 DAS recorded significantly more grain and straw yields which was at par with two hand weedings at 15 and 35 DAS.

CONCLUSION

Among the different integrated weed management practices penoxsulam, 35 g/ha at 10 DAS + 1 HW at 35 DAS proved to be most effective for weed control in direct seeded rice. The same treatment recorded significantly higher grain and straw yields and was on par with two hand weeding at 15 and 35 DAS.

Table 1. Effect of integrated weed management treatments on weed density, weed dry weight, grain and straw yields in direct-seeded rice

Treatment	Weed density (No/m²)		Weed dry weight (g/m²)		Grain yield (t/ha)	Straw yield (t/ha)
	60 DAS	at harvest	60 DAS	at harvest		
Bispyribac Na 25 g/ha at 10 DAS + 1 HW at 35 DAS	24.27[b] (81.33)	38.13[c] 205.07)	16.62[bc] (39.20)	27.72[c] (113.49)	5.05[b]	9.89[b]
Bispyribac Na 25 g/ha at 20 DAS + 1 HW at 35 DAS	25.56[b] (90.67)	38.70[b] (211.47)	17.41[b] (43.54)	28.16[b] (117.27)	4.94[b]	7.526[d]
Bispyribac Na 12.5 g/ha + azimsulfuron 15 g/ha at 10 DAS + 1 HW at 35 DAS	19.76[cd] (53.33)	33.87[g] (161.60)	13.89[de] (26.21)	24.60[f] (88.30)	5.15[b]	9.81[b]
Bispyribac Na 12.5 g/ha + azimsulfuron 15 g/ha at 20 DAS + 1 HW at 35 DAS	21.38[c] (62.67)	35.01[e] (172.93)	14.89[cde] (30.58)	25.45[e] (95.09)	4.42[bc]	8.38[bcd]
Bispyribac Na 12.5 g/ha + (chlorimuron ethyl + metsulfuron methyl) 2 g/ha at 10 DAS + 1 HW at 35 DAS	20.68[c] (60.00)	34.52[f] (167.60)	14.43[de] (29.25)	25.24[e] (93.95)	4.94[b]	9.42[bc]
Bispyribac Na 12.5 g/ha + (chlorimuron ethyl + metsulfuron methyl) 2 g/ha at 20 DAS + 1 HW at 35 DAS	21.74[c] (65.33)	35.47[d] (176.93)	15.14[cd] (32.10)	25.90[d] (98.87)	4.01[c]	7.81[cd]
Penoxsulam 35 g/ha at 10 DAS + 1 HW at 35 DAS	16.70[e] (37.33)	30.67[i] (132.40)	11.93[f] (18.00)	22.29[h] (71.87)	6.19[a]	12.76[a]
Penoxsulam 35 g/ha at 20 DAS + 1 HW at 35 DAS	18.56[de] (46.67)	31.68[h] (141.47)	13.05[ef] (22.41)	22.95[g] (76.11)	4.58[bc]	8.98[bcd]
2 HW at 15 and 35 DAS	4.95[f] (0.00)	20.66[j] (57.87)	5.26[g] (0.53)	15.38[i] (32.39)	6.45[a]	12.99[a]
Weedy	31.71[a] (141.3)	51.57[a] (384.67)	44.83[a] (350.24)	37.93[a] (224.66)	1.04[d]	2.00[e]
CV (%)	5.74	0.58	8.60	0.60	0.93	0.97

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Effect of irrigation scheduling on weed growth and rice production in transplanted under rice-wheat cropping system

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Rice (*Oryza sativa* L.) is one of the major staple food grain crops of India. India has achieved self-sufficiency in rice production in last 50 years. To meet the demand of 114 mt by year 2030, we have to increase our productivity. Though our productivity is quite low but there is large gap between achieved and achievable yield with exception of Tamil Nadu (15%) and Punjab (22%). The yield gap is in range of 35.7% for most of the state. Major factor that rice being rainfed, facility and excessive irrigation in irrigated area causing soil salinity, imbalance use of fertilizer nutrient. Since water is one of crucial input of agriculture. Thus, efficient utilization and sustainable use of irrigation water through reducing the losses of water from paddy field and improvements from the soil surface and by evapotranspiration from plant surface is a major component of seasonal water losses from paddy field. The proper use of available irrigation water to available soil moisture may play important role in minimizing present large gap between yields achieved and yield achievable.

It is well known fact that water management is one of the major factors responsible for achieving better harvest in crop production. As more than 90% of water is used for irrigation. Priority should be fixed for high WUE in the field .Despite the diversion of 45% available irrigation resources toward cultivation little attention has been devising efficient water management schedule In general farmers use to keep paddy field submerged through out the growth period on the basis of assumption in their mind that higher grain yield of rice can be achieved only by doing this practice.

METHODOLOGY

The field experiment was conducted at Agronomy Research Farm of N. D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P) during *Kharif* season of 2009 and 2010. The experiment was laid out in randomized block design with 4 replications consisting of 9 irrigation schedule *i.e,* Submersed condition, 7 cm irrigation 1 DADPW, 7 cm irrigation 3 DADPW, 7 cm irrigation 5 DADPW(tillering, late jointing, flowering and milking, late jointing, flowering and Milking, flowering and milking, milking) and Control. Rice (*Sarjoo-52*) was taken as test crop.

Table 1. Impact of moisture regimes on weed growth, yield, WUE and economics of rice under rice-wheat cropping system

Treatment	Weed density (no/m²)	Weed dry weight (g/m²)	Plant height (cm)	Grain yield (q/ha)	Straw yield (q/ha)	WUE (kg/ha-cm)	B:C ratio
Submerged condition, 7 cm irrigation	2.62 (5.9)	2.68 (6.3)	123.40	55.80	78.70	36.63	1.63
1DADPW, 7 cm irrigation	3.71 (12.8)	5.24 (23.5)	118.4	54.60	76.90	41.50	1.73
3DADPW, 7 cm irrigation	3.75 (10.4)	4.06 (23.5)	115.8	52.40	74.50	42.15	1.60
5 DADPW, 7 cm irrigation	4.60 (22.0)	7.03 (48.0)	105.0	45.00	64.40	44.50	1.35
Tillering, late jointing, flowering and milking	5.10 (20.0)	8.10 (50.5)	104.1	35.80	51.50	33.36	0.81
late jointing, flowering and milking	5.15 (20.5)	8.17 (52.0)	100.08	30.40	44.20	38.33	0.59
Flowering and milking	5.17 (23.5)	8.20 (57.5)	95.76	25.60	37.40	23.85	0.34
Milking	5.25 (24.0)	8.22 (57.0)	90.60	22.50	38.10	20.96	0.30
Control	10.5 (110.5)	12.2 (140.5)	90.40	22.40	39.20	20.80	0.20
LSD (P=0.05)	(0.31)	(0.32)	10.80	3.60	6.40	-	-

DADPW=Disappearance of pounded water

Crop was sown on 15/6/2010.Transplanting of rice seedling in experimental field was done as per transplanting method two seedling of 22 days after sowing. Soil of experimental field was silt loam with pH 8.2 having low in organic carbon (0.28%) and low in available nitrogen (160.45 kg/ha), phosphorous (18.5 kg/ha) and high in potassium (280 kg/ha). The sowing was done in 15 x 10 cm^2 distance using a seed rate of 25 kg/ha. The amount of fertilizer was applied uniformly 120 kg N 60 kg P_2O_5 and 40 kg K_2O. Half dose of nitrogen and total phosphorous and potash were applied as basal application before puddling. Remaining half of nitrogen used as top dressing in two equal does each at tillering and panicle initiation stage Irrigation treatment based on day after disappearance of pounded water was started just after transplanting with 7 cm.

RESULTS

It is the clear from the Table 1 that the minimum number of weeds m^{-2} was recorded under submerged condition and the maximum number of weeds/m^2 was recorded under control plot. The maximum plant height was recorded under submerged condition which being at par with 1 DADPW and 3 DADPW was found significantly superior over other treatment. Irrigation under submerged condition produce maximum grain yield (5.58 t/ha) which was at par with 1 DADPW (5.460 t/ha) and 3 DADPW (5.24 t/ha) and significantly superior over other treatments and lowest yield was recorded under no irrigation (2.24 t/ha). Further, water use efficiency decreased markedly with increasing level of moisture regime. The maximum benefit cost ratio (1.73) was found 1DADPW and minimum benefit cost ratio (0.2) was found no irrigation.

CONCLUSION

On the basis of results it may be concluded that maximum grain yield and straw yield and minimum weed growth were observed under submerged condition which was at par with 1 DADPW (Disappearance of Pounded Water) and 3 DADPW.

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Evaluation of new herbicide combinations for weed control in transplanted rice

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Rice is the world's most important food crop, as it is the staple food for almost 3 billion people. Rice crop is infested with grasses, broad leaved weeds, and sedges (Saha 2005). Weeds are more competitive in the early growth stages than at later stages. Several new herbicide molecules are available in the market and there is a need to test their efficacy to control weeds in transplanted rice.

METHODOLGY

Field experiments were carried out at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) to study the bio-efficacy of new herbicide molecules and their combinations for weed control in transplanted rice during kharif season of 2012 in a randomized block design with three replications having 12 treatments (Table 1). Fertilizer nutrients were applied at 120, 60, 60 kg/ha NPK respectively, uniformly through urea, single super phosphate and muriate of potash. Herbicides were sprayed as per the schedule. Data on weed crop performance were recorded and analyzed for economics.

RESULTS

It is clear from the Table 1 that all the weed control treatments significantly reduced the density and dry weight of total weeds as well as weed control efficiency over weedy check at 60 DAT. Among the treatments, combination of Bispyribac Na (20 g/ha) and ethoxysulfuron (18.75 g/ha) recorded the lowest weed density (2.77) and weed dry weight (4.59 g), and highest WCE (86.46%), grain yield (5.62 t/ha) and straw yield (5.86 t/ha). A combination of almix or ethoxysulfuron with bispyribac-Na or pretilachlor either as tankmixed or in a rotational application controlled the wide spectrum of weeds very effectively and resulted in higher WCE and grain and straw yields. Among the different weed control treatments bispyribac + ethoxysulfuron recorded higher B-C ratio (2.37 per Re invested)

Table 1: Effect of various weed control treatments on weed growth yield and economics in transplanted rice

Treatment	Weed density (no/m^2)	Weed dry weight (g/m^2)	WCE at 60 DAT (%)	Grain yield (t/ha)	Straw yield (t/ha)	Net return (x10^3 `/ha)	B:C ratio
Bispyribac-Na (25)	(20.2) 4.60	(48.5) 7.03	67.34	5.17	5.45	458.7	2.12
Pretilachlor (1000)	(35.2) 6.09	(82.4) 9.13	44.51	4.67	5.01	402.6	1.93
Penoxsulam (22.5)	(23.0) 4.89	(42.5) 6.59	71.38	5.14	5.37	460.3	2.19
Pyrazosulfuron (20)	(23.9) 4.98	(98.3) 9.96	33.80	4.14	4.35	331.9	1.59
Bispyribac sodium. + thoxysulfuron (25+18.75)	(10.4) 3.37	(22.7) 4.06	84.71	5.62	5.86	508.2	2.37
Bispyribac sodium. + almix (20+4)	(6.7) 2.77	(20.1) 4.59	86.46	5.51	5.67	497.4	2.25
Pretilachlor fb ethoxy (750/18.75)	(14.7) 3.96	(26.5) 5.24	82.15	5.50	5.71	497.9	2.26
Pretila fb almix (750/4)	(12.8) (3.71)	(23.6) 5.24	84.1	5.61	5.81	515.5	2.27
Pyrazo fb MW (20)	(16.9) 4.23	(23.9) 4.98	83.90	5.25	5.44	449.0	1.92
Pretilachlor+Bensulfuron 660	(25.2) 5.11	(65.6) 8.16	55.82	4.96	5.33	433.1	2.02
Weed free (20 and 45HW)	(5.9) 2.62	(6.2) 2.68	95.0	5.77	5.99	475.0	1.73
Weedy check	(123.0) 11.13	(148.5) 12.22	0.0	4.01	4.31	183.0	0.92
LSD (P=0.05)	0.33	0.34	-	0.487	0.537	-	-

CONCLUSION

Complex weed flora in transplanted rice can be controlled effectively by using the combination of bispyribac -Na (25 g/ha) and ethoxysu -furon (18.7 g/ha), *fb* applied at 25 days after transplanting of rice.

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Effect of seed rate and weed management practices on yield and weed density of direct-seeded rice

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In Chhattisgarh, rice is grown by different methods (broadcast, *biasi*, drilling/line sowing, *lehi* and transplanting) depending upon the type of soil, topography of the land, availability of water and labour. The predominant method of rice cultivation in this area is broadcast *Beushening* (Biasi). However, these methods have their own limitations. In order to increase the productivity of Direct Seeded Rice (DSR) in Chhattisgarh, efforts have been made in recent years through line sowing system of cultivation, which not only maintains plant population but also facilitates easy intercultural operations, proper weed control and basal application of fertilizers. Line sowing coupled with application of herbicides may prove to be very promising in farmers' fields. Manual weeding in rice is not only costly and difficult but is time consuming also due to morphological similarity of grass type weeds and rice, especially during early growth stages (Phuong *et al.* 2005). Considering the above facts, there is a need to manage the weeds during critical crop-weed competition period either by physical methods or through herbicides.

METHODOLOGY

The present investigation was carried out at the Instructional cum Research Farm, IGKV, Raipur (Chattisgarh) during *kharif* season (June to October) of 2011 to find out the optimum seed rate and effective weed management practices for rice crop. The experiment was laid out in Split Plot Design (SPD) replicated thrice. The rice crop was sown 20 cm apart. The treatments comprised of weed management practices given in main plot as M_1 - Fenoxaprop at 60 g/ha + Ethoxysulfuron at 15 g/ha at 20-25 DAS + Hand Weeding at 35-40 DAS, M_2 - Fenoxaprop at 60 g/ha + Ethoxysulfuron at 15 g/ha at 18-20 DAS followed by Bispyribac Na at 20 g/ha at 35 DAS, M_3 - Hand Weeding at 18-20 and 35-40 DAS (Farmers' practice) and M_4- Control,-and sub plot treatment as S_1- 20 kg/ha, S_2- 30 kg/ha, S_3- 40 kg/ha and S_4- 80 kg/ha (recommended practices). Recommended dose of chemical fertilizer 100 kg N + 60 kg P_2O_5 + 40 kg K_2O /ha was applied through urea, single super phosphate and muriate of potash.

RESULTS

The results from Table 1 revealed that the growth and yield of direct-seeded rice and weed control efficiency were the highest, whereas weed density/m^2 was the lowest under the application of Fenoxaprop at 60 g/ha + Ethoxysulfuron at 15 g/ha, at 18 DAS *fb* Bispyribac Na at 20 g/ha at 35 DAS (M2). This was followed by hand weeding twice (M3). The seed yield (5.22 t/ha) and straw yield (6.53) were also the maximum in the above treatment. It was observed that highest grain yield (4.54 t/ha) and straw yield were recorded under seed rate of 80 kg/ha (S4) but, it was at par to 40 kg/ha (S3) and 30 kg/ha (S2). The lowest weed density/m^2 was recorded under seeding rate of 80 kg/ha (S4). The lowest weed density at initial stage was found under hand weeding twice (M3), but at later stages, treatment of Fenoxaprop at 60 g/ha + Ethoxysulfuron at 15 g/ha, PoE, fb Bispyribac Na at 20 g/ha (M2) was found with significantly better than others. In respect to the different seeding rates, treatment of 80 kg/ha (S4) recorded lowest weed density throughout the crop growth. Interaction between weed management and seeding rate was significant and at initial stages, lowest density was recorded under interaction between hand weeding twice (M3) x 80 kg/ha (S4) but later on, interaction between Fenoxaprop at 60 g/ha + Ethoxysulfuron at 15 g/ha, PoE, *fb* Bispyribac Na at 20 g/ha (M2) x 80 kg/ha (S4) recorded the lowest value. Mahajan *et al.* (2010) have also reported similar results.

Table 1. Effect of weed control practices and seed rate on weed growth and rice yield

Treatment	Weed density/m^2			Seed yield (t/ha)	Straw yield (t/ha)
	15 DAS	30 DAS	At harvest		
Weed control					
M1-Post-emergence (PoE) application of Fenoxaprop 60 g/ha, + Ethoxysulfuron 15 g/ha, at 23 DAS + hand weeding at 35 DAS	101.33 (10.08)	42.50 (6.51)	53.08 (7.24)	4.72	5.94
M2- Post-emergence (PoE) application of Fenoxaprop 60 g/ha, + Ethoxysulfuron 15 g/ha, at 18 DAS *fb* Bispirybac Na 20 g/ha at 35 DAS	102.58 (10.15)	28.41 (5.32)	30.66 (5.51)	5.22	6.53
M3-Hand Weeding at 18-20 and 35 DAS	99.66 (10.00)	16.66 (4.06)	37.58 (6.09)	5.20	6.37
M4-Control	102.32 (10.13)	121.83 (10.98)	165.08 (12.78)	1.93	2.53
LSD (P=0.05)	NS	7.76 (0.50)	9.30 (0.50)	0.36	0.48
Seed rate (kg/ha)					
S1- 20	103.33 (10.18)	70.75 (7.92)	98.00 (9.38)	3.81	4.62
S2-30	101.58 (10.09)	56.25 (7.03)	77.83 (8.32)	4.25	5.26
S3-40	100.50 (10.04)	45.66 (6.32)	61.25 (7.38)	4.47	5.59
S4-80	100.51 (10.04)	36.75 (5.61)	49.33 (6.53)	4.54	5.89
LSD (P=0.05)	NS	1.93 (0.15)	5.88 (0.25)	0.32	0.24

CONCLUSION

Among weed management treatments, post-emergence application of Fenoxaprop at 60 g/ha + Ethoxysulfuron at 15 g/ha, PoE, *fb* Bispyribac Na at 20 g/ha (M2) was found most remunerative and gave highest net monetary return as well as B:C ratio. Among seed rate treatments, highest net return and B:C ratio was obtained under 80 kg/ha, but this was hardly 1.85% higher in net return and 0.52% in B:C ratio over 40 kg of seed rate/ha.

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Effect of weed management options on yield and weed control efficiency of scented rice

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In rice production, weeds are considered to be one of the major limiting factors due to manifold harmful effects (Kalyanasundaram *et al.* 2006). Rice yield losses due to uncontrolled weed growth and weed competition were least (12%) in transplanted rice and highest in aerobic direct seeded rice on a furrow-irrigated raised-bed system and in dry-seeded rice sown without tillage (Singh *et al*. 2011). Global demand for organically grown foods is increasing and organic agriculture is rapidly gaining acceptance in recent years. In most rice growing areas, increasing cost of labour and its scarcity during the critical period of crop-weed competition are the major reasons for rice farmers using hand weeding only as a supplement to mechanical weeding or to herbicides. As far as non-chemical methods of weed control are concerned, no work has been carried out earlier to study their effect on weeds in scented rice. Keeping aforesaid points in view, an investigation was conducted with the objective to find the appropriate method to suppress weeds and to achieve higher productivity of scented rice in Chhattisgarh.

METHODOLOGY

The field experiment was conducted during *Kharif* season of 2011 at the Instructional Cum Research Farm of Indira Gandhi KrishiVishwavidyalaya, Raipur (Chattisgarh) to find out the most effective weed management method. Treatments consisted of eight weed management practices *viz.* weedy check (T_1), cono-weeding (T_2) at 25 and 45 DAT, one hand weeding (H.W) at 25 DAT (T_3), 2 HW at 25 and 45 DAT (T_4), acetic acid (20%) (T_5), Ambika paddy weeder (T_6), Burn oil spray (T_7), and closer row spacing (T_8). The trial was laid out in Randomized Block Design (RBD) with three replications. Rice variety Kasturi was transplanted on 24th July, 2011 and harvested at maturity. Observations on weed control efficiency and yield were taken. The crop was fertilized with 80, 60 and 40 kg N, P_2O_5 and K_2O /ha, respectively.

RESULTS

The grain yield of rice showed marked variations due to weed control methods. The rice grain yield ranged from 2.63-3.56 t/ha depending upon methods of weed control followed. Yield increase over weedy check was found to be in the range of 13.64-35.20%. Higher grain yield with cono-weeder (T_2) (3.56 t/ha) might be due to less weeds competition, lower weed density (7.34 /m^2), lower dry weight of weeds (8.35 g/m^2) and higher weed control efficiency (65.72%). The mechanical weeding accomplished through cono-weeder (T_2) produced the highest straw yield (7.38 t/ha) and it was identical with treatment T_6 (7.12 t/ha) and superior to all other weed control treatments. Weed control efficiency (WCE) at different periods of crop growth was significantly better when cono-weedering was performed at 25 and 45 DAT and this was followed by the treatment ambika paddy weeder.

Table 1: Yield and weed control efficiency (WCE) of rice as influenced by various weed management treatments

Treatment	Weed control efficiency (WCE)				Grain yield (q/ha)	Straw yield (q/ha)
	20 DAT	40 DAT	80 DAT	Harvest		
T_1-Weedy check (20x10 cm)	-	-	-	-	26.39	64.53
T_2-Use of conoweeder (20x20 cm) –25,45 DAT	11.13	66.04	63.18	65.72	35.68	73.88
T_3-1 H.W (20x10 cm) –25 DAT	0.89	63.11	54.70	50.16	31.46	70.11
T_4-2 H.W (20x10 cm) –25,45 DAT	6.45	60.81	62.26	55.05	33.29	69.97
T_5-Acetic acid (20%)(20x10 cm) –25,45 DAT	26.61	31.86	45.08	42.07	30.44	68.61
T_6-Ambika paddy weeder(20x10 cm) –25,45 DAT	12.47	65.06	60.82	65.80	34.69	71.27
T_7- Burn oil spray at 15 and 30 DAT + 1 HW at 45 DAT (20x10 cm)	12.47	20.71	33.67	43.39	30.18	69.89
T_8-Closer row spacing (15x10 cm)	31.06	24.06	33.77	42.56	29.99	68.66
SEm+	-	-	-	-	1.79	1.59
LSD (P=0.05)	-	-	-	-	5.43	4.83

DAT: Days after transplanting

At later period of growth, lower weed density and dry matter accumulation under treatment cono-weeder favoured significant enhancement in number of effective tillers, total tillers, weed control efficiency, straw yield and grain yield which was at par with other treatments.

CONCLUSION

Mechanical weeding by cono-weeder at 25 and 45 DAT (T_2) could be adopted as weed control practice for scented rice cultivation in Chhattisgarh for more production.

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Efficacy of herbicides on nutrient uptake and yield of wet-seeded rice

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Direct seeding of rice (*Oryza sativa* L.) refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Farooq *et al.* 2011). In Asia yield losses due to uncontrolled weeds in DSR are between 45 and 75% and in transplanted rice it is approximately 50% (Chauhan *et al.* 2011). Repeated use of any single herbicide in a crop also generates a shift in the composition of weed flora with the result that secondary weeds may become of primary concern. In view of serious concerns about weed shift, combination of herbicides is advisable.

METHODOLOGY

A field experiment was conducted during *Kharif* season 2012 at Agricultural Research Station, Malnoor, Karnataka, to investigate the effect of weed management practices on growth and yield of wet seeded rice. Fifteen treatments consisting of three pre-emergent herbicides (Butachlor, Anilophos, Oxyfluorfen) sprayed alone at 8 DAS or followed by post emergent herbicides 2,4-D or Bispyribac sodium or hand weeding at 25 DAS, compared with hand weeding thrice, weed free and weedy check were laid in randomized block design with three replications. Rice variety *'BPT-5204'* was wet seeded in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at 150 kg N, 75 kg P_2O_5 and 75 kg K_2O /ha, respectively. Observations on weed growth, nutrient uptake and grain yield were recorded.

RESULTS

Among different weed control treatments weed free check recorded maximum nutrient uptake by crop (103.40, 21.24 and 60.27 kg NPK /ha, respectively) followed by butachlor fb bispyribac sodium (97.38, 20.03 and 57.52 kg NPK /ha) and butachlor *fb* 2, 4-D sodium salt (94.96, 19.19 and 57.52 kg NPK/ ha) which were on par (Table 1). However, weedy check registered significantly lower uptake of nutrients (40.91, 6.15 and 30.68 kg NPK /ha, respectively) due to higher crop weed competition. Thus higher nutrient uptake in above treatments was largely due better control of weeds recording reduced weed index values and increased grain yield. However, application of herbicides in combination is the best possible way to achieve sustained grain yield along with reduced cost of cultivation.

Table 1. Weed density, nutrient uptake and yield of wet seeded rice as influenced by different weed control treatments

Treatment	Weed density (no/m^2)	N (kg/ ha)	P (kg/ ha)	K (kg/ ha)	Weed index (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1 – Butachlor 50 EC	8.30 (68.33)*	69.08	12.83	46.75	27.21	3710	4195
T_2 – Anilophos 30 EC	8.35 (69.33)*	65.78	12.50	46.37	28.80	3630	4110
T_3 – Oxyfluorfen 23.5 EC	8.77 (76.50)	52.71	9.93	39.41	52.90	2397	2828
T_4 – Butachlor 50 EC fb 2,4-D sodium salt 80 WP	4.75 (22.07)	94.95	19.20	57.15	5.93	4801	5227
T_5 – Anilophos 30 EC fb 2,4-D sodium salt 80 WP	5.32 (27.83)	91.19	18.05	54.26	10.36	4566	4998
T_6 – Oxyfluorfen 23.5 EC fb 2,4-D sodium salt 80 WP	7.25 (52.12)	78.54	14.21	49.91	42.79	2820	3309
T_7 – Butachlor 50 EC fb bispyribac sodium 10 SC	4.45 (19.33)	97.38	20.03	57.52	4.57	4871	5269
T_8 – Anilophos 30 EC fb bispyribac sodium 10 SC	5.57 (30.60)	90.35	17.35	53.84	10.97	4536	4995
T_9 – Oxyfluorfen 23.5 EC fb bispyribac sodium 10 SC	6.93 (47.50)	80.91	14.74	50.69	39.02	3072	3552
T_{10} – Butachlor 50 EC fb hand weeding at 25 DAS	4.98 (24.33)	93.08	18.80	55.78	8.31	4671	5109
T_{11} – Anilophos 30 EC fb hand weeding at 25 DAS	5.84 (33.67)	87.82	15.93	53.03	11.91	4488	4979
T_{12} – Oxyfluorfen 23.5 EC fb hand weeding at 25 DAS	7.09 (49.83)	80.03	14.55	50.21	41.80	2947	3317
T_{13} – Hand weeding (thrice) at 20, 40 and 60 DAS	2.07 (3.83)	100.12	20.69	59.56	0.76	5072	5449
T_{14} – weedy check	13.07 (173.00)	40.91	6.14	30.68	63.45	1864	2273
T_{15} – Weed free check	0.71 (0.00)	103.40	21.24	60.27	0.00	5108	5460
LSD (P=0.05)	0.91	9.02	2.50	4.64	9.54	497	549

*Values in parentheses are original. Data transformed to square root transformation

CONCLUSION

Sequential application of herbicides resulted in effective control of weeds, enhance nutrient uptake by the crop and ultimately leading to profitable rice production.

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Effect of different weed management practices in *Boro* rice cultivation

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Boro rice cultivation is an old practice in areas where irrigation facility is assured. It is only recently that it has emerged as a major breakthrough in enhancing rice productivity, not only in traditional, but also in non-traditional *Boro* rice areas. *Boro* rice cultivation mainly depends on assured irrigation and modern inputs. Among the modern management options, effective weed management plays a vital role. In transplanted rice, Bispyribac sodium is a suitable and economical herbicid for weed management (Veeraputhiran *et al.* 2013).

METHODOLOGY

A field experiment was conducted during the *Boro* season of 2013-14 on sub-humid sub-tropical lateritic belt of Agricultural farm, Palli Siksha Bhavana (Institute of Agriculture) at Visva-Bharati, Sriniketan, India to study the effect of different weed management practices in *Boro* rice cultivation. This experiment was conducted in Randomised Block Design having three replications with nine treatments constituting of two doses of Bispyribac sodium at 25 and 50 g/ha at 25 DAT, two doses of Orthosulphamuron at 80 and 150 g /ha at 15 DAT, Butachlor at 1kg /ha at 3 DAT, Butachlor at 1.0 kg/ha at 3 DAT + hand weeding at 20 DAT, cono weeding at 20 and 40 DAT, hand weeding at 20 and 40 DAT and weedy check. Rice variety "*IR-36*" was transplanted in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at 140 kg N, 70 kg P_2O_5 and 70 kg K_2O /ha, respectively. Data on weed count, weed dry matter, yield performance and economics were recorded.

RESULTS

From the experiment it was observed that weed count and weed dry matter values were lower with the application of Bispyribac sodium at 25 g/ha at 25 DAT and with application of Butachlor at 1 kg/ha at 3 DAT followed by hand weeding at 20 DAT and the values were statistically at par with the weed free check where hand weeding was done twice at 20 and 40 DAT. Highest grain yield was obtained with application of Butachlor at 1 kg/ ha at 3 DAT + hand weeding at 20 DAT which was statistically at par with Bispyribac sodium at 25 g/ ha at 25 DAT and weed free check where hand weeding was done twice at 20 and 40 DAT. However, among all the weed management options, net return and return per rupees invested was found higher by application of Bispyribac sodium at 25 g/ha at 25 DAT.

Table 1. Effect of weed management on weed count, weed dry matter, grain yield, net benefit and return per rupee invested in *Boro* rice cultivation

Treatment	Weed count (no./m^2)	Weed dry matter(g/m^2)	Grain yield (t/ha)	Net benefit (`/ha)	Return /rupee invested
Bispyribac sodium 25 g/ha at 25 DAT	7.00	0.31	6.57	61720	2.86
Bispyribac sodium 50 g/ha at 25 DAT	15.33	0.78	5.47	45260	2.35
Ortho sulphamuron 80g/ha at 15 DAT	45.33	1.47	5.90	51337	2.55
Ortho sulphamuron 150g ha at 15 DAT	38.00	1.41	6.03	55017	2.66
Butachlor 1 kg/ha at 3 DAT	43.00	2.27	6.13	55227	2.67
Butachlor 1 kg/ha at 3 DAT + Hand weeding at 20 DAT	8.00	0.37	6.70	56383	2.43
Cono weeding at 20, 40 DAT	24.00	1.75	6.37	55417	2.54
Hand weeding at 20, 40 DAT	0.00	0.00	6.80	53460	2.17
Weedy check	128.67	3.46	4.80	36793	2.12
LSD (P=0.05)	6.4	0.2	0.9	-	-

CONCLUSION

Application of Bispyribac sodium at 25 g/ha was most effective for controlling weeds, improving grain yield and profitability in *boro* rice cultivation.

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Weed control in rice under different establishment methods

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Rice (*Oryza sativa L.*) is the major crop of Andhra Pradesh, India. However, due to variations in the occurrence of rainfall in the South-West monsoon period and resulting late release of water to canals and late filling of tanks, transplanting of rice is delayed during *Kharif*. As an alternative, the practice of direct seeding through different methods is becoming popular. However, weed management is the main constraint in direct seeded rice. Without effective weed control yield loss up to 60-80% was reported. Application of post-emergence herbicides, *viz.* chlorimuron + metsulfuron, bentazone and pyrazosulfuron were reported to be promising for controlling broad- leaved weeds and sedges in direct sown drilled rice (Dixit and Varshney 2008) The present investigation was taken up to study the efficacy of weed control methods as influenced by rice establishment techniques.

METHODOLOGY

A field experiment was taken up during *Kharif* seasons of 2009-10 and 2010-11 at the Agricultural Research Station, Garikapadu, Andhra Pradesh in the light soils of Nagajun Sagar Project left canal command area with an objective to study the different methods of rice establishment and weed control practice on weeds and rice yields. The experiment was conducted in a strip plot design with three replications with four different methods of raising rice, *viz.* drilling of dry seed in prepared soil, drilling of sprouted seed with drum seeder in puddled soil, broadcasting of sprouted seed in puddled soil, farmer's method of transplanting as main treatments and three weed control practices *viz.*, weed control through pre and post emergence herbicides alone, integration of herbicides with one hand weeding, and hand weeding alone as sub plot treatments. A recommended fertilizer dose of 240-60-40 kg/ha of N, P_2O_5, K_2O were applied uniformly for all treatments. However, nitrogen was given in four splits for the direct sowing treatment and in three splits for transplanted rice. Data on weed dry matter, yield and yield attributes of rice and economics were calculated.

RESULTS

The grain yield with broadcasting of sprouted seed in puddled soil (4.95 t/ha), drilling of sprouted seed with drum seeder in puddled soil (5.00 t/ha) and drilling of dry seed in prepared soil (5.04 t/ha) was on a par with each other and significantly lower as compared to farmer's method of transplanting (5.62 t/ha).

Among the different weed control methods in rice, inclusion of hand weeding resulted in significant increase in grain yield (5.26 t/ha) as compared to pre and post emergence herbicide use alone (4.81 t/ha). Weed management in drill sowing of dry seed in prepared soil with use of pre emergence application of pendimethalin at 0.75 kg/ha *fb* bispyribac sodium at 25 g/ha at 20 DAS resulted in on par grain yield (4.91 t/ha) with that of pendimethalin at 0.75 kg/ha as pre emergence followed by bispyribac sodium at 25 g/ha at 20 DAS + one hand weeding (5.13 t/ha) and hand weeding alone (5.10 t/ha). However, in drilling of sprouted seed with drum seeder or broadcasting in puddled soil methods, pre-emergence application of oxadiargyl at 80 g/ha at 2-3 DAS + bispyribac sodium at 20 DAS alone could not give significantly higher grain yield as compared with oxadiargyl at 80 g/ha at 2-3 DAS as pre emergence followed by bispyribac sodium at 25 g/ha at 20 DAS + one hand weeding and hand weeding alone treatment. Similar higher yield of rice with herbicides followed by hand weeding was reported by Jaikumar *et.al.* (2009).

CONCLUSION

It can be concluded that integration of hand weeding with pre- or post-emergence herbicides is required for effective weed control and higher rice yield.

Table 1. Grain yield (kg/ha) as influenced by different planting methods and weed control methods in direct seeded rice

Planting Method (PM)	Weed Control Method (WCM)			Mean
	W1	W2	W3	
Drilling of seed in prepared soil	4914	5131	5100	5048
Drilling of sprouted seed with drum seeder	4388	5301	5330	5006
Broadcasting of sprouted seed in puddled soil	4448	5090	5337	4958
Farmer method of transplanting	5516	5539	5825	5627
Mean	4817	5265	5398	5160
	PM	WCM	Interaction	
LSD (P=0.05)	191	124	248	

W1: Pendimethalin at 0.75 kg/ha + Bispyribac sodium at 25 g/ha at 20 DAS in drilling of dry seed in prepared soil and Oxadiargyl at 80 g/ha 2-3 DAS as pre emergence followed by Bispyribac sodium at 25 g/ha at 20 DAS in the other three methods

W2: W1 followed by one hand weeding at 40 DAS

W3: Weed control by hand weeding alone

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Response of direct-seeded rice under integrated weed management practices

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Rice is the main staple food crop of India, covering an area of about 43.97 mha with the total production and productivity of 104.32 mt and 2.37 t/ha of rice, respectively during 2011-2012 (Anonymous 2013a). Although, transplanting method of establishment is reported to be the best for higher productivity of rice, but looming water crisis, water intensive nature of rice cultivation and escalating labour costs drive the search for alternative management methods to increase water productivity and profitability in rice cultivation. Direct seeded rice (DSR) has much attention because of its low input demand. Keeping these points in view, the present investigation was planned to develop a suitable weed management practice for DSR.

METHODOLOGY

A field experiment was conducted during *Kharif* season of 2010-11 and 2011-12 at C.C.R.PG. College, Muzaffarnagar UP (28R"N latitude and 77R"E longitude, 245.83 m above the msl). The soil was sandy loam in texture with pH 7.1 and O.C. 0.35%. The experiment was laid out in a randomized block design with three replications. The experiment consisted of fourteen weed management treatments, *viz*. T1, pendimethalin 1.0 kg/ha PE; T2, pendimethalin 1.0 kg/ha PRE *fb* almix 0.004 kg /ha POE at 25 DAS; T3, pendimethalin 1.0 kg/ha PRE *fb* one HW at 45 DAS; T4, anilophos 0.4 kg/ha PRE; T5, anilophos 0.4 kg/ha PRE *fb* almix 0.004 kg/ha POE at 25 DAS; T6, anilophos 0.4 kg./ha PRE *fb* one HW at 45 DAS; T7, almix 0.004 kg/ha POE at 25 DAS; T8, almix 0.004 kg/ha POE at 25 DAS *fb* one HW at 45 DAS; T9, *Sesbania fb* 2,4-D 0.5 kg/ha POE at 30 DAS; T10, *Sesbania fb* 2,4-D 0.5 kg/ha POE at 30 DAS *fb* oneHW at 45 DAS; T11, one HW at 30 DAS; T12, two HW at 20 and 45 DAS; T13, weed free and T14, weedy check.

Rice variety '*Pant Dhan-12*' was sown in the last week of June during both the years. The dry-seeding was done in 20cm row spacing with 60 kg seed/ha. *Sesbania* was broadcast at 50 kg seed/ha along with rice seeding and it was killed by spraying 2,4-D at 0.5 kg/ha at 30 DAS. 150 kg N, 60 kg P_2O_5, 60 kg K_2O, 25 kg Zn and 50 kg Fe/ha were applied.

RESULTS

The pooled result (Table 1) revealed that the yield attributing characters, *viz*. number of panicles/m², panicle length, number of grains/panicle and 1000-grain weight were recorded highest under T13 but it remained at par with T3. Treatment T3 resulted in to maximum plant height and dry matter production next to T13. More number of shoots and dry matter production under T3 might be due to less weed population which provided sufficient space for horizontal growth of crop that led to higher dry matter accumulation and yield attributes. The grain yield was significantly influenced due to weed control treatments. Significantly highest grain yield was noticed under T13, being at par with T3.

The superiority of T3 over rest of the weed management treatment in terms of grain yield might be owing to production of more growth parameter and yield components that resulted in to more grain yield of the crop. This confirms the finding of Mohan *et al.* (2005). As regards economic analysis, maximum net return and B:C ratio were registered with application of T3. The possible reason for generating maximum net return and B:C ratio was due to production of more grain yield under the respective treatment.

Table 1. Effect of weed management treatments on growth, yield attributes, yield and economics of direct seeded rice (Pooled data of two cycles)

Treatment	Plant height at maturity (cm)	Dry matter production at harvest (g/m²)	Panicles (no./m²)	Panicle length (cm)	Number of grains/panicle	1000-grain weight (g)	Grain yield (g/ha)	Net return (x10^3 `ha)	B:C ratio
T1	97.3	496.6	327.5	20.0	58.4	19.0	37.5	16.31	1.32
T2	94.7	490.0	331.6	20.0	59.4	19.4	42.5	19.76	1.57
T3	100.7	574.4	340.4	22.0	67.7	20.6	47.6	22.46	1.66
T4	94.7	490.6	309.5	19.5	57.0	18.6	35.1	15.26	1.32
T5	97.6	484.7	331.1	20.4	59.3	19.3	40.8	19.27	1.63
T6	93.2	472.5	331.7	20.4	60.5	19.7	40.8	18.12	1.42
T7	89.4	502.7	301.9	19.3	55.9	18.3	25.9	9.01	0.79
T8	91.1	505.7	313.3	19.8	57.6	18.8	35.3	14.38	1.14
T9	94.0	514.9	308.3	19.5	56.4	18.5	34.2	14.95	1.32
T10	92.1	513.8	313.9	19.9	58.3	18.9	36.4	15.18	1.21
T11	93.2	515.6	296.9	19.1	54.4	18.1	24.6	7.12	0.58
T12	96.3	527.9	327.8	20.2	58.5	19.1	43.0	19.19	1.42
T13	108.9	588.2	344.2	23.3	69.8	21.0	49.4	19.10	1.04
T14	83.8	53.5	74.0	14.3	35.8	17.0	6.5	-5.48	-0.49
LSD(P=0.05)	9.2	14.1	4.7	1.3	3.1	0.7	6.4	-	-

CONCLUSION

Pendimethalin 1.0 kg/ha PE *fb* one HW at 45 DAS *i.e.* T3 was most effective weed management practicesfor growth, yield attributes, yield and economics of direct-seeded rice under irrigated agro-eco system of western Uttar Pradesh.

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Effect of weed management practices in direct-seeded dibbled rice in coastal region of Konkan

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The traditional 'slash and burn agriculture' is common in equatorial regions of the world as also north-eastern hilly states of our country. Similarly, farmers of coastal Maharashtra heat surface area of their nursery soil by burning various organic materials to raise vigorous seedlings through weed control in nursery area by destroying live weed seeds in soil, killing harmful soil borne insects and pathogens and improving nutrition, locally known as *'Rabbhajne'*. Besides, this practice has many direct disadvantages, *viz*. air pollution particularly CO_2 emission responsible for global warming, stunted trees being topped annually, exposure of soil to intense rains and erosion *etc*. Direct seeded rice (DSR) suffers from more weed competition than transplanted rice. But direct seeded rice either drilled or dibbled can save costs many items. An effective weed management is the only key behind the success of DSR. Hence, the present investigation was carried out for studying comparative performance of the transplanted and dibbled rice with evaluation of proper weed management practices.

METHODOLOGY

The experiment was conducted on coastal lateritic soil of *Konkan* during *Kharif* 2013 at Agronomy Farm, College of Agriculture, Dapoli. Dist. Ratnagiri. The experiment was laid out in randomised block design with three replications. Sowing of crop (*'Ratnagiri-1'*) in situ and in nursery as per treatments was done simultaneously on 6th June, 2013. The paired row dibbled rice was sown at the spacing of 15 cm x 15 cm - 25 cm following two way skipping pattern and in case of traditional transplanting, 3 weeks old seedlings raised on Rab treated area were randomly transplanted in the puddled and levelled field using 2-3 seedlings/hill. The conventionally transplanted crop was fertilized at 100:50:50 kg N, P_2O_5 and K_2O /ha using urea, SSP and MOP. However at the time of dibbling a uniform dose of 50 kg K_2O /ha was applied and urea-DAP briquettes were placed in squares of 15 cm x 15 cm to a depth of 8 cm. Thus briquettes containing 34% N and 19.9% P_2O_5 were applied to PRDR at 169 kg/ha (57.5 kg N + 33.6 kg P_2O_5 /ha). The treatment comprised of 13 weed management practices (Table 1).

RESULTS

At 30 DAS, conventionally transplanted rice exhibited least weed incidence of all weed species compared to paired row dibbled rice which in turn caused least weed growth. But at 60 and at 90 DAS as compared to conventionally transplanted rice hand weeded twice, the treatment of PRDR hand hoeing thrice and integrated with hand weeding once at 45 DAS (T_3) was found to be most effective treatment in reducing both density and growth of weeds.

At 30, 60 and 90 DAS, the total growth of monocots and BLWs together was found to be the least in case of the treatment T_3 - *PRDR* + Hand hoeing thrice 15,30 and 45 DAS **+** One Hand Weeding 45 DAS where hand hoeing with Japanese weeder thrice at 15, 30 and 45 DAS was combined with hand weeding once at 45 DAS. This treatment thus exhibited highest weed control efficiency of 93.37, 99.69 and 93.08 per cent respectively at 30, 60 and 90 DAS. The next treatment in order of less weed growth and in turn higher weed control efficiency of 91.5, 96.4 and 83.8 at 30, 60 and 90 DAS respectively was the treatment T_2- Paired row dibbled rice (*PRDR)* + Hand weeding twice 20 and 40 DAS. Both of these treatments were statistically at par in respect of their weed growth. Similarly, Hussain (2008) recorded highest WCE due to hand weeding twice (98.18). Grain and straw yield was found to be highest in case of the treatment T_3 (PRDR 3 HHs 15, 30 and 45 DAS + 1 HW 45 DAS) 4.17 t/ ha. As compared to unweeded control the per cent increase in grain yield due to the former treatment was 45.4% and that due to the treatment T_9 (PRDR PE Oxyfluorfen at 0.25 kg/ ha + 2HHs 30 and 45 DAS) was 43.3%. Such increase in both grain and straw yield of these effective treatments could be contributed to reduced weed competition for nutrients and light leading to enhanced crop growth, increased yield attributes like panicle number per unit area, panicle length, number of filled grains/panicle and thus increased nutrient uptake causing significant increase in grain and straw yield. The next good treatment was conventionally transplanted rice hand weeded twice recorded 2.61% increase in grain yield as compared to dibbled rice with hand weeding twice.

Table 1. Weed growth, weed control efficiency and yield of rice as influenced by different weed management treatments

Treatment	Weed density (0.25 m^2)		Weed dry matter (0.25 m^2)		WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)
	Monocot	Dicot	Monocot	Dicot			
T_1: CT 2HWs 20 and 40 DAS	2.67 (1.74)	1.67 (1.46)	5.35 (2.39)	11.25 (3.42)	71.46	3.95	4.37
T_2 PRDR 2HWs 20 and 40 DAS	1.00 (1.17)	0.67 (1.05)	5.35 (2.39)	4.07 (1.93)	83.81	3.82	5.04
T_3: PRDR 3HHs 15, 30 and 45 DAS + 1HW 45 DAS	0.00 (0.71)	0.00 (0.71)	4.02 (1.92)	0.00 (0.71)	93.08	4.17	5.52
T_4: PRDR PE *Oxadiargyl* @ 0.12 Kg/ ha	7.67 (2.83)	3.00 (1.86)	4.77 (2.24)	14.00 (3.76)	75.91	3.60	4.33
T_5: PRDR PE *Butachlor* @ 1.5 Kg/ha	10.00 (3.21)	2.00 (1.56)	21.42 (4.56)	15.21 (3.90)	36.96	3.58	4.63
T_6: PRDR PE *Oxyfluorfen* @ 0.25 kg/ha	6.33 (2.61)	4.33 (2.20)	19.87 (4.45)	15.63 (3.94)	38.92	3.65	4.81
T_7: *PRDR* PE *Oxadiargyl* @0.12 kg/ha+ 2HHs 30 and 45 DAS	11.33 (3.41)	1.67 (1.46)	3.20 (1.90)	14.88 (3.84)	68.89	3.83	4.90
T_8: *PRDR*PE *Butachlor* @ 1.5 Kg/ha+ 2HHs 30 and 45 DAS	6.33 (2.60)	1.67 (1.46)	4.49 (2.21)	14.55 (3.83)	67.24	4.07	4.95
T_9: *PRDR* PE *Oxyfluorfen* @ 0.25 kg/ha+ 2HHs 30 and 45 DAS	3.33 (1.93)	0.67 (1.05)	4.80 (2.15)	9.89 (3.14)	74.72	4.10	5.20
T_{10}: PRDR PE *Oxadiargyl* @ 0.12 Kg/ha+ POE MsM + CmE	9.67 (3.16)	2.00 (1.56)	24.09 (4.91)	18.27 (4.27)	27.12	3.30	4.41
T_{11}: PRDR PE *Butachlor* @ 1.5 Kg/ha+ POE MsM + CmE	12.00 (3.48)	2.67 (1.77)	18.37 (4.27)	16.30 (4.03)	40.35	3.21	4.34
T_{12}: PRDR PE *Oxyfluorfen* @ 0.25 kg/ha+ POE MsM + CmE	13.33 (3.64)	3.33 (1.95)	19.87 (4.46)	12.28 (3.50)	44.66	3.35	4.29
T_{13}: PRDR UWC	24.47 (4.93)	12.00 (3.46)	29.51 (5.43)	28.63 (5.35)	0.00	2.32	4.37
LSD (P=0.05)	0.50	0.37	0.95	0.68	-	5.90	11.59

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Bio-efficacy and phytotoxicity of propanil for weed control in direct-seeded rice

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Rice is the world's most important staple food - grown in over 100 countries, consumed regularly by over two billion people and the primary source of protein for millions. The risk of yield loss by weeds in direct-seeded (DS) rice is greater than transplanted rice. Chemical weed management appears to be the best low cost alternative. New herbicides are being introduced in a regular manner but their ecosafety and efficiency need to be investigated. The present experiment was undertaken to study the efficacy of Propanil on weed growth and yield in direct seeded rice.

METHODOLOGY

A field experiment was carried out during *Kharif* 2013 at Kalyani 'C' Block Farm, BCKV, Nadia, West-Bengal to evaluate the bio-efficacy and phytotoxicity of Propanil 36% EC in direct seeded rice. The experiment was laid out in randomized block design with 7 treatments (Table 1) replicated thrice in a sandy loam soil. The pre- germinated seeds of variety '*IET-4786*' were sown during last week of June in 6 m x 4 m plots with a spacing of 20 cm x 20 cm. The recommended fertilizer (NPK: 60:30:30 kg/ha) doses were used. Irrigation was applied following SRI ADW methodology. Post emergence herbicide Propanil at 3 doses and Bispyribac sodium were sprayed at 2-3 weed leaf stages and compared with farmers practice and weedy check.

RESULTS

The predominant weed flora in the experimental plot comprised of *Echinochloa colona* (7%), *Cynodon dactylon* (5%), *Cyperus rotundus* (35%), *Cyperus difformis* (14%) and *Ammania baccifera* (39%). Herbicidal treatments significantly influenced the population and dry matter production of weeds (Table 1). At 30 DAA, among the herbicidal treatments, Propanil 36% EC at 6.60 kg/ha at recorded highest WCE (78.4%), lowest weed density and dry weight followed by its next dose at 3.30 kg/ha. No phytotoxicity symptoms were observed on-rice crop at 5, 15 and 30 DAA. The maximum grain yield (4.26 t/ha) was obtained from highest dose of Propanil at 6.6 kg/ha while the minimum was from the untreated check (2.41 t/ha). Propanil 3 applied at higher two doses of 3.3 and 6.6 kg/ha recorded at par grain yield with farmers' practice which were significantly higher than standard Bispyribac sodium. The straw yield also showed similar variations. The findings were similar to results obtained by Ghosh *et al.* (2013).

Table 1. Effect of treatments on dry weight of dominant weeds (g/m) and weed control efficiency

Treatment	Formulation dose (kg/ha)	*Echinochloa spp*	*Cynodon dactylon*	*Cyperus rotundas*	*Cyperus difformis*	*Ammania baccifera*	Other monocots	Other dicots	WCE %
Untreated check	-	17.45	14.21	87.21	44.32	75.54	35.52	42.23	0.00
Farmers' practice	-	5.13	2.42	32.63	18.02	33.92	12.93	7.02	64.59
BPS 10 SC @ 25 g/ha	-	5.42	3.45	30.23	15.23	33.82	12.24	8.34	65.64
Propanil 36% EC @ 1.26 kg/ha	3.50	8.56	4.12	32.24	13.54	31.11	15.23	9.17	63.99
Propanil 36% EC @ 1.60 kg/ha	4.50	6.82	4.04	29.34	12.31	27.24	12.24	9.52	67.93
Propanil 36%EC @ 3.30 kg/ha	9.15	4.78	2.34	24.92	6.52	25.43	6.21	4.32	76.45
Propanil 36%EC @ 6.60 kg/ha	18.30	4.23	2.11	23.74	4.92	24.25	5.23	4.02	78.35
LSD (P=0.05)	-	0.57	0.28	1.27	1.72	1.25	1.03	0.34	-

CONCLUSION

The results revealed that Propanil at 3.3 and 6.6 kg/ha showed better control of all types of weeds and the yield of rice with no phytotoxic effects on crop.

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Bio-efficacy of different herbicides for weed control of transplanted rice

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Rice is the staple food of our country and plays an important role in the economic development. The productivity of wet season rice is very low due to severe weed problem. With the introduction of short statured high yielding rice varieties with erectophylic leaves, the weed menace has become more acute. The floristic composition in transplanted condition includes grasses, sedges and broad leaved weeds causing considerable yield reduction of rice. Therefore, evaluation of new herbicides and herbicides mixtures is very imperative to control the wide spectrum control of weeds. Considering these facts, the present study was undertaken to evaluate the performance of some new herbicides and their combinations in transplanted *Kharif* rice.

METHODOLOGY

A field experiment was conducted during *Kharif 2014* at Central research farm, OUAT, Bhubaneswar. The soil of the experimental site was sandy clay loam in texture, neutral in soil reaction (pH7.4) ,low in organic carbon C(0.41 %) and available N (192 kg/ha),medium in available P (12.8 kg/ha) and K (235 kg/ha).The experiment was laid out in a randomized block design with nine treatments consisting of Bispyribac Na at 0.025 kg/ha at 25 DAT, Pretilachlor 1.0 kg/ha at 3 DAT , Penoxsulam 0.0225 kg/ha at 12 DAT, Pyrazosulfuron 0.02 kg/ ha at 3 DAT, Bispyribac Na + ethoxysulfuron (0.025 + 0.01875) at 25 DAT, Bispyribac Na + almix (0.02 + 0.004) at 25 DAT, Pretilachlor + Bensulfuron (ready mix product) 0.66 kg/ha at 5 DAT, weed free -two hand weeding at 25 and 45 days after transplanting (DAT) and non weeded control replicated three times. The variety '*Pratikhya*' was used as the test crop which was transplanted on 22nd July 2014 and harvested on 21st November 2014.

RESULTS

The floristic composition of the experimental site was dominated by grasses like *Digitaria ciliaris*, *Cynodon dactylon*, *Echinochloa colona*, and broad leaf weeds like *Ageratum conyzoides*, *Cleome viscosa*, *Ludwigia parviflora*, *Physalis minima*, *Chrozoffera rottleri and Monocharia vaginalis*. The dominant sedges observed were *Cyperus rotundus* and *Cyperus iria.* Other weeds observed in lower density were *Panicum repens*, *Sporobolus diander*, *Alternanthera sessilis*, *Eclipta alba* and *Cyperus difformis.*

Significant differences in weed densities were observed at 30, 60 DAS and at harvest due to different weed management practices. Weed free treatment recorded significantly lower weed density of 2.0 and 1.9 /m^2 at 60 DAP and at harvest, respectively. Among different weed management practices, post emergence application of bispyribac + almix recorded significantly less weed density at all stages of observation followed by post emergence application of bispyrbac + ethoxysulfuron (Table 1). The weed biomass at different growth stages of rice are presented in Table 1. There was increasing trend with respect to weed biomass from 30 DAT to harvest irrespective of treatments. Weed free treatment recorded significantly lower biomass of 1.6, 2.4 and 2.6 g/m^2 at 30, 60 DAT and at harvest, respectively. At 30 DAS, post emergence application of bispyribac + almix recorded significantly lower biomass of 1.6 g/m^2 which was at par with bispyribac + ethoxysulfuron (1.7 g/m^2) at later stages. Also bispyribac + almix treated plots exhibited lower values of biomass. Weedy check plots recorded significantly higher biomass at all the stages of observation.

Table 1: Effect of different herbicides combinations on weed density, weed biomass, yield and economics in transplanted rice

Treatment	Weed density (m^{-2})			Weed biomass (g/m^2)			Grain yield (t/ha)	Net return (`/ha)	B:C Ratio
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest			
Bispyribac-Na	3.78 (13.8)	5.0 (24.7)	6.1 (36.5)	2.9 (7.7)	4.7 (21.5)	5.5 (30.2)	4.83	19413	1.65
Pretilachlor	4.68 (21.5)	5.8 (32.7)	7.7 (58.3)	3.1 (9.5)	4.9 (23.7)	5.9 (34.2)	4.56	16454	1.56
Penoxsulam	4.16 (16.8)	5.4 (28.5)	7.1 (49.5)	3.0 (8.4)	4.9 (23.8)	5.7 (32.6)	3.84	18266	1.61
Pyrazosulfuron	4.4 (18.7)	5.3 (27.8)	7.2 (52.0)	3.1 (9.3)	4.9 (23.5)	5.9 (34.3)	4.78	16660	1.56
Bispyribac + ethoxysulfuron	2.8 (7.6)	4.0 (15.2)	4.3 (18.5)	1.7 (3.2)	3.3 (10.5)	4.2 (17.0)	4.98	20713	1.79
Bispyribac + almix	2.8 (4.8)	2.1 (13.8)	4.3 (17.8)	1.6 (2.8)	2.6 (6.3)	3.4 (11.2)	5.02	21478	1.85
Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	3.7 (13.8)	5.0 (24.7)	6.0 (35.7)	2.8 (7.2)	4.5 (19.5)	5.3 (27.2)	4.64	20507	1.70
Weed free treatments(Hand weeding at 25 and 45DAT)	2.4 (5.3)	2.0 (3.5)	1.9 (3.2)	1.6 (2.0)	2.4 (5.2)	2.6 (6.3)	4.63	18790	1.59
Weedy check	8.4 (70.5)	10.0 (100.5)	11.2 (124.8)	5.2 (26.8)	6.0 (35.7)	7.0 (48.5)	2.60	270	1.01
SEm±	0.15	0.15	0.17	0.12	0.10	0.12	0.83	-	-
LSD (P=0.05)	0.45	0.45	0.51	0.35	0.31	0.36	1.24	-	-

Original values given in the bracket are square root transformation•(x+1) for statistical analysis

Post emergence application of bispyribac + almix recorded significantly higher yield of 5.02 t/ha which was at par with post emergence application of bispyribac + ethoxy sulfuron (4.98 t/ha). Weed free plots recorded rice yield of 4.63 t/ha where as weedy treatment recorded the lowest yield (2.60 t/ha). The higher yields of different treatments were supported with higher yield attributes. The findings were in close conformity with those of Singh *et al.*(2005) and Rekha et al.(2002). Highest net return of Rs. 21478 /ha was obtained from post emergence application of bispyribac + almix followed by bispyribac + ethoxysulfuron (Rs 20713 /ha), also the highest B: C ratio of 1.85 was observed with bispyribac + almix treated plots and the next best B: C ratio in order was bispyribac + ethoxysulfuron (1.79).

CONCLUSION

Based on the observations, it can be concluded that post emergence application of bispyribac + almix was the most effective in controlling all types of weeds and also recorded significantly higher yield and B:C ratio than all other treatments.

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Effect of rice-based cropping systems on weed dynamics and crop productivity

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Direct seeded culture has become increasingly important in rice cultivation due to scarcity of farm labour and higher water requirement and higher production cost of transplanted rice (Azmi and Baki 2007). In South Asia, rice based cropping systems accounts for more than half of the total acreage where rice is grown in sequence with rice or upland crops like maize or legumes. Rice based cropping systems provide food security and livelihoods for millions. Rice–wheat cropping systems alone occupy 13.5 mha in the Indo-Gangetic plains of South Asia. Direct seeded rice may be sequence with different crops due to dynamics in DSR what type of crops should be planted are of more interest.

METHODOLOGY

A field experiment was conducted at Crop Research Centre, R.A.U., Bihar, Pusa in split plot design with seven rice based cropping system (direct seeded rice-wheat, direct seeded rice-chickpea, direct seeded rice-field pea, direct seeded rice-mustard, direct seeded rice-linseed, direct seeded rice-potato and direct seeded rice-berseem) in main plot and three weed control methods in sub-plot (weedy check, recommended herbicide, and hand weeding (rice-2HW; *Rabi* crop-1 HW) replicated thrice. The soil of the experimental plot was clay loam with pH 8.79 and organic carbon 0.40%. The fertility status of the soil was low in available nitrogen (203.2 kg/ha), phosphorus (17 kg P_2O_5 /ha) and potassium (101.7 kg K_2O /ha). The recommended package and practices were followed for each crop. The recommended herbicide for each crop was applied with knapsack sprayer fitted with flat fan nozzle.

RESULTS

The lowest number of weeds and weed dry weight (in both *Kharif* and *Rabi* crops) were recorded under rice-berseem cropping system followed by rice-linseed cropping system. Among weed control methods, the lowest weed count and weed dry weight were recorded under Hand weeding followed by recommended herbicide. The highest rice equivalent yield was recorded under rice-potato cropping system (11.7 t/ha) followed by rice-berseem cropping system. Among weed control methods, the highest rice equivalent yield was recorded under hand weeding followed by recommended herbicide. However, the highest net return (`60000/ha) was obtained under rice-berseem cropping system followed by rice-mustard cropping system and by recommended herbicide (`1512/ha) among weed control methods.

Table 1. Effect of different treatments on weed dry weight, rice equivalent yield and economics in rice based cropping systems

Treatment	Total weed count in all the crops in cropping system	Weed dry matter (g/m^2)	Rice equivalent yield (q/ha)	Gross return (`/ha)	Cost of cultivation (`/ha)	Net return (`/ha)
A. Cropping sequence						
DSR-Wheat	10.63 (112.4)	13.40 179.3)	69.5	83400	41000	42400
DSR-Chickpea	10.43 (108.2)	12.98 (168.1)	68.5	82200	33500	48700
DSR-field pea	10.53 (110.3)	13.33 (177.2)	61.9	74280	33500	40780
DSR-mustard	10.24 (104.4)	12.05 (144.8)	67.3	80760	30000	50760
DSR-linseed	9.84 (96.4)	10.98 (120.2)	52.1	62520	30500	32020
DSR-potato	10.06 (100.8)	11.69 (136.2)	117.0	140400	95000	45400
DSR- berseem	9.64 (92.5)	10.76 (115.3)	82.5	99000	30000	60000
LSD (P=0.05)	1.09	1.21	6.1	-	-	-
B. Weed management						
Weedy check	15.62 (243.4)	17.82 (317.1)	61.3	73560	41928	31632
Recommended herbicide	6.22 (38.2)	8.58 (73.2)	78.7	94440	42928	51512
Hand weeding	5.45 (29.2)	7.50 (55.8)	82.3	98760	51928	46832
LSD (P=0.05)	1.12	1.25	7.2	-	-	-

DSR: Direct seeded rice

CONCLUSION

Among the rice based cropping systems, direct seeded rice-berseem and direct seeded rice-mustard were found more profitable with recommended herbicides.

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Effect of time of sowing and weed control methods in direct-seeded rice

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Rice is the world's most important crop and is a staple food for more than half of the world's population. Direct seeded culture has become increasingly important in rice cultivation due to scarcity of farm labour and higher water requirement and higher production cost of transplanted rice (Azmi and Baki 2007). For a direct seeded rice crop there are two ticklish problems. The first one is to decide the time of sowing of a variety of a particular maturity group and secondly to undertake adequate measure for control of weeds, which grow rake and luxuriantly under direct seeded conditions. A direct seeded rice crop may nil sown at the start of monsoon or after at few weeks when soil is more saturated some scientists are in the opinion that if sowing is delayed beynd 1st week of July drastic reduction in yield may occur. However, a number of factors including the climatic ones are there, which influence the time of sowing and the same will have to be decided conclusively. Thus, it is of paramount importance to search out ways and means to eliminate loss in rice yields due to delayed and erratic monsoon. A very large number of herbicides are there which have been observed to have effective control of weeds in direct seeded rice. Weed competition would be less severe under transplanting than those under direct-seeding because of emerging direct seeded rice seedlings are less competitive with concurrently emerging weeds and the initial flush of weeds is not controlled by flooding in wet and dry direct seeded rice (Rao *et al.* 2007).

METHODOLOGY

A field experiment was conducted to evaluate the effect of sowing time and weed management practices on yield and economics of direct seeded rice at Crop Research Centre of R.A.U., Bihar Pusa in Split plot design in three replications. The variety used was '*BPT-5204*'. The soil of the experimental plot was silt loam having pH 8.25, organic carbon 0.38%, low in available nitrogen (234.5 kg/ha), Phosphorus (21.6 kg/ha) and Potassium (91.8 kg/ha) and slightly alkaline in reaction. The factors under

study comprised two time of sowing *i.e.* before onset of monsoon and after onset of monsoon in main plot and six weed control treatments (Pretilachlor 50.5 kg/ha Pre-emergence (5 DAS), Butachlor 1.5 kg/ha Pre-emergence + 1 Hand weeding (30 DAS), Fenoxaprop 60 g/ha (30 DAS) POE, Sesbania (broadcast) + 2, 4-D 0.5 kg/ha (30 DAS), Weedy check and Weed free) in sub plots. Hand weeding was done manually with the help of sovel as per treatment in the weed free check hand weeding was done on 20th, 40th and 60th days after sowing. The recommended dose of fertilizers i.e. 100-60-40 kg N, P_2O_5 and K_2O /ha was applied. Half dose of nitrogen and full dose of Phosphorus and Potassium were applied as basal dose and remaining dose of nitrogen was applied in two equal splits at active tillering and Panicle initiation stages. Herbicides were applied with the help of knapsack sprayer fitted with flat fan nozzle. Data were recorded on weeds and yield of rice crop.

RESULTS

The results revealed that the lowest weed population and weed dry weight were recorded in post monsoon sowing. Among the weed management methods the lowest weed count and weed dry weight were recorded in weed free condition followed by Sesbania (broad cast + 2,4-D 0.5 kg/ha at 30 DAS and Butachlor + One hand weeding. The highest grain yield (49.5 q/ha) was recorded under weed free condition which was at par with butachlor 1.5 kg/ha Pre-emergence + 1hand weeding (4.84 t/ha) and followed by Sesbania (broadcast) + 2,4-D 0.5 kg/ha at 30 DAS. There was no significant effect of time of sowing before or after monsoon on grain yield of rice. The highest net return (Rs. 26460 /ha) was obtained under weed free condition which was at par with Butachlor 1.5 kg/ha Pre-emergence + 1 hand weeding which was followed by Sesbania (broad cast) + 2,4-D 0.5 kg/ha at 30 DAS. Significantly higher net return (Rs. 2280/ha) was recorded under post monsoon sown crop over pre monsoon sown crop. The highest weed control efficiency (76.28%) was recorded by weed free followed by Sesbania (broadcast) + 2, 4-D 0.5 kg/ha at 30 DAS.

Table 1. Effect of time of sowing and weed management practices on weed density, weed biomass, grain yield and economics of direct seeded rice

Treatment	Weed density/m²	Weed biomass (g/m²)	Grain yield (t/ha)	Net return (`/ha)	WCE (%)
Time of sowing					
Before onset of monsoon	6.23 (38.3)	5.83 (33.5)	3.85	18665	-
After onset of monsoon	5.9 (34.8)	5.08 (25.3)	4.26	22280	-
LSD (P=0.05)	0.29	0.41	NS	580	-
Weed control					
Pretilachlor-S 0.5 kg/ha pre-em	6.16 (37.4)	5.74 (32.5)	3.95	19590	28.34
Butachlor 1.5 kg/ha Pre em + 1 hand weeding	4.80 (22.5)	4.51 (19.8)	4.84	2550	43.69
Post em fenoxaprop 60 g/ha	6.39 (40.3)	5.89 (34.2)	4.25	22650	26.47
Sesbania (broadcast) + 2, 4-D 0.5 kg/ha at 30 DAS	4.67 (21.3)	4.43 (19.1)	4.38	23540	44.69
Weedy	8.60 (73.5)	8.01 (63.7)	2.95	12600	-
Weed free	2.21 (4.4)	1.90 (3.1)	4.95	26460	76.28
LSD (P=0.05)	0.52	0.61	0.43	1150	-

CONCLUSION

Sowing after onset of monsoon resulted in comparatively less weed density and weed dry weight. The highest net return (Rs. 26460 /ha) was obtained under weed free condition which was at par with Butachlor 1.5 kg/ha Pre-emergence + 1 hand weeding which was followed by Sesbania (broad cast) + 2, 4-D 0.5 kg/ha at 30 DAS.

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Effect of weed management practices and seed rate on weeds, yield and economics of broadcast-sown rice

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Rice is the main livelihood of rural population in India and is a predominant crop of Chhattisgarh too. Direct seeding of rice is becoming popular in rainfed lowlands, as it is a better and cheaper alternative to transplanted system. But crop weed competition in this system is more severe and hence weed control is a major concern for direct seeded rice. Majority of farmers in the region follow a crop management system called broadcast *biasi* or *bueshening* to control weeds in their field. In traditional broadcast *biasi* method, labour requirement is quite high and peak labour requirement in this method is for weeding operation. It is well established that the *biasi* operation in rice delays its maturity by one week. Thus, timely *biasi* operation and sufficient labour availability and favorable water regimes are the factors that help in production of good rice yield but these conditions are rarely available causing low productivity of rice under broadcast *biasi* method of rice cultivation. The high cost and scarcity of labour at critical weed competition period make herbicides a suitable alternative. With the availability of post emergence herbicide, weed management become easier and timely as a result farmers are now adopting the use of herbicide for weed control in direct seeded rice. So a study to evaluate better weed management practices like application of herbicides and *biasi* operation on direct seeded rice was taken up.

METHODOLOGY

An experiment was conducted during the *kharif* season of 2011 at India Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The soil of the experimental field was clay loam in texture (*alfisols*) locally known as "*Dorsa*" soil. The soil was neutral in reaction. It had low nitrogen (218 kg/ha), medium phosphorus (17.20 kg/ha) and high potassium (311 kg/ha) contents. The experiment was laid out in split plot design and was replicated thrice. There were three main plots and each of these main plots was sub divided into four sub-plots.. Three weed management practices *Biasi* operation + HW, application of post emergence herbicides (fenoxaprop-p-ethyl 60g a.i. ha^{-1} + ethoxysulfuron 15 g/ha) + HW and weedy check were arranged in main plots and four seed rates (60, 80, 100 and 120 kg/ha) in sub plots. *Biasi* is a kind of intercultural operation and partial transplanting in rice for control of weeds. It is an age old practice followed by farmers in direct dry seeded rice. In this method seeds are sown by broadcasting and when crop is about 30-35 days old, it is lightly ploughed by *desi* plough under water impounding condition of the field. '*MTU-1010*', a semi dwarf variety for rice, was used as test crop.

RESULTS

The differences in grain yield due to various treatments were significant (Table 1). Amongst the weed management practices, seed yield was significantly superior in herbicide treatments. This was due to timely control of weeds using herbicide. The seed yield of *biasi* operation was significantly inferior to herbicide treated plots but significantly superior to unweeded check. Straw yield was in accordance to seed yield. Similar result was also reported by Lakpale *et al*. (1999). Seed rate influenced seed and straw yield significantly. Seed rate can be reduced upto 80 kg/ha without sacrificing yield of rice. Higher seed rate however, enhanced straw yield but not grain yield. Interaction amongst the weed management practices and seed rate was significant on grain yield of rice. The maximum grain yield was recorded with 80 kg seed/ha and weed control by using post emergence herbicide. This was followed by 60 kg seed/ha and weed control by using post emergence herbicide. These two treatments were statistically similar and significantly superior over other treatments. Amongst the *biasi* operation, seed yield showed additive trend with increasing seed rate and the maximum seed yield was recorded in 120 kg/ha seed rate. Similar trend was observed in unweeded check. It is well established that *biasi* operation reduced plant population thereby farmers are using higher seed rate but higher seed rate increased the cost of input on one side and scarcity of seed on other side. In *biasi* operation, 80 kg/ha seed rate gave yield statistically on par with 120 kg/ha seed rate. Increasing seed rate beyond 80 kg/ha reduced yield due to low tillering capability and high plant population. Net return was the maximum in weed control using post emergence herbicide in broadcasted rice. Application of herbicide increased the net return by 64% when herbicide was applied in place of *biasi* operation in traditional broadcast *biasi* system and 200% over unweeded check. Benefit cost ratio was highest in herbicide treated plot. Lowest ratio was recorded in broadcast seeding unweeded check followed by *biasi* operation. The findings are in accordance to the results reported by Ali *et al.* (2006).

Table 1. Effect of weed management practices and seed rate on weed control, yield and economics of broadcast seeded rice

Treatment	Weed control efficiency (%)	Grain yield (q/ha)	Straw yield (q/ha)	Cost of cultivation (`/ha)	Net return (`/ha)	B:C ratio
Weed management						
*Bias*i operation	84.39	33.61	37.37	23486	16840	0.72
Herbicide	88.84	39.44	46.65	19674	27653	1.41
Un-weeded check	0.00	21.97	33.64	17132	9228	0.54
LSD (P=0.05)	-	4.04	5.63	-	-	-
Seed rate (kg/ha)						
60	57.22	29.33	36.93	19639	15552	0.80
80	58.18	32.62	38.00	19945	19196	0.95
100	56.97	32.08	40.46	20251	18244	0.90
120	58.59	32.66	41.51	20557	18637	0.91
LSD (P=0.05)	-	2.64	2.91	-	-	-
Interaction (W*S)	-	4.57	NS	-	-	-

CONCLUSION

Use of 80 kg/ha seed rate and application of post emergence herbicide (Fenoxaprop-p-ethyl 60 g/ha + Ethoxysulfuron 15 g/ha) was superior in controlling weeds, giving higher grain yield and resulting in higher net income and more benefit cost ratio.

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Motorized and chemical weed management in direct-seeded rice

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Herbicides are very effective in controlling weeds in direct seeded rice. However, their continuous use has been found to be unsafe for crop and environment. Keeping above in view, ~~s~~ a trial was conducted to study the possibilities on integration of motorized, chemical and manual methods of weeding and its economic viability in direct seeded rice.

METHODOLGY

A field experiment was carried out at Indira Gandhi Krishi Vishwavidyalaya, Raipur during rainy seasons of 2013 and 2014**,** in collaboration with IRRI, Philippines. The experimental soil was inceptisols, low in organic carbon, available nitrogen, medium in phosphorus and high in potassium with neutral soil reaction. Nine treatments comprised of either herbicides alone or different combinations of herbicides and motorized weeding including one standard check untreated control. The experiment was laid out in randomized block design replicated thrice. The gross plot size was 5 m x 5 m. Medium duration rice cultivar *MTU-1010* was taken as test crop. Recommended dose and splits of fertilizer i.e. 100:50:30 kg/ha N:P:K were applied.

RESUTLS

Experimental field was dominated by broad leaf weeds and sedges including *Alternanthera traiandra*, *Cynotis axillaris* and *Cyperus iria* whereas, *Echinochloa colona* was the dominating weed among grasses. Significantly lower weed dry matter was recorded under azimsulfuron at 35 g/ha at 2-3 leaf stage (14 DAS) *fb* bispyribac Na at 20 g/ha (30 DAS) as compared to weedy check. Weed control efficiency also showed a similar trend. Seed yield varied significantly due to different weed management practices. Significantly higher seed yield was recorded under azimsulfuron at 35 g/ha at 2-3 leaf stage (12-18 DAS) *fb* bispyribac Na at 20 g/ha at 30 DAS as compared to weedy check, but it was at par with rest of the treatments except motorized weeding thrice at 15, 25 and 35 DAS, motorized weeding twice at 15 and 25 DAS *fb* bispyribac Na at 25 g/ha at 35 DAS and bispyribac Na alone at 25 g/ha at 35 DAS, in order. Yadav *et al.* (2011) have also reported similar results. The highest reduction in seed yield was recorded under weedy check. The gross income, net income and benefit: cost ratio were the highest under azimsulfuron at 35 g/ha at 14 DAS *fb* bispyribac Na at 20 g/ha at 30-35 DAS followed by bispyribac Na at 20 g/ha at 18 DAS *fb* pretilachlor + bensulfuron at 660 g/ ha along with first top dressing of nitrogen.

CONCLUSION

Significantly lower weed dry matter and higher seed yield were recorded under azimsulfuron at 35 g/ha at 2-3 leaf stage (12-18 DAS) *fb* bispyribac Na at 20 g/ha at 30 DAS as compared to weedy check. The benefit: cost ratio was highest under bispyribac NA at 20 g/ha at 18 DAS *fb* pretilachlor + bensulfuron at 660 g/ha along with first top dressing of nitrogen.

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Long-term effects of weed management on productivity of rice-wheat cropping system in subtropical foothill plains of Jammu

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Rice (*Oryza sativa* L.) and Wheat (*Triticum aestivum* L.) are the major staple food crops of the world. Globally, they have been recognized as an integral and indispensable part of agricultural production systems. Rice in India cultivated over an area of 43.46 mha with production and productivity of 101.8 mt and 3.36 t/ha, respectively (Anonymous 2013a). Wheat due to its wide spread cultivation in tropics regions of the world, it is cultivated over an area of 29.25 mha in the India with production and productivity of 92.30 million tones and 2.93 t/ha, respectively (Anonymous 2013b). The low productivity of Rice-Wheat cropping system by and large can be attributed to several limiting factor and all but most important among these has been the poor weed management which poses a major threat to crop productivity. Timely weeding is a most important to minimize the loss in yield and management of weeds through the use of herbicides has also been found as effective.

METHODOLOGY

A field experiment was conducted to study the effect of herbicidal weed management in sub tropical irrigated Rice-Wheat in Jammu at research farm of division of agronomy, main campus chatha SKUAST-J during the *Kharif* and *Rabi* season of 2013-14. The soil of the experimental site was sandy clay loam in texture, low in organic carbon and nitrogen, medium in available phosphorous and potassium. The experiment was laid out in split-plot design during both in kharif and *Rabi* season with three replication and 20 plots. The treatments were comprised of weedy check, mechanical weeding-2, butachlor 1.5 kg/ha, anilophos 0.5 kg/ha as in main plot in rice where as the sub plot treatments included weedy check, mechanical weeding-2, isoproturon 1.0kg/ha, isoproturon 1.0 kg/ha, isoproturon 0.75 kg/ha tank mix 1.0% urea, isoproturon 0.75 kg/ha mix 0.1 percent surfactant/ adjuvant in wheat crop. The varieties of *Kharif* rice is Basmati-370 and wheat RSP-561 respectively were used.

RESULTS

Amongst the weed control treatments in rice, the lowest weed population of 5.32 was recorded where application of Butachlor at 1.5 kg/ha was made, followed by two mechanical weeding (MW at 30 and 60 DAT). Almost a similar trend was also observed with respect to weed dry matter accumulation in rice. Highest rice grain yield was observed to the tune of 3.38 t/ha with herbicidal application of Butachlor at 1.5 kg/ha followed by two mechanical weedings (MW at 30 and 60 DAS). In wheat crop grown during rabi 2013-2014, weed population, dry weight of weeds and grain yield of wheat were not significantly influenced by weed control measures taken up in previous year rice crop. However, weed control measures in wheat showed significant variations in weed population, dry weed weight and grain yield of wheat. Significantly highest grain yield of 3.79 t/ha was recorded in the treatment with Isoproturon at 1.0 kg/ha and was at par with the treatments where 0.75 kg Isoproturon + 1.0% tank mix urea or 0.1% surfactant were applied. However, lowest grain yield of wheat was recorded in case of weedy check treatment. Application of Isoproturon at 1.0 kg/ha in wheat also proved itself superior to all other weed management treatments with respect to suppression of weed population recording significantly lowest weed count at 60 days after sowing. Almost a similar trend was observed with respect to dry matter production of weeds in wheat at 60 DAS.

Table 1. Weed count, dry weight and grain yield of rice in rice-wheat system as influenced by different weed control treatments

Treatment	Weed count at 60 DAT (no/m^2)	Weed dry wt. at 60 DAT (g/m^2)	Grain yield (kg/ha)	Weed control efficiency (%)
Weedy check	10.52 (110.70)	38.40	1996	0.0
Mechanical weeding (2)	6.59 (43.50)	14.78	3028	61.51
Butachlor at 1.5 kg/ha	5.32 (28.40)	8.40	3389	78.12
Anilophos at 0.5 kg/ha	6.77 (45.90)	16.80	2789	56.25

Table 2. Weed count, dry weight and grain yield of wheat in rice-wheat system as influence by different weed control treatments

Treatment	Weed count at 60 DAS (no//m^2)	Weed dry wt 60 DAS (g/m^2)	Grain yield (kg/ha)	Weed control efficiency (%)
Weed management in rice				
Weedy check	7.02 (48.34)	14.51	3354.00	0.0
Mechanical weeding	6.87 (44.89)	13.11	3366.00	9.65
Butachlor @ 1.5 kg/ha	6.27 (38.40)	12.90	3397.00	11.09
Anilophos @ 0.5 kg/ha	6.38 (39.70)	12.78	3361.33	11.92
LSD (P=0.05)	NS	NS	NS	-
Weed management in wheat				
Weedy check	11.51 (131.4)	35.13	2021.33	0.0
Mechanical weedings (two)	5.93 (34.15)	9.85	3457.58	71.96
Isoproturon @ 1 kg/ha	5.00 (24.03)	5.39	3791.67	84.66
Isoproturon 0.75 kg + urea 1% tank mix	5.21 (26.18)	7.50	3789.08	78.65
Isoproturon 0.75 kg + surfactant 0.1%	5.45 (29.67)	9.01	3788.75	74.35
LSD (P=0.05)	0.26	2.13	277.67	-

CONCLUSION

Based on these results it is concluded that Rice crop was well established under application of Butachlor at 1.5 kg/ha was applied followed by two mechanical weeding (MW at 30 and 60 DAT) and in wheat isoproturon at 1.0 kg/ha was recorded highest grain and was at par with the treatments 0.75 kg Isoproturon + 1% tank mix urea or 0.1% surfactant.

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Effect of time of planting and weed management in direct-seeded aromatic rice in foot hills of Jammu and Kashmir Himalayas

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Rice (*Oryza sativa* L.) is the important staple food crop of India which provide food security to about 77% of the country's population. Out of 42.2 mha of rice area in the country basmati or aromatic rice is cultivated over an area of about 7.76 mha with production of about 6.5 mt and achieves an export of about 11.96 mt (Anonymous 2013). Basmati rice being a relatively long duration crop needs early establishment to avoid stress periods which lead to lodging and lower seed setting. Direct dry drilling can be an option for early establishment of rice crop in the months of June or July instead of transplanting in August that will enable the crop to avoid transplanting shock and may lead to strudy stem. The low productivity of basmati rice-wheat system can be attributed to several limiting factors and all but one important factor amongst those has been the poor weed management. It becomes more relevant under direct seeding rice culture where owing to upland conditions weeds achieve an advantageous position. For controlling weeds in basmati rice in Jammu region, a number of pre and post emergence herbicides have already found their place in cultivation package of rice however; continuous use of some of the herbicides may result in development of herbicidal resistance in weeds over the time. Hence the present investigation was undertaken.

METHODOLOGY

A field experiment was conducted at agricultural research farm, SKUAST-J, during *Kharif* seasons of 2012 in split- plot design replicated thrice. The main plot treatments consisted of two times of planting viz 15th June and 10th July and sub plots comprised of seven weed management treatments viz weedy check, weed free, azimsulfuron at 35 g/ha at 20 DAS, cyhalofop- butyl + 2,4-D at 90 g/ha + 0.5 kg/ha at 30 DAS, bispyribac at 30 g/ha at 30 DAS , anilophos + ethoxysulfuron at 0.375 + 0.015 kg/ha at 15 DAS and pre-emergence oxadiargyl at 100 g/ha. Basmati rice variety" Basmati 370" was direct seeded as per main plot treatments. The crop was fertilized with 30 kg N, 20 kg P_2O_5 and 10 kg K_2O/ha through urea, diammonium phosphate and muriate of potash respectively. Data on weed count, weed dry weight, yield and economics were recorded.

RESULTS

The experimental field was mainly infested by *Echinochloa crusgalli, Cyanodon dactylon, Commelina benghalensis, Cyperus rotundus, Cyperus difformis* and *Ammania baccifera*. Times of planting and weed management treatments significantly reduced the total weed count and dry matter of weeds at 60 DAS. As regards the yield of crop statistically non-significant results were obtained with respect to time of planting treatments. Post-emergence application of cyhalofop-butyl + 2,4-D at 90 g/ha + 0.5 kg/ha at 30 DAS followed by treatments bispyribac at 30 g/ha and anilophos + ethoxysulfuron at 0.375 + 0.015 kg/ha significantly reduced the weed density, weed biomass and resulted in 77.2, 66.0 and 58.1% higher grain yield. These results are in conformity with the findings of Choubey *et al.* (2001). The B:C ratio was found maximum with cyhalofop-butyl + 2,4-D at 90 g/ha + 0.5 kg/ha, bispyribac post-emergence at 30 g/ha and anilophos + ethoxysulfuron post-emergence at 0.375 + 0.015 kg/ha .

Table 1. Effect of time of planting and differential weed management treatments on weed growth, yield and B: C ratio in rice

Treatment	Weed count (no./m^2)	Weed dry weight (g/m^2)	Grain yield (t/ha)	Weed control efficiency (%)	B:C ratio
Time of planting					
15th June	10.92 (118.3)	9.98 (98.8)	19.02	-	1.61
10th July	12.32 (150.8)	11.38 (128.6)	18.03	-	1.48
LSD (P=0.05)	1.23	0.52	NS	-	
Weed management					
Azimsulfuron @35g/ha	9.88 (96.7)	9.29 (85.4)	1.61	58.36	1.78
Cyhalofop-butyl + 2,4-D @ 90 g/ha + 0.5 kg/ha	8.23 (66.7)	7.43 (54.3)	2.11	73.52	2.66
Bispyribac @30 g/ha	8.37 (69.2)	7.71 (58.5)	1.97	71.47	2.56
Anilophos + ethoxysulfuron @ 0.375 + 0.015 g/ha	8.59 (72.1)	7.86 (60.9)	1.88	70.31	2.33
Oxadiargyl @ 100g/ha	9.90 (97.2)	9.32 (85.9)	1.51	58.12	1.77
Weedy check	17.29 (258.1)	14.35 (205.1)	1.192	0.00	1.34
Weed free	1 (0.00)	1 (0.00)	2.51	100	2.82
LSD (P=0.05)	0.43	0.39	0.26	-	-

*Figures in parenthesis are original values subject to "x+1 square root transformations

CONCLUSION

It can be concluded that post-emergence application of cyhalofop-butyl + 2,4-D was found effective in controlling mixed weed flora irrespective of of whether rice is sown on 15th June and 10th July.

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Bio-efficacy of triasulfuron against weeds in transplanted rice

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Rice (*Oryza sativa* L.) is important staple food crop grown extensively in India. Weed competition is one of the major factors responsible for low yield of transplanted rice. Competition offered by infestation of heterogeneous weed flora becomes the biggest biological constraint and yield losses in transplanted rice had been reported to be 28-45% due to uncontrolled weeds (Singh *et al.* 2003, Bali *et al.* 2006). It has been observed that whenever there is effective control of grasses, broad leaved weeds and sedges emerge in high density competing with the crop, resulting in heavy yield losses (Singh *et al.* 2004). Therefore, there is necessity of herbicides to control all types of weeds. Keeping these points in view, a field experiment was conducted to evaluate bio-efficacy of Triasulfuron against weeds in transplanted rice.

METHODOLOGY

A field experiment was conducted during *Kharif* 2014 at Research farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha to evaluate the effect of Triasulfuron on diverse weed flora and yield of transplanted rice. The experiment was laid out in Randomized Block Design with seven treatments including weed free and weedy check and replicated four times. The soil of the experimental site was low in nitrogen, medium in phosphorus and potassium. The Basmati rice variety '*Basmati-564*' was transplanted at a spacing of 20 cm x 15 cm and recommended package of practices were followed to raise the crop. All the herbicides were applied at standard time of their application by using a knapsack sprayer fitted with flood jet nozzle with spray volume of 500 liters water/ha. The weed count and weed dry matter accumulation was recorded at 60 days after transplanting by quadrate method.

RESULTS

The data revealed that weeds caused 47% reduction in grain yield of transplanted rice. The important weed flora in the experimental field were *Echinochloa* spp., among grasses; *Ammania baccifera*, *Caesulia axillaris*, *Commelina benghalensis* and *Eclipta alba* among broad leaved weeds; *Cyperus rotundus*, and *C. iria* among sedges. Other weeds species with very low density were *Alternanthera* spp., and *Leptochloa chinensis*. All the weed control treatments recorded significantly lower weed density and dry matter of weeds over weedy check. Among the herbicides, the lowest weed density and dry weight were found with application of Triasulfuron at 12 g/ha as post emergence which was at par with Ethoxysulfuron at 15 g/ha and Triasulfuron at 10 g/ha. The highest weed control efficiency was recorded with Triasulfuron at 12 g/ha which was followed by Triasulfuron at 10 g/ha. The maximum grain yield of rice was recorded in weeds free treatment. Among the herbicides, the highest grain yield of rice was obtained with application of Triasulfuron at 12 g/ha as post emergence which was significantly higher than weedy check and Triasulfuron at 8 g/ha.

Table 1. Weed density, weed dry weight, weed control efficiency, and grain yield of rice as influenced by treatments

Treatment	Weed density/m^2 at 60 DAA*	Weed dry weight at 60 DAA (g/ha)	Weed control efficiency (%)	Grain yield (t/ha)
Weedy check	11.81(139)	12.75 (162)	-	1.81
Triasulfuron @ 8 g/ha	9.30 (83)	11.24 (125)	22.84	2.59
Triasulfuron @ 10 g/ha	7.41 (54)	9.72 (94)	41.98	2.98
Triasulfuron @ 12 g/ha	7.16 (50)	9.45 (87)	46.30	3.03
Metsulfuron methyl @ 4 g/ha	8.17 (66)	10.65 (113)	30.25	2.85
Ethoxysulfuron @ 15 g/ha	7.31 (53)	10.10 (101)	37.65	2.92
Weed free	1.00 (0)	1.00 (0.0)	-	3.39
SEm±	0.12	0.22	-	0.11
LSD (P=0.005)	0.34	0.66	-	0.32

Figures in parentheses are original values. Data subjected to subject to "x+1 square root transformations; DAA=Days after application

CONCLUSION

Triasulfuron at 10 or 12 g/ha can control weeds in transplanted rice effectively resulting in higher weed control efficiency and higher grain yields.

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Efficacy of different herbicides against weed flora in dibbled rice under coastal environment of Konkan

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Rice is grown either by direct seeding or by transplanting. In *Konkan* rice is mostly grown by transplanting method. However, there are some pockets, where drilled, dibbled rice is also practiced. Direct seeded rice has become increasing important in cultivation due to scarcity of farm labour and higher water requirement and higher production cost of transplanted rice. Direct seeded rice needs only 34% of the total labour requirement and saves 27% of the total cost of transplanted crop. (Mishra and Singh 2011) The direct seeded rice culture is subjected to grater weed competition than transplanted rice because both weed and crop emerge same time and compete with each other from its germination resulting in loss in grain yield a weed free period for the first 30-40 DAS is required. Herbicides are more efficient in timely control of weeds in direct seeded rice. Keeping this in view, the present experiment was undertaken to evaluate the pre-emergence and post-emergence herbicides either alone or in combination for effective weed control.

METHODOLOGY

An experiment was undertaken at the ASPEE, Agricultural Research and Development Foundation Experimental Farm Nare, Dist. Thane during *Kharif*, 2013. The trial was laid out in a randomized block design. There were 16 treatments which were replicated thrice. The treatments mainly comprised of single herbicides, pre and post-emergence combination or herbicides mixture. Thus, the gross plot size was 3.75 m x 3.00 m and net plot size was 3.45 m x 2.60 m, respectively. The seeds of variety '*Karjat-3*' were sown by dibbling method at distance 20 cm x 15 cm.

RESULTS

The most dominant weed species found in the experimental field throughout the crop growth in rice were; *Echinochloa colona*, *Ischamum globosa*, *Elusine indica*, Cyperus spp., *Commelina banghalensis*, *Alternanthera sessilis and Ludwigia octovalvis*. The herbicidal treatments significantly influenced population and dry matter production of weeds. Among the herbicidal treatments, lowest density of weeds both monocots (0.00/0.25 m^2) as well as dicots (0.33/ 0.25 m^2) was observed under Oxyfluorfen + 2,4-D at 300 + 500 g/ha at 0-4 DAS *fb* 30 DAS, followed by Two hand weedings at 20 and 40 DAS (0.67 and 0.00/0.25 m^2). In respect of dry weight of weeds Oxyfluorfen + 2,4- D at 300 + 500 g/ha at 0-4 DAS *fb* 30 DAS registered significantly the lowest total dry weight of weeds followed by treatment Two hand weedings at 20 and 40 DAS. Further, all the weed control treatments were significantly superior over weedy check.

Among the different weed control treatments, weed control efficiency was highest (86.38%) with oxyfluorfen PE *fb* 2,4-D PoE followed by Pretilachor-s PE *fb* [Fenoxaprop p-ethyl + (CmE + MsM)] PoE (84.72%) and two hand weedings at 20 and 40 DAS (84.3%). This clearly indicated that weeds were controlled effectively under treatment Oxyfluorfen + 2,4-D at 300 + 500 g/ha at 0-4 DAS *fb* 30 DAS.

Table 1. Effect of different weed control treatments on weed density, total dry matter and weed control efficiency at harvest

Treatment	Weed density (no./0.25 m^2)		Total dry weight of weeds (q/ha)	Weed control efficiency (%)
	Monocots	Dicots		
Pyrazosulfuron @ 25 g/ha at 3-7 DAS	4.33 (2.20)	8.67 (2.98)	25.79	40.17
Pretilachlor-s @ 750 g/ha at 0-5 DAS	3.33 (1.93)	8.33 (2.96)	23.98	44.38
Cyhalo butyl @ 90 g/ha at 25 DAS	3.33 (1.95)	3.60 (2.03)	20.50	52.44
Fenoxa p-ethyl @ 60 g/ha at 30 DAS	2.00 (1.48)	3.67 (1.97)	21.47	50.19
Cyhalo + (CmE + MsM) @ 90+ 4 g/ha at 25-30 DAS	2.33 (1.68)	1.00 (1.22)	15.59	63.84
Fenoxa p-ethyl + (CmE + MsM) @ 60+4 g/ha at 25-30 DAS	1.33 (1.27)	1.00 (1.17)	13.29	69.18
Pyrazosulfuron @ 25 g/ha + [Cyhalo + (CmE + MsM)] @ 90+ 4 g/ha at 3-7 DAS *fb* 25-30 DAS	2.00 (1.52)	1.00 (0.17)	10.76	75.03
Pyrazosulfuron @ 25 g/ha + [Fenoxa p ethyl +(CmE + MsM)] @ 60+ 4 g/ha at 3-7 DAS *fb* 25 30 DAS	0.67 (1.00)	0.67 (1.05)	7.81	81.88
Pretilachlor-s @ 750 g/ha + [Cyhalo + (CmE + MsM)] @ 90+ 4 g/ha at 0-3 DAS *fb* 25-30 DAS	0.67 (1.05)	1.33 (1.27)	7.98	81.48
Pretilachlor-s @ 750 g/ha + [Fenoxa p-ethyl + (CmE + MsM)] @ 60+4 g/ha at 0-3 DAS *fb* 25-30 DAS	0.33 (0.88)	1.00 (1.17)	6.59	84.72
Azimsulfuron @ 35 g/ha at 20 DAS	4.00 (2.11)	3.67 (2.03)	21.03	51.23
Bispyribac- Na @ 25 g/ha at 20 DAS	2.00 (1.56)	2.00 (1.56)	16.88	60.86
Fenoxa p-ethyl + Ethoxysulfuron @ 60 +15 g/ha at 25-30 DAS	3.33 (1.95)	2.30 (1.64)	13.79	68.00
Oxyfluorfen + 2,4- D @ 300 + 500 g/ha at 0-4 DAS fb 30 DAS	0.00 (0.71)	0.33 (0.88)	5.87	86.38
Two hand weeding at 20 and 40 DAS	0.67 (1.05)	0.00 (0.71)	6.77	84.29
Weedy check	7.67 (2.84)	11.0 (3.33)	43.11	0.00
LSD (P=0.05)	0.52	0.61	3.60	-

CONCLUSION

On the basis of results obtained during study, it can be concluded that the herbicides used in pre and post emergence combination gives better results as compared their single use. Use of oxyfluorfen + 2,4-D at 300 + 500 g/ha at 0-4 DAS *fb* 30 DAS was the most effective treatment followed by of two hand weedings at 20 and 40 DAS to control weeds effectively in dibbled rice during *Kharif* season

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Effect of herbicides on yield and economics of dibbled rice under coastal environment of Konkan

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Rice is grown either by direct seeding or by transplanting. In *Konkan*, rice is mostly grown by transplanting method. However, there are some pockets, where drilled, dibbled rice is also practiced. Area under direct seeded rice is increasing due to scarcity of farm labour and higher water requirement and higher production cost of transplanted rice. Direct seeded rice needs only 34% of the total labour requirement and saves 27% of the total cost of transplanted crop (Mishra and Singh 2011). The direct seeded rice culture is subjected to greater weed competition than transplanted rice because both weed and crop emerge at the same time and compete with each other from germination resulting in loss in grain yield. A weed free period for the first 30-40 DAS is required. Herbicides are more efficient in timely control of weeds in direct seeded rice. Keeping this in view, the present experiment was undertaken to evaluate pre-emergence and post-emergence herbicides either alone or in combination for effective weed control.

METHODOLOGY

The experiment was conducted at the ASPEE, Agricultural Research and Development Foundation Farm, Nare, Dist. Thane (M.S.) during *Kharif* 2013. The field experiment was laid out in randomized block design comprising of sixteen treatments replicated three times. The soil of the experimental plot was clay in texture, medium in available nitrogen (282.00 kg/ha) and phosphorus (13.80 kg/ha), moderately high in available potassium (276.22 kg/ha), medium in organic carbon (9.7 g/kg) and alkaline in reaction (pH 7.81). The sowing (*Karjat-3*) was done in the experimental area by dibbling at a distance of 15 cm in between the plants and 20 cm in between the rows.

Table 1. Effect of treatments on grain yield, straw yield and economics of dibbled rice

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (`/ha)	Net income (` /ha)	B:C ratio
Pyrazosulfuron ethyl @ 25 g/ha at 3-7 DAS	37.92	43.30	58195.6	143.9	1.00
Pretilachlor-s @ 750 g/ha at 0-5 DAS	38.49	44.26	61585.9	-2309.3	0.96
Cyhalofop butyl @ 90 g/ha at 25 DAS	37.77	43.06	57833.1	263.3	1.00
Fenoxaprop p-ethyl @ 60 g/ha at 30 DAS	36.81	43.43	57920.4	-1015.4	0.98
Cyhalofop + (CmE + MsM) @ 90+ 4 g/ha at 25-30 DAS	41.23	49.48	59293.0	4613.5	1.08
Fenoxaprop p-ethyl + (CmE + MsM) @ 60+4 g/ha at 25-30 DAS	41.33	49.18	59590.0	4383.5	1.07
Pyrazosulfuron @ 25 g/ha + [Cyhalo + (CmE + MsM)] @ 90+ 4 g/ha at 3-7 DAS fb 25-30 DAS	45.16	49.67	61677.0	7414.5	1.12
Pyrazosulfuron @ 25 g/ha + [Fenoxa p ethyl+(CmE + MsM)] @ 60+ 4 g/ha at 3-7 DAS fb 25 30 DAS	45.15	50.57	61991.1	7269.7	1.12
Pretilachlor-s @ 750 g/ha + [Cyhalo + (CmE + MsM)] @90+ 4 g/ha at 0-3 DAS fb 25-30 DAS	45.23	50.73	64962.6	4438.4	1.07
Pretilachlor-s @ 750 g/ha + [Fenoxa p-ethyl + (CmE + MsM)] @ 60+4 g/ha at 0-3 DAS fb 25-30 DAS	46.04	51.11	65437.8	5099.0	1.08
Azimsulfuron @ 35 g/ha at 20 DAS	41.42	50.53	58379.8	5980.3	1.10
Bispyribac-Na @ 25 g/ha at 20 DAS	41.94	48.91	60460.6	4261.6	1.07
Fenoxaprop p-ethyl + Ethoxysulfuron @ 60 +15 g/ha at 25-30 DAS	43.70	50.52	60287.7	7064.8	1.12
Oxyfluorfen + 2,4- D @ 300 + 500 g/ha at 0-4 DAS fb 30 DAS	50.01	56.02	63858.5	12864.2	1.20
Two hand weedings at 20 and 40 DAS	47.12	52.30	63729.7	8457.4	1.13
Weedy check	19.55	23.46	52002.1	-21704.8	0.58
LSD (P=0.05)	5.12	5.93	-	-	-

RESULTS

All the herbicide treatments resulted in significant increase in grain yield compared to weedy check. The highest grain and straw yield was observed under the plots sprayed with Oxyfluorfen + 2,4-D at 300 + 500 g/ha at 0-4 DAS fb 30 DAS (5.0 and 5.6 t/ha respectively) followed by two hand weedings at 20 and 40 DAS (4.7 and 5.2 t/ha respectively). The grain and straw yield in weedy check (1.9 and 2.3 t/ha respectively) was significantly lower than other weed control treatments.

Among the different weed control treatments, Oxyfluorfen + 2,4- D at 300 + 500 g/ha at 0-4 DAS fb 30 DAS was highly remunerative and gave the highest net profit of Rs 12864 /ha followed by the treatment, two hand weedings at 20 and 40 DAS (Rs 8457 /ha). Also, the highest B:C ratio (1.20) was obtained for oxyfluorfen + 2,4- D at 300 + 500 g/ha at 0-4 DAS *fb* 30 DAS followed by two hand weedings at 20 and 40 DAS (1.13).

CONCLUSION

Use of oxyfluorfen + 2,4- D at 300 + 500 g ha/ha at 0-4 DAS *fb* 30 DAS was the most effective and economical treatment to control weeds in dibbled rice.

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Influence of weed management practices on nutrient uptake and productivity of rice under different methods of crop establishment

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Rice (*Oryza sativa* L.) is one of the most important cereal crops as it is the staple food of more than 70% of the world's population. The method of establishment in rice largely affects the initial stand and uniformity. Although, transplanting in rice is considered as best for higher productivity of crop, it is not much profitable due to higher labour wages and problem of unavailability of labour during the peak period of operation. Some alternatives such as SRI and direct sowing of sprouted seeds under puddled condition are suggested to overcome these problems. In the absence of effective control measures, weeds remove considerable quantity of applied nutrients resulting in a significant yield loss. Weeds cause substantial losses in yield through production of growth inhibiting compounds - a phenomenon referred as allelopathy (Yaduraju *et al*. 2005). Hence, the present experiment was conducted to find out an efficient weed management practice in relation to crop establishment methods.

METHODOLOGY

An experiment was conducted during *kharif* seasons of 2010 and 2011 at College Farm, College of Agriculture, Acharya N.G. Ranga Agricultural University, Hyderabad. The soil was sandy loam with a pH of 7.8. The available N, P and K content in the soil was 234.5, 28.9 and 271.6 kg/ha respectively. The main treatments comprised of three crop establishment methods, *viz*. SRI, Direct sowing of sprouted seeds under puddled condition and transplanting, and four weed management practices in sub plots : bensulfuron-methyl 60 g + pretilachlor 600 g/ha applied on 3 DAS/T *fb* mechanical weeding at 30 DAS/T, bispyribac sodium at 25 g/ha as early post emergence at 15 DAS/T, famer's practice (hand weeding twice at 20 and 40 DAS in direct seeded rice and transplanted rice, conoweeding thrice with 10 days interval from 20 DAT in SRI) and weedy check. The experiment was laid out in split plot design with three replications. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O /ha. Half dose of N (60 kg) and full dose of phosphorus (60 kg/ha) and potassium (40 kg/ha) was applied as basal before sowing. The remaining half nitrogen (60 kg/ha) was top dressed in two equal splits at tillering and panicle initiation stages. Rice variety MTU1010 was sown.

RESULTS

Grain yield of rice was influenced significantly by rice establishment methods and weed management practices. Transplanting method recorded significantly higher grain yield (4.40 and 4.59 t/ha) and it was on par with SRI (4.26 and 4.43 t/ha) and both registered significantly superior grain yield over direct seeded rice (3.89 and 4.07 t/ha) under puddled condition. Among weed management practices, higher grain yield (5.60 and 5.85 t/ha) was recorded in S_3 *i.e.* farmer's practice (two hand weedings at 20 and 40 DAS in direct seeded rice and transplanted rice and cono weeding in SRI) was at par with bensulfuron methyl 60 g + pretilachlor 600 g/ha *fb* mechanical weeding at 30 DAS/T (5326 and 5585 kg/ha) and in turn these two treatments were significantly superior over other treatments during both the years. Saha and Rao *et al.* (2010) and Sunil *et al.* (2010) reported similar type of findings in their study. Significant interaction was not found between rice establishment methods and weed management practices. The same trend was observed with nutrient uptake by rice grain.

Table 1. Nutrient uptake by rice grain (kg/ha) at harvest as influenced by rice crop establishment methods and weed management practices

Treatment	Grain yield (kg/ha)		N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
Planting method	2010	2011	2010	2011	2010	2011	2010	2011
M_1 – SRI	4265	4438	59.96	62.38	11.96	12.44	11.48	11.96
M_2 – Direct sown rice	3894	4075	54.27	56.77	10.19	10.66	10.01	10.48
M_3 – Transplanting	4408	4593	62.84	65.44	12.40	12.92	12.13	12.65
SEm±	91	90	1.42	1.44	0.33	0.33	0.32	0.35
LSD (P=0.05)	356	354	5.59	5.66	1.28	1.29	1.26	1.37
Weed control								
S_1 – Bensulfuron methyl+ pretilachlor *fb* mechanical weeding at 30 DAS/T	5326	5585	75.92	79.60	15.10	15.83	14.82	15.55
S_2 – Bispyribac sodium	3975	4158	55.21	57.74	10.37	10.84	10.20	10.67
S_3 – Farmer's practice	5601	5857	80.35	83.96	16.07	16.79	15.51	16.21
S_4 – Weedy check	1854	1874	24.62	24.82	4.53	4.56	4.31	4.36
SEm±	95	107	1.47	1.54	0.37	0.33	0.26	0.31
LSD (P=0.05)	283	318	4.37	4.58	1.10	0.98	0.78	0.91

The nitrogen, phosphorus and potassium uptake by rice in transplanting method and SRI was significantly higher compared to direct seeded rice (sprouted seeds) under puddled condition (54.27 and 56.77 N kg/ha 10.19 and 10.66 P kg/ha and 10.01 and 10.48 K kg/ha, respectively) and it was due to decreased weed competition in transplanted rice, which might have augmented the uptake of applied nutrients as well as soil nutrients.

Among weed management practices, farmer's practice recorded significantly higher uptake of nitrogen (80.35 and 83.96 kg/ha) phosphorus (16.07 and 16.79 kg/ha) and potassium (15.51 and 16.21 kg/ha). This was at par with bensulfuron-methyl, 60 g + pretilachlor, 600 g/ha *fb* mechanical weeding at 30 DAS/T (75.92 and 79.60 N kg/ha; 15.10 and 15.83 P kg/ha and 14.82 and 15.55 kg/ha) and in turn was significantly superior over other treatments during both the years. Higher nutrient uptake is due to better control of weeds leading to lower depletion of nutrients by weeds and higher nutrient uptake by rice. The results are in conformity with the findings of Sanjay (2006).

CONCLUSION

Transplanting method of establishment resulted in significantly higher grain yield and it was comparable with SRI and among weed management practices, farmer's practice of weeding recorded significantly higher grain yield of rice and it was on par with bensulfuron-methyl 60 g + pretilachlor 600 g/ ha *fb* mechanical weeding at 30 DAS/T.

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Management of complex weed flora in direct-seeded rice

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Weeds are the most serious biological constraints in direct seeded rice, because, their emergence coincides with the seedlings and they compete for moisture, nutrients, light and space and as a consequence, weed infestation in direct seeded rice results in yield losses to the tune of 30-90%. Rice grain production in India suffers a yearly loss of 15 mt due to weed competition (Kathiresan 2002). Keeping above constraints in view, combinations of pre and post emergence herbicides have been tried with the objectives of studying the bio-efficiency of combination of herbicides against weed complex and their effect on growth and yield of direct-seeded rice.

METHODOLOGY

Field experiments were carried out at Indira Gandhi Krishi Vishwavidyalaya, Raipur during rainy seasons of 2012 and 2013. The experimental soil was inceptisol low in organic carbon, available nitrogen, medium in phosphorus and high in potassium with neutral soil reaction. Ten treatments included either herbicides alone or in different combinations as well as two standard checks, *viz*. hand weeding and untreated control. The experiment was laid out in randomized block design replicated thrice. The gross plot size was 5 m x 5 m. Medium duration rice cultivar MTU 1010 was taken as test crop. Recommended dose and splits of fertilizer *i.e.* 100:50:30 kg/ha $N:P_2O_5:K_2O$ were applied.

RESULTS

Weed flora of the experimental field consisted of *Echinochloa colona* among grasses, *Cyperus iria* among sedges and *Alternanthera triandra, Spilanthes acmella, Cynotis axillaris* among broad leaf weeds. Significantly lower dry matter was recorded under pendimethalin *fb* bispyribac–Na at 1000 g/ha *fb* manual weeding 45 DAS but it was statistically at par with weed free (hand weeding at 20, 40 and 60 DAS). However, at harvest the lowest weed dry matter was recorded under pendimethalin *fb* bispyribac–Na at 1000 g/ha *fb* manual weeding 45 DAS which was statistically at par with weed free (hand weeding at 20, 40 and 60 DAS). Significantly higher grain yield was recorded under pendimethalin *fb* bispyribac Na at 1000/25 g/ha *fb* manual weeding 45 DAS, however, it was statistically at par with rest of the treatments except bispyribac–Na at 25 g/ha applied alone as post emergence. The highest reduction in seed yield was to the tune of 82% in weedy check. This might be due to timely and effective control of weeds with combination of pre and post emergence herbicides. Walia *et al*. (2008) and Yadav *et al*. (2011) have also reported the similar results. Though the gross return was maximum under pendimethalin *fb* bispyribac–Na at 1000 g/ha *fb* manual weeding 45 DAS treatment , benefit-cost ratio was highest under the treatment pendimethalin *fb* bispyribac Na at 1000 *fb* 25 g/ha and three mechanical weedings (rotary weeding at 20, 40, 60 DAS).

CONCLUSION

Weed control efficiency and grain yield of direct seeded rice was highest under pendimethalin *fb* bispyribac–Na at 1000 g/ha *fb* manual weeding at 45 DAS, whereas, benefit-cost ratio was highest under pendimethalin *fb* bispyribac –Na at 1000 *fb* 25 g/ha and three mechanical weedings (rotary weeding at 20, 40, 60 DAS).

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Management of weeds in transplanted rice

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Rice (*Oryza sativa* L.) is a staple food for more than half of the world population. Weed infestation during the early stages of crop growth is one of the major factors responsible for low productivity of rice. More than one third of the total loss (33%) is caused by weeds alone (Mukherjee 2006). Weeds can reduce the grain yield of transplanted paddy by 62.6%, wet seeded paddy by 70.6% and dry seeded paddy by 75.8% (Singh *et al.* 2005). Weeds also increase the cost of cultivation, reduce input efficiency, interfere with agricultural operations and impair quality. Weeds can be controlled by adopting different methods. Hence, present study was carried out to evaluate the efficacy of different chemical and mechanical weed control methods and its economics in transplanted rice.

METHODOLOGY

A field experiment was carried out during *Kharif* 2014 at Agricultural Research Station, Vadgaon Maval, Pune, Maharashtra. The experiment consisted of ten treatments (Table 1) including unweeded check and weed free. The experiment was laid out in randomized block design with three replications. The middle late rice variety '*Phule Samruddhi*' was transplanted during *Kharif* 2014 with recommended package of practices.

RESULTS

In the experimental plots dominant weed flora consisted of monocots *Echinochloa colona* and *Cynodon dactylon* among grasses, *Cyperus iria* and *Cyperus difformis* among sedges and dicots like *Eclipta alba*, *Portulaca oleracea*, *Celosia argentea* and *Ludwigia parviflora*. The data presented in the table showed that the lowest dry matter of weed and weed index with highest weed control efficiency were recorded in the weed free treatment. The second best treatment was pre emergence application of pretilachlor at 0.50 kg/ha at 2-3 DAT and post emergence application of metsulfuron methyl + chlorimuron ethyl at 0.02 kg/ha at 25 DAT recording lowest weight of dry matter of weed (15.3 g/m^2) , higher weed control efficiency (91.74%) and lower weed index (2.78). The highest weed biomass was recorded in unweeded check. Similar results have been reported by Mukherjee (2006). The highest grain and straw yield of paddy (5.76 t/ha and 6.50 t/ha, respectively) were obtained in the weed free treatment. It was at par with pre-emergence application of pretilachlor at 0.50 kg/ha at 2-3 DAT and post emergence application of metsulfuron methyl + chlorimuron ethyl at 0.02 kg/ha at 25 DAT with grain yield of 5.59 t/ha and straw yield of 6.32 t/ha. The results are in conformity with those of Singh *et al.* (2005). Significantly higher net returns (Rs. 56004 /ha) and B:C ratio (2.0) were obtained with pre emergence application of pretilachlor at 0.50 kg/ha at 2-3 DAT and post-emergence application of metsulfuron methyl + chlorimuron ethyl at 0.02 kg/ha at 25 DAT, which was at par with the weed free treatment (Rs. 51761/ha).

Table 1. Weed growth, yield and economics of rice as influenced by different weed control treatments

Treatment	Weed dry weight (g/m^2)	Weed control efficiency (%)	Weed index	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (`/ha)	B:C ratio
Pendimethalin @ 1.0 kg/ha at 2-3 DAT	121.8	34.66	40.44	3.42	3.81	11469	1.2
Pretilachlor @ 0.50 kg/ha at 2-3 DAT	108.68	41.48	38.50	3.53	3.93	15275	1.3
Metsulfuron methyl + chlorimuron ethyl @ 0.02 kg/ha at 25 DAT	106.73	42.47	34.83	3.75	4.17	19836	1.4
Pendimethalin @ 1.0 kg a.i./ha at 2-3 DAT and metsulfuron methyl + chlorimuron ehtyl @ 0.02 kg/ha at 25 DAT	33.35	82.00	11.92	5.06	5.67	43730	1.8
Pretilachlor @ 0.50 kg a.i./ ha at 2-3 DAT and metsulfuron methyl + chlorimuron ethyl @ 0.02 kg/ha at 25 DAT	15.3	91.74	2.78	5.59	6.32	56004	2.0
Pendimethalin @ 1.0 kg a.i./ha at 2-3 DAT + one hand weeding at 30 DAT	87.57	52.76	29.58	4.04	4.49	19560	1.3
Pretilachlor @ 0.50 kg a.i./ ha at 2-3 DAT + one hand weeding at 30 DAT	84.36	54.35	26.02	4.26	4.73	25588	1.4
Metsulfuron methyl + chlorimuron ethyl @ 0.02 kg/ha at 25 DAT + one hand weeding at 45 DAT	87.80	52.53	28.91	4.08	4.53	22196	1.4
Unweeded check	187.33	0.00	60.32	2.29	2.51	- 8795	0.8
Weed free	0.00	100.00	0.00	5.76	6.50	51761	1.8
LSD (P=0.05)	15.96	7.85	12.26	7.11	7.97	14078	0.24

CONCLUSION

For effective management of weeds in transplanted paddy, pre-emergence application of pretilachlor at 0.50 kg/ha at 2-3 DAT followed by post-emergence application of metsulfuron methyl + chlorimuron ethyl at 0.02 kg/ha at 25 DAT is recommended.

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Effect of seed rate and weed management practice in rice-wheat cropping system under elevated altitude region of Eastern Himalaya

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Rice-wheat is a predominant cropping system in India (10.5 mha) except Eastern part of Himalaya region. This system sustained over years, in few pockets, but productivity of cropping system is quite low not only in hill but also in whole country (Chaudhay *et al*. 2014). Decrease in productivity of the rice –wheat system can be attributed due to poor agronomic manipulation of crop and devastating weed problem in the field, because of Eastern Himalaya come under high rainfall zone (annual rainfall > 1600 mm). Weeds in this system generally controlled with manual and cultural, and this leads to high cost of cultivation, and farmer avoid this system. However feasibility of this system is good if proper care regarding proper seed rate, fertilizer and herbicide application in scientific way (Mukherjee 2010). Keeping these facts in view, a study was undertaken to investigate the comparative performance of different weed management practice in rice and wheat under varying seed rate under high altitude zone of Himalaya.

METHODOLOGY

A field experiment was conducted during 2011 to 2013 at Algarah hill (1800 amsl), Regional Research Station, Uttar Banga Krishi Viswavidayalaya, in the mid hills of Darjeeling district (West Bengal) to asses improved management practices for enhancing grain production of rice and wheat in farmer field in high altitude zone. The soils of experimental field had 278.35 kg available N/ha, 17.98 kg available P/ha, 279 kg 1 N ammonium acetate exchangeable K/ha, orgnic carbon 0.89% with pH 5.2 (1:2.5 soil:water). Experiment was conducted under split plot design with three replications. The treatment comprised different weed management practices undr subplot for rice (2,4 DEE at 0.50 kg/ha, butachlor at 1.0 kg/ha, anilophos at 0.50 kg/ha, anilophos 0.50 kg/ha *fb* 2,4 DEE at 0.50 kg/ha, hand weeding at 25 and 50 days after transplanting (DAT) and weedy check) and wheat (isoproturon at 0.75 and 1.0 kg/ha, sulfosulfuron at 20 and 30 g/ha, hand weeding at 25 and 50 days after showing (DAS) and weedy check) under same rate of seed (70, 80, 90, 100 and 110 kg/ha) as main plot treatments. Pregerminated seeds of rice variery Aditya were direct sown on 12th July, 2011 and 15th July, 2012. After harvest of rice, wheat cultivar of PBW-343 was sown on 27 November, 2011 and 29 November, 2012.

RESULTS

Minimum weed population and dry matter production was registered with the rice seed rate of 100 kg/ha. Under subplot treatment, minimum above parameter was registered with the hand weeding twice and showed parity with the incorporation of anilophos at 0.50 kg/ha followed by 2,4 DEE (at 0.50 kg/ha and statistically superior to other set of subplot treatment of rice under rice- wheat cropping system. In rice crop, seed rate of 90 kg/ha caused the highest decrease in weed dry matter accumulation and recorded significantly higher rice yield and NPK uptake over other seed rates.

Table 1. Effect of various treatments on weed density, weed dry matter accumulation, yield and economics under rice-wheat system

Treatment		Weed population (no./m^2)		Weed dry weight (g/m^2)		Grain yield (q/ha)		B: C ratio	
Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Seed rate (kg/ha)									
70	70	8.70 (74.2)	7.83 (61.4)	6.98 (47.9)	7.23 (52.1)	29.02	21.69	0.74	0.98
80	80	7.51 (55.2)	7.07 (50.1)	6.40 (40.2)	6.79 (45.7)	34.25	24.56	0.81	1.24
90	90	6.99 (48.7)	6.87 (47.3)	6.74 (45.3)	6.68 (44.3)	39.54	27.03	1.01	1.02
100	100	6.41 (40.2)	5.67 (32.2)	5.51 (30.3)	4.51 (20.3)	38.47	30.21	0.92	1.33
110	110	6.50 (41.4)	5.75 (33.1)	5.72 (32.6)	4.35 (18.1)	37.98	28.11	0.89	1.19
LSD (P=0.05)		0.81	0.56	0.78	0.51	2.26	2.25	-	-
Weed management									
2,4 DEE (at 0.5 kg/ha)	Isoproturon (0.75 kg/ha)	7.09 (50.0)	6.89 (47.3)	5.89 (34.6)	5.57 (30.1)	30.47	22.36	0.89	1.32
Butachlor (at 1 kg/ha)	Isoproturon (1.0 kg/ha)	6.78 (45.7)	6.39 (40.1)	5.61 (30.6)	5.78 (33.5)	34.65	29.01	0.74	1.35
Anilophos (at 0.50 kg/ha)	Sulfosulfuron (20 g/ha)	7.98 (63.3)	7.32 (52.3)	6.48 (41.2)	6.88 (47.1)	29.23	23.65	0.79	1.28
Anilophos (at 0.50 kg/ha) *fb* 2,4 DEE (at 0.50 kg/ha)	Sulfosulfuron (40 g /ha)	4.71 (22.1)	4.71 (38.1)	3.21 (10.3)	4.89 (23.9)	36.25	30.24	0.94	1.57
Hand weeding 25 and 50 DAT	Hand weeding 25 and 50 DAT	3.49 (12.1)	4.75 (22.3)	2.65 (7.0)	3.92 (15.3)	37.64	31.98	0.88	1.45
Weedy check	Weedy check	9.91 (98.4)	8.65 (74.3)	8.71 (75.3)	7.29 (53.1)	14.25	17.36	0.40	0.65
LSD (P=0.05)		1.27	0.53	1.49	0.85	3.69	3.74	-	-

Figures in parenthesis are original values whereas above figures are "x+0.5 transformed values

Incorporation of anilophos at 0.50 kg/ha as pre-emergence followed by 2,4 DEE at 0.50 kg/ha as post-emergence application recorded significantly lower dry matter accumulation of weeds, and in turn increased rice yield and NPK uptake than the other wed management practices. This treatment gave 154.3% increase in rice grain yield over weedy check. In case of wheat grown after rice, 100 kg seed/ha reduced dry matter accumulation of weeds, and resulted in the highest wheat yield and NPK uptake which was similar to 110 sowing was found most effective in reducing weed dry matter accumulation, and maximizing wheat yield and NPK uptake which was at par with sulfosulfuron 30 g/ha at 25 DAS. Hand weeding (at 25 and 50 DAS) and sulfosulfuron at 30 g/ha registered 84.2 and 74.1%, increase in wheat grain yield over weedy check, respectively. Net return and benefit:cost ratio in rice was highest (Rs. 23,315 /ha) with 90 kg seed/ha and among weed management treatments, maximum net return and benefit:cost ratio (Rs. 23,587/ha and 0.94) were recorded with anilophos at 0.50 kg/ha *fb* 2,4 DEE at 0.50 kg/ha. Net return and benefit:cost ratio in wheat was highest (Rs. 28,785 /ha) with 100 kg seed/ha, and Rs.26,587/ha and 1.57 with sulfosulfuron at 30 g/ha.

CONCLUSION

For realizing higher yield, economic gain and effective weed management under rice –wheat system in high altitude zone, 90 kg seed/ha of rice along with anilophos at 0.50 kg/ha *fb* 2,4 DEE at 0.50 kg/ha and 100 kg seed/ha of wheat along with sulfosulfuron at 30 g/ha at 25 DAS to the succeeding wheat crop was found to be the best option.

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Effects of soil moisture and submergence on emergence, growth and efficacy of soil-applied herbicide in seedling of three grass weeds in rice fields of tropical savanna

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In Republic of Ghana in Sub-Saharan Africa where lack of foods and poverty have become serious problems by a rapid population growth and delay in the economic development (Sumita *et al*. 2012), a research project on development of stable rice production system of no till direct sowing method using flood of the rainy season without mechanization such as tractor and irrigation schemes in flooded plains, has been conducted by Japan International Research Center for Agricultural Sciences (JIRCAS) collaborated with Savanna Agricultural Research Institute (SARI), Ghana. To support the project, ecological characteristics of major target grass weed such as *Acroceras zizanioides*, *Digitaria longiflora* and *Paspalum scrobiculataum* were studied concerning the emergence, growth performances and changes in the efficacy of butachlor under different soil moisture conditions using facilities in Akita, Japan on the assumption of beginning of rainy season in lowland savanna of northern Ghana.

METHODOLOGY

Four experiments on *A. zizanioides*, *D. longiflora* and *P. scrobiculataum* (hereafter abbreviated as Ac, Di and Pa) collected in northern Ghana were carried out using ando soil in a greenhouse (25!: Experiment 1) and in a growth chamber (25!/21!, quantity of photon 114 ìmol m{ ^{2} s{ ^{1}: Experiment 2 to 4) of Akita Prefectural University in Akita, Japan. Exp.1: Effects of soil moisture rate on emergence pattern in seeds exposed for an artificial dry season were examined, for seeds of Di and Pa incorporated in soil, kept dry for four months and treated into 38% of soil moisture rate and 1 cm of submergence as upland and lowland field conditions respectively, and were alternated on one week. Emergence pattern of Ac was compared with barnyard grass, *Echinochloa crus-galli*, under six different moisture rates from 33% to 47%. Exp.2 : Effects of soil moisture rate on initial growth of seedling at 1 leaf stage planted in a plastic cup of 300 cm^3 filled with soil, were examined for Di under 11 different moisture rates from 34% to 54% and for Ac under 9 moisture rates from 32% to 58%. Exp.3: Effects of submergence depth from 1.5 cm to 8 cm for 2 to 4 weeks on initial growth of seedlings at emergence, 1 and 2 leaf stages in Ac, Di and Pa planted in plastic cup as Exp. 2, were examined. Exp.4: Effects of soil moisture rate on the efficacy of soil applied herbicide with butachlor 5% granule at 1.5 kg/ha at emergence time, 1 and 1.5 leaf stages were evaluated for Di and barnyard grass sown in plastic cup filled with 244 g of soil under four soil moisture conditions of 59%, 61%, saturated and 1 cm of submergence.

RESULTS

Exp.1: Emergence of Di was greater in upland soil moisture than in submergence, while that of Pa was inferior in upland moisture. Ac emerged between 40% and 44% of soil moisture rates, whereas barnyard grass emerged in wider range of soil moisture. Exp.2: As for the dry matter weight (DMW) of aerial part, optimum soil moisture condition was above 67% for Di and between 90% and 106% for Ac, respectively. Exp.3: Seedlings of Di were killed completely by 2-weeks' submerge treatment at 1 and 2 leaf stage and were suppressed strongly by 4-weeks' treatment at 2 leaf stage. Suppression in Ac was not clear, but negative correlation was obtained between DMW and submergence depth. Exp.4: The efficacy of butachlor granules decreased under 59% and 61% of soil moisture rates compared to those under saturation and submergence both in Di and barnyard grass. The degree of decrease became greater as delay in application time.

CONCLUSION

Principal information on the performances under different soil moisture conditions was obtained for three major grass weed species of rice fields in lowland savanna of northern Ghana. Controlling them completely by submergence seemed to be difficult except for the time just after their emergence. Further studies on biology and changes in efficacy of soil-applied herbicides including other factor such as formulation, under fluctuating soil moisture conditions.

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Evaluation of some botanicals and pre-emergence herbicides for weed management in transplanted rice

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In India rice is gown in an area of around 44 mha annually with a production of 104 mt contributing 45% of the total food grain production of the country (Prakash *et al*. 2013). Transplanted rice, in particular, is infested by heterogeneous types of weed flora consisting of grassy, broadleaf weeds and sedges causing yield reduction up to 76%. Effective control of weeds increases the grain yield by 86% (Mukherjee and Singh 2004). Hand weeding is expensive, time consuming, difficult and often limited by scarcity of laborers in time. On the other hand, herbicides offer economic and efficient weed control if applied at proper dose and stage (Poddar *et al.* 2014). The present investigation was undertaken to find out the performance of different botanics which have allelopathic effect and different pre emergence herbicides to control the weeds in transplanted rice.

METHODOLOGY

The research work was done during *rabi* season of 2012-13 and 2013-14 at Kalyani C-Block Farm of Bidhan Chandra Krishi Viswavidyalaya to study the efficiency of the different botanics and pre-emergence herbicides. The soil of the experimental field was sandy loam with a pH of 6.78 and medium fertility status with low water holding capacity. The crop was grown under irrigated condition. There were seven treatments which were replicated thrice in randomized block design. The aqueous extracts of botanics were made in the weed science laboratory at BCKV.

RESULTS

Grass weeds were predominant (43%), followed by broad-leaved (31%) and sedges (26%). *Cyperus rotundus* and *Cyperus difformis* were the major sedge where as *Echinochloa colona* among the grassy weeds and *Ammania baccifera* among the broad-leaved weeds were more dominant. Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among different treatments, the lowest weed density (11.3 /m^2) was observed under hand weeding twice at 20 and 40 DAT, followed by pretilachlor at 500 g/ha (47.3 /m^2) (Table 1). Oxadiargyl at 100 g/ha and cyhalofop butyl at 80 g/ha resulted in at par weed population and dry matter production. The minimum weed dry weight was also recorded in these treatments, which was significantly lower than all other treatments. These results are in conformity with the findings of Poddar *et al.* (2014) that chemical weed management reduced the weed population and dry matter production. Among the botanics no significant variation was observed. Maximum weed control efficiency (95.32%) was recorded in hand weeding twice followed by Pretilachlor at 500 g/ha (80.61%).

The highest grain yield (6.47 t/ha) was recorded with hand weeding (20 and 40 DAT) and the lowest (2.42 t/ha) was under control. The yield loss due to uncontrolled growth of weeds as compared to hand weeding was 62.59%. Among the herbicidal treatments, pretilachlor 30.7 EC at 500 g/ha recorded maximum grain yield (5.86 t/ha), which was significantly higher with other treatments. Oxadiargyl at 100 g/ha and cyhalofop butyl at 80 g/ha produced at par result and botanical application of *Bambusa vulgaris* (root + leaf=2:1) aqueous extract (15%) + Tween 20 at 1.0 l/ha also resulted at par result among themselves. Oxadiargyl 80 WP at 100 g/ha and Cyhalofop butyl at 80 g/ha recorded 13.48 and 12.80% less grain yield as compared to pretilachlor 30.7 EC at 500 g/ha, respectively. The maximum straw yield (7.60 t/ha) was recorded in two hand weeding and the lowest (4.30 t/ha) in unweeded check. Herbicidal treatments resulted in considerably lower cost of cultivation compared with hand weeding. The B:C ratio was found maximum with pretilachlor at 500 g/ha, followed by cyhalofop butyl 10 EC at 80 g/ha and oxadiargyl at 100 g/ha.

Table 1. Weed growth, yield and economics of rice as influenced by different weed control treatments

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	B:C ratio
T_1	9.99 (99.33)*	40.56	48.37	4.16	7.40	36	2.04
T_2	9.17 (83.67)	38.64	50.81	4.33	7.06	38	2.07
T_3	6.92 (47.33)	15.23	80.61	5.86	6.35	48	2.62
T_4	8.57 (73.00)	30.72	69.81	5.07	6.72	43	2.23
T_4	8.48 (71.33)	25.67	67.32	5.11	7.35	41	2.34
T_6	3.44 (11.33)	3.68	95.32	6.47	7.60	46	2.11
T_7	13.04 (169.67)	78.56	0.00	2.42	4.30	36	1.24
LSD (P=0.05)	0.26	1.92	-	0.21	0.30	-	-

*Figures in the parenthesis are original values which are subjected to square root transformation "(x+1).

T_1 = Parthenium + Calotropis + Tectona grandis (1:1:1) leaf aqueous extract (15%) + Tween 20 at 1 lit ha^{-1}, T_2 = Bambusa vulgaris (root + leaf=2:1) aqueous extract (15%) + Tween 20 at 1 lit ha^{-1}, T_3 = Pretilachlor 30.7 EC at 500 g/ha, T_4 = Oxadiargyl 80 WP at 100 g/ha, T_5 = Cyhalofop butyl 10 EC at 80 g/ha, T_6 = Hand weeding at 20 and 40 DAT, T_7 = Control

CONCLUSION

Pre-emergence application of pretilachlor at 500 g/ha was most effective for controlling weeds, improving grain yield and profitability of transplanted rice.

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Evaluation of efficacy of herbicides and their combinations for broad-spectrum weed control in direct-seeded rice

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In the 21st century along with population pressure, rising scarcity of agricultural land and water and continuing shortage of labour will maintain pressure for a shift towards direct seeding method of rice production system (Mortimer *et al*. 2005). Among various problems in limiting the production in direct seeded rice, heavy weed infestation is the major one. Weeds cause heavy damage to the (DSR) crop, which can be to the tune of 10-100%. Farmers in general use only pre-emergence herbicides in DSR which is not sufficient to control the complex weed flora in the DSR through out the crop growth period. In this situation, the suitable combinations of pre and post-emergence herbicides are needed to control the weed. Therefore the present experiment was carried out to evaluate the bioefficacy of different herbicides and its combinations to control the complex weed flora in direct seeded rice.

METHODOLOGY

The field experiment was conducted at the central farm, OUAT in the *Kharif season* 2014 to evaluate different pre and post emergence herbicides and their combinations against broad spectrum weed control in direct seeded rice. The experiment was planned in randomized block design with three replications. The soil of the experimental site was low in organic carbon and available nitrogen and medium in available P and K_2O. Total nine treatments (Table 1) were tested on the rice crop. All the herbicides were applied using a knapsack sprayer fitted with flat fan nozzle using 500 l water per hectare. The crop variety '*Khandagiri*' was sown on 18.06.2014 and harvested on 18.10.2014.

RESULTS

The weed flora of the experimental site was dominated with grasses like *Digitaria ciliaris*, *Cynodon dactylon*, *Echinochloa colona* and broad leaf weeds like *Ageratum conyzoides, Cleome viscosa, Celosia argentia, Oldenlandia corymbosa, Ludwigia parviflora, Physalis minima and Amaranthus viridis.* The dominant sedges observed were *Cyperus rotundus and Cyperus iria.* Significant difference in weed densities was observed at 30, 60 DAS and at harvest to different herbicide combinations treatments. Weed free treatment (HW at 20, 40 and 60 DAS) recorded significantly lowest weed density of 1.7, 2.0 and 1.4 /m^2 at 30, 60 DAS and at harvest, respectively. Among different herbicide combinations, application of pendimethalin *fb* bispyribac Na recorded significantly lowest density of 2.4 and 3.3 /m^2 at 30 and 60 DAS, but at harvest oxadiargyl *fb* bispyribac Na treated plots recorded significantly lowest value of 5.5/m^2 followed by pyrazosulfuron *fb* bispyribac Na (6.1 /m^2) and pendimethalin *fb* bispyribac (6.2/m^2). Weed free treatment recorded significantly lowest weed biomass of 1.5, 1.4 and 1.5 g/m^2 at 30, 60 DAS and at harvest, respectively. Among different herbicide combinations, application of pendimethalin *fb* bispyribac Na exhibited significantly lowest weed biomass of 1.8, 2.1 and 4.5 g/m^2 at 30, 60 DAS and at harvest, respectively followed by oxadiargyl fb bispyribac Na treatment. The weedy check plots showed highest weed biomass at all the stages of crop growth. Weed free treatment (HW at 20, 40 and 60 DAS) recorded significantly highest yield of 4.47 t/ha where as weedy check treatment recorded the lowest yield (1.84 t/ha). Among different herbicide combinations, significantly higher grain yield of 4.40 t/ha was obtained with application of pendimethalin *fb* bispyribac Na. These findings are well supported by (Singh *et al*. 2009). Highest net return and B:C ratio of Rs.18900/ha and 1.67 were obtained respectively from application of pendimethalin *fb* bispyribac Na followed by oxadiargyl *fb* bispyribac Na (Rs. 17600/ha and 1.61).

Table 1. Bioefficacy of new herbicides& its combinations on weed density, weed biomass, yield and economics in direct seeded rice

Treatment	Weed density (no/m^2)	Weed biomass (g/m^2)	Yield (t/ha)		Net return (`/ha)	B:C ratio
			Grain	Straw		
Bispyribac-Na	5.2 (26.5)	3.6 (12.5)	3.66	4.64	11500	1.39
Oxadiargyl *fb* bispyribac-Na	3.9 (14.7)	2.5 (5.8)	4.32	5.74	17600	1.61
Pyrazosulfuron *fb* bispyribac Na	5.1 (25.3)	2.8 (7.2)	4.27	5.35	17100	1.59
Pendimethalin *fb* bispyribac Na	3.3 (10.3)	2.1 (3.8)	4.40	5.82	18900	1.67
Pendimethalin *fb* manual weeding	4.9 (23.8)	3.1 (9.5)	4.00	5.22	12500	1.39
Bispyribac Na + (chlorimuron + metsulfuron)	4.0 (25.0)	3.2 (9.8)	3.84	5.00	13300	1.46
Three mechanical weeding (cono weeder)	5.1 (25.5)	3.3 (10.5)	3.79	4.81	11300	1.35
Weed free (HW at 20, 40 and 60 DAS)	2.0 (3.7)	1.4 (1.9)	4.47	5.29	12100	1.32
Weedy check	10.0 (98.7)	4.6 (20.8)	1.84	2.25	-1300	1.04
SE(m)±	0.19	0.11	0.150	0.189	-	-
LSD (P=0.05)	0.55	0.31	0.443	0.561	-	-

fb- followed by, HW-Hand weeding, DAS-Days after sowing

CONCLUSION

Based on the present investigation, it can be concluded that pendimethalin at 1.0 kg/ha applied at 2 DAS *fb* bispyribac Na 0.025 kg/ha applied at 25 DAS can be used for satisfactory weed control in the direct seeded rice field.

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Weed management in transplanted rice under deltaic coastal ecosystem

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Rice (*Oryza sativa* L.) is the major crop cultivated in Puducherry UT. Weed competition is the major biotic constraint contributes to the yield loss to an extent of 36-40% in transplanted rice (Ramachandra *et al.* 2014). Dependence on manual weed control alone is time consuming and costly. So, use of herbicides is gaining popularity in rice fields due to their rapid effects and the lower costs compared with the traditional methods. Hence, a field investigation was undertaken to study the effect of different pre and post-emergence herbicides alone or in combination of a hand weeding for transplanted rice in deltaic coastal ecosystem of Karaikal, Puducherry UT.

METHODOLOGY

A field experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), Karaikal, Puducherry U.T during *Rabi* (September 2013- January 2014) to study the effect of herbicide combinations for control of complex weed flora in transplanted rice. The experiment was laid out in randomized block design with twelve treatments (Table 1). Observations on weeds were recorded with the help of quadrate 0.25 x 0.25 m^2 placed randomly at four spots in each plot at 60 DAP. The data on weed density and dry weight were then analyzed by using square root transformation ("x+0.5) to normalize their distribution. The rice cultivar ADT 46 was transplanted with the spacing of 20 x 10 cm^2 and all the recommended package of practices except weed control was ado pted during the period of experimentation.

RESULTS

The dominant weed flora observed in the study area was *Echinochloa crusgalli* (L), *Echinochloa colona* (L.), *Leptochloa chinensis* (L.), *Bergia capensis* (L.), *Eclipta alba* (L.) *Marsilea quadrifolia* (L.), *Cyperus iria* (L.) and *Cyperus difformis* (L.). Hand weeding twice significantly reduced the weed density (6.7 no./m^2) and dry weight (2.9 g/m^2) and resulted in higher rice yield (4.7 t/ ha). It was on par with the sequential application of pretilachlor fb (chlorimuron +metsulfuron), pre-emergence application of pyrazosulfuron ethyl (20 g/ha) +hand weeding at 25 DAT and pretilachlor (6%) + bensulfuron (0.6%) 6.6% GR in terms of weed control and rice yield. Dharumarajan *et al.* (2009) earlier indicated that pretilachlor application was found effective against grasses, sedges and broad leaved weeds in transplanted rice. Post emergence application of bispyribac sodium alone or in combinations was found ineffective in weed control, which eventually resulted in 19.4-20.9% yield loss. However, maximum yield loss (37.2%) was observed with unweeded control. Economic analysis revealed that application of pretilachlor fb (chlorimuron + metsulfuron) was better in terms of B:C ratio (2.73). It was followed by pre-emergence application of pyrazosulfuron ethyl (20 g/ha) integrated with a manual weeding at 25 DAT (2.54) and pretilachlor (6%) + bensulfuron (0.6%) 6.6% GR (2.51), respectively in coastal ecosystem of Karaikal, Puducherry UT (Table 1).

Table 1. Weed growth, yield and economics of transplanted rice as influenced by weed control treatments

Treatment	Dose (g/ha)	Weed density (no/m^2)	Weed dry weight (g/m^2)	Grain yield (t/ha)	Weed index	B:C ratio
Bispyribac-Na	25	7.20 (48.7*)	7.29(50.9*)	3.72	20.9	2.00
Butachlor	1500	4.07 (23.3)	3.61 (12.9)	4.02	14.5	2.44
Penoxsulam	22.5	5.55 (33.3)	4.78 (18.9)	3.97	15.5	2.30
Pyrazosulfuron	20	5.23 (25.3)	4.64 (18.4)	3.94	16.2	2.41
Bispyribac + ethoxysulfuron	25+18.75	6.47 (36.0)	6.58 (62.2)	3.79	19.4	1.98
Bispyribac+(chlorimuron + metsulfuron)	20+4	6.27 (34.0)	8.73 (67.7)	3.72	20.9	2.02
Pretilachlor fb ethoxysulfuron	750/18.75	4.78 (18.7)	5.69 (27.9)	4.13	12.1	2.47
Pretilachlor *fb* (chlorimuron +metsulfuron)	750/4	3.44 (8.7)	3.37 (8.3)	4.37	7.0	2.73
T_4 fb manual weeding	20	3.76 (10.7)	3.13 (7.0)	4.48	4.7	2.54
Pretilachlor (6%) + bensulfuron (0.6%) 6.6% GR	660 (10 Kg/ha)	4.53 (17.3)	3.41 (8.7)	4.26	9.4	2.51
Hand weeding	25 & 45 DAT	2.89 (6.7)	2.20 (2.9)	4.70	-	2.40
Weedy check	-	8.02 (56.7)	10.39 (97.9)	2.95	37.2	1.68
LSD (P=0.05)	-	2.78	3.76	0.66	-	-

*Original figures in parenthesis were subjected to square root transformation ("x+0.5) before statistical analysis

CONCLUSION

Manual weeding twice resulted in better weed control and maximum rice yield. But, sequential application of pretilachlor *fb* (chlorimuron + metsulfuron) found to be economically viable for managing weeds in transplanted rice under deltaic coastal ecosystem of Karaikal, Puducherry UT.

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Effect of bensulfuron-methyl + pretilachlor on weed control and economics in transplanted rice

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Weed infestation is one of the limiting factors in rice cultivation. The loss in grain yield due to unchecked weed growth throughout the crop growth period was estimated to be 32% in transplanted rice (Moorthy and Saha 2002). Mechanical and cultural methods are not always possible to be adopted on account of scarcity and high cost of labour during peak period of rice cultivation and secondly hand weeding is slow and tedious process. Similarly removal of the weeds at the critical period by mechanical means is not possible due to unfavorable weather conditions. Under such situation, the use of herbicides is the only way to control weeds. In view of above, the present study was undertaken to study the effect of herbicide alone and in combination with mechanical methods for weed control in lowland / transplanted paddy.

METHODOLOGY

The study was conducted at Agronomy Farm, College of Agriculture, Nagpur during *Kharif* 2013-14. The experiment was conducted on clayey soil with pH 7.8. The soil was low in nitrogen, medium in phosphorus and high in potassium. The experiment was laid out in a randomized block design with nine treatments replicated thrice. The paddy crop (*PKV-HMT*) was transplanted in field on 3rd August 2014. The treatments (Table 1) were imposed accordingly. Herbicides were sprayed with knapsack sprayer having flat fan nozzle using 500 liters of water/ha.

RESULTS

The weed control treatments showed significant reduction in weed dry matter as compared to weedy check. The treatment comprising of two weedings and two hoeings at 15 and 30 DAT showed maximum reduction in weed dry matter and highest weed control efficiency amongst all other treatments except treatments of bensulfuron methyl + pretilachlor at 825 g/ha + 1 hoeing at 30 DAT (T_7) and bensulfuron methyl + pretilachlor at 660 g/ha + 1 hoeing at 30 DAT (T_6). However, they were found at par with 2 weeding + 2 hoeing at 15 and 30 DAT (T_8) in respect of weed dry matter. This could be due to better control of weeds by hoeing and weeding and application of chemical herbicides. Kachroo and Bazaya (2011) reported that weed dry matter was reduced significantly thereby increasing weed control efficiency due to combined use of herbicide and cultural methods.

The grain and straw yield of paddy was found significantly higher with the treatment of 2 weedings + 2 hoeings at 15 and 30 DAT (T_8) as compared to other treatments. However, the treatment of bensulfuron methyl + pretilachlor at 825 g/ha + 1 hoeing at 30 DAT (T_7) and bensulfuron methyl + pretilachlor at 660 g/ha + 1 hoeing at 30 DAT (T_6) were at par with 2 weeding + 2 hoeing at 15 and 30 DAT (T_8). Similar results were recorded by Sunil *et al.* (2011). Two weedings + 2 hoeings at 15 and 30 DAT (T_8) recorded significantly higher gross monitory returns as compared to all other treatments except bensulfuron methyl + pretilachlor at 825 g/ha + 1 hoeing at 30 DAT (T_7) + bensulfuron-methyl + pretilachlor at 660 g/ha + 1 hoeing at 30 DAT (T_6) which were found at par with 2 weeding + 2 hoeing at 15 and 30 DAT (T_8). Bensulfuron methyl + pretilachlor at 825 g/ha + 1 hoeing at 30 DAT (T_7) recorded significantly higher net returns and was followed by 2 weedings and 2 hoeing at 15 and 30 DAT (T_8) and bensulfuron methyl + pretilachlor at 660 g/ha + 1 hoeing at 30 DAT (T_6). The highest B:C ratio was recorded with bensulfuron methyl + pretilachlor at 825 g/ha + 1 hoeing at 30 DAT (T_7) followed by bensulfuron methyl + pretilachlor at 660 g/ha + 1 hoeing at 30 DAT (T_6) and two weeding And two hoeing at 15 and 30 DAT (T_8).

Table 1. Effect of treatments on weeds, crop yield and economic returns

Treatment	Weed dry matter (g/m^2)	Weed control efficiency (%)	Grain yield (kg/ha)	Straw yield (kg/ha)	NMR (` /ha)	B: C ratio
T_1- Bensulfuron methyl + pretilachlor @ 495 g/ha	7.06 (49.36)	63.50	1971	3305	19718	1.78
T_2- Bensulfuron methyl + pretilachlor @ 660 g/ha	6.83 (46.10)	65.91	2088	3441	22282	1.89
T_3- Bensulfuron methyl + pretilachlor @ 825 g/ha	6.54 (42.22)	68.78	2172	3568	24144	1.96
T_4- Butachlor @ 1.5 kg a.i./ha + 1 hoeing at 30 DAT	5.85 (33.87)	75.10	2341	3783	27078	2.04
T_5- Bensulfuron methyl + pretilachlor @ 495 g/ha + 1 hoeing at 30 DAT	6.08 (36.42)	73.07	2238	3627	25047	1.97
T_6- Bensulfuron methyl + pretilachlor @ 660 g/ha + 1 hoeing at 30 DAT	5.26 (27.20)	79.88	2408	3834	28795	2.12
T_7- Bensulfuron methyl + pretilachlor @ 825 g/ha + 1 hoeing at 30 DAT	5.01 (24.60)	81.81	2535	3956	31555	2.23
T_8- 2 weedings + 2 hoeings at 15 and 30 DAT	4.73 (21.85)	83.84	2583	3959	30231	2.08
T_9- Weedy check	11.65 (135.25)	-	1432	3256	8437	1.33
SEm±	0.35	-	79	58	925	-
LSD (P=0.05)	1.05	-	239	175	2775	-

Figures in parenthesis are original values whereas above figures are "x+0.5 transformed values

CONCLUSION

Application of bensulfuron methyl + pretilachlor at 660 to 825 g/ha + 1 hoeing at 30 DAT showed significant reduction in weed dry matter and increased weed control efficiency thereby increasing monetary returns and B:C ratio amongst all the other treatments.

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Herbicidal control of Chinese sprangletop (*Leptochloa chinensis*) in rice

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Chinese sprangletop or red sprangletop (*Leptochloa chinensis* (L.) Nees.) is emerging as a serious weed in direct seeded rice. Until a decade ago, it was not at all a problem in the major rice ecosystems in India. It is a C_4 grass native to tropical Asia and is now widely distributed in South and South-east Asia, Africa and Australia. Shifting from traditional manual transplanting to direct seeding and increased dependence on herbicides for weed control are suggested to be the reasons for increased incidence of Chinese sprangletop (Azmi *et al*. 2005). Because of the morphological similarity of *Leptochloa chinensis* to rice, manual weeding gives only incomplete control of the weed. The competition from *Leptochloa* has become very severe in some rice fields, resulting in severe crop loss and sometimes forcing the farmers to abandon the crop. Therefore a trial was conducted to evaluate the available post-emergence herbicides effective against grassy weeds in rice for control of *Leptochloa chinensis*.

METHODOLOGY

The trial was conducted during 2013 and 2014 in the rabi and *Kharif* seasons in a rice field in Thrissur of Kerala state where severe incidence of *Leptochloa* was observed during the previous two seasons. The trial consisted of three doses of cyhalofop butyl (80, 100 and 120 g/ha), fenoxaprop p-ethyl (60 g/ha), bispyribac sodium (30 g/ha) and azimsulfuron (35 g/ha), compared with hand weeded and unweeded control. The trial was laid out in RBD in plots of 20 sq. m size, with three replications. The rice variety used was Jyothi, with a duration of 115-120 days. Pre germinated seeds of rice were broadcast sown after puddling the field. Herbicides were applied at 20 DAS with a backpack sprayer fitted with flood jet nozzle, using 350 L of water per hectare. As the main objective of the study was to test the herbicides on *Leptochloa chinensis* and other grasses, broad leaved weeds and sedges were controlled by applying chlorimuron ethyl + metsulfuron methyl at the rate of 4g a.i/ha (20g /ha) two days after application of cyhalofop butyl and fenoxaprop p-ethyl. Observations were recorded on the effect of treatments on count of *Leptochloa chinensis* as well as other grass weeds.

RESULTS

Results indicated that cyhalofop butyl at 100 and 120g/ha as well as fenoxaprop p-ethyl at 60g/ha resulted in very good control of *Leptochloa chinensis*, on par with hand weeding in both the seasons. cyhalofop butyl 80g/ha and azimsulfuron 35g/ha reduced the weed population significantly compared to unweeded control. However bispyribac sodium was not at all effective against *Leptochloa chinensis* and resulted in equal or more count of the weed than in unweeded control. In earlier studies also, Abeysekera and Wickrama (2004) had reported that bispyribac sodium was the least effective herbicide for controlling *Leptochloa chinensis*. All herbicides were equally effective against other grassy weeds present in field *viz. Echinochloa crusgalli, E. stagnina and Sacciolepis interrupta*.

Hand weeded control recorded the highest yield closely followed by cyhalofop butyl at 120g/ha, which was statistically on par. All herbicide treatments resulted in significant increase in yield compared to unweeded control.

CONCLUSION

The study revealed that cyhalofop butyl at 120 and 100 g/ha was very effective for controlling *Leptochloa chinensis* and associated grassy weeds in direct seeded rice, resulting in higher grain and straw yield.

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Herbicides combinations for management of complex weed flora in drum-seeded puddled rice

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In the last five years the cost of production on different operations is increased by 33% on seed, 45% on fertilisers, 100% on labour wages, 35-40% on tillage operations. Because of increase in cost of production the cultivation of rice has become unprofitable in Andhra Pradesh (Rao *et* al. 2013). Under these circumstances rice production systems are undergoing several changes and one of such changes is shift from transplanted rice to direct seeding. But sprouted rice seed on puddled soil is confronted with problem of profuse growth of weeds. Weed competition reduced the grain yield by 50-60% in direct-seeded low land rice.

METHODOLOGY

The investigation was carried out at college farm, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17°19' N latitude and 78°23' E longitude. The experiment was laid out in CRD with 3 replications having 11 treatments with MTU-1010 as test variety. The sprouted seed was sown in well puddled soil. The recommended fertilizer dose of 150-60-40 kg NPK/ha was applied as per the scheduled time of application. Data on weeds and yield of the drum seeded rice was recorded at 120 DAS.

RESULTS

Weed Spectrum observed during crop growing season were *Cyperus difformis*, *Eclipta alba*, *Echinocloa colona*, *Echinochloa crusgalli* and *Paspalum distichum. Research results showed that, the lowest weed density was noticed* with pyrazosulfuron ethyl *fb* HW at 40DAS and was on par with weed free treatment, which inturn was on par with early post emergence application of bispyribac sodium *fb* HW (40 DAS). But the lowest weed drymatter was recorded with weed free treatment and was onpar with pyrazosulfuron ethyl *fb* HW at 40DAS, early post emergence application of bispyribac sodium *fb* HW (40 DAS) and pretilachlor+safener *fb* azimsulfuron. Significantly the highest weed density and weed drymatter was recorded with weedy check.

Table 1. Weed growth, yield and economics of rice as influenced by different weed control treatments

Treatment	Weed Density (no./m^2)	WDM (g/m^2)	WCE (%)	Weed index	Straw yield kg/ha	Grain yield kg/ha	Cost of cultivation (x10^3/ha)	BC ratio
Azimsulfuron 35 g/ha (25-30 DAS)	6.60 (42.67)	12.17 (47.33)	16.61	41.09	3720	2227	35.32	0.88
Pretilachlor 450 g/ha + safener *fb* HW (40 DAS)	7.46 (54.67)	8.69 (74.67)	57.74	23.27	4450	2900	34.94	1.16
Pretilachlor + safener 450 g/ha *fb* azimsulfuron 35 g/ha (25-30 DAS)	5.35 (28.00)	6.55 (42.00)	76.23	13.52	4980	3269	37.267	1.23
Bensulfuron methyl + pretilachlor 60 + 600 g/ha *fb* HW (40 DAS)	5.08 (25.00)	7.72 (58.67)	66.79	31.90	4455	2574	39.38	0.92
Bispyribac sodium 25 g/ha *fb* HW (40 DAS)	4.12 (16.00)	6.43 (40.67)	76.98	10.44	5030	3385	39.03	1.21
Pyrazosulfuron ethyl 20 g/ha *fb* HW (40 DAS)	2.95 (8.00)	6.34 (39.33)	77.74	5.22	5050	3483	37.80	1.29
Oxadiargyl 80 g/ha *fb* HW (40 DAS)	6.69 (44.00)	8.53 (72.00)	59.25	56.06	3180	1661	37.68	0.62
Pyrazosulfuron ethyl 20 g/ha *fb* azimsulfuron 35 g/ha (25-30 DAS)	5.62 (30.70)	8.34 (68.67)	61.13	12.86	4590	3294	36.13	1.28
Oxadiargyl 80 g/ha *fb* *a*zimsulfuron 35 g/ha (25-30 DAS)	5.25 (26.7)	10.88 (117.3)	33.59	46.43	3020	2025	36.01	0.79
Weed free (hand weeding at 20 and 40DAS)	3.73 (13.33)	6.29 (38.67)	78.11	0.00	5330	3780	41.00	1.29
Weedy check	7.08 (49.33)	13.32 (176.7)	0.00	79.17	2700	787	33.00	0.33
LSD (P=0.05)	0.96	0.91			864.01	8.36		
C.V	11.11	6.12			11.89	11.53		

*Values in paccrantheses are original. Data transformed to square root transformation

*Significant increase in grain and straw yield was noticed with weed free treatment (*3780 and 5330 kg/ha) and was on par with pyrazosulfuron ethyl *fb* hand weeding at 40DAS, bispyribac sodium *fb* HW (40 DAS), pyrazosulfuron ethyl *fb* azimsulfuron (25-30 DAS) and pretilachlor + safener *fb* azimsulfuron (25-30 DAS) respectively. Similar trend was reflected with weed control efficiency also. Among the herbicides tested the lowest weed index values were observed with pyrazosulfuron ethyl *fb* hand weeding at 40DAS, bispyribac sodium *fb* HW (40 DAS), pyrazosulfuron ethyl *fb* azimsulfuron (25-30 DAS) and pretilachlor + safener *fb* azimsulfuron (25-30 DAS) respectively. The yield loss due to uncontrolled growth of weeds as compared to hand weeding was 79%.

CONCLUSION

Under labour scarce condition either pre emergence application of pyrazosulfuron ethyl 20 g/ha at 8-10 DAS fb manual weeding at 40 DAS or pyrazosulfuron ethyl 20 g/ha at 8-10 DAS fb *a*zimsulfuron 35g/ha at 25-30 DAS was found to be effective to get higher yield (3483 and 3294kg/ha) and benefit cost ratio (1.29 and 1.28).

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Effect of penoxulam + cyhalofop-butyl on weed control of transplanted rice in Cauvery command areas of Karnataka

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Rice-rice is the major cropping system in Southern Karnataka where in long duration varieties of rice adopted by the farmers leave less time for field preparation between rice harvest during summer and sowing in rainy season. As a result weed infestation is more and existing pre-emergence herbicides are less effective against weeds like *panicum repens, cyperus spp* etc. Weed infestation in transplanted rice is a critical factor that reduced the yield to the extent of 15-45 per cent (Chopra and Chopra 2003). Keeping these points in view, the present investigation was under taken to study the effect of combination of herbicides and to develop economic methods of the new herbicide for transplanted rice.

METHODOLOGY

The field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka, during rainy seasons of 2011-12. The treatments are as follows; T_1:butachlor 50 EC (1500 g a.i/ha) applied at 5 DAT, T_2: penoxulam (1.02 % wv) + cyhalofop-butyl w/w (5.1% ww) (5.0 wv) (120 g a.i/ha) applied at 15 DAT, T_3: penoxulam (1.02 % wv) + cyhalofop-butyl w/w (5.1% ww) (5.0 wv) (135 g a.i/ha) applied at 15 DAT. T_4: bispyribac sodium (100 g LSC) (35 g a.i/ha) applied at 15 DAT, T_5: 2 hand weeding at 20 & 40 DAT and T_6: non-weeded control. As per the treatment, herbicide combination was sprayed using Knapsack sprayer with a spray volume of 500 l/ha. Observations on weed dry weight (g /m^2), weed control efficiency and yield were recorded and statistically analyzed at 5% level of significance.

Table 1. Yield and yield components of rice as influenced by weed management practices

Treatment		Dosage (g/ha)	Time of application (DAT)	No. of weeds/ m^2	Weed dry wt.(g)	Weed Control efficiency (%)	Panicle No./ m^2	Panicle weight (g)	Grain yield (kg/ha)
T_1	Butachlor 50 EC	1500	5	4.85	3.24	20.98	391	3.66	5049
T_2	Penoxulam (1.02% wv)+Cyhalofop-butyl w/w (5.1% ww) (5.0wv)	120	15	4.19	2.93	28.54	411	3.86	5308
T_3	Penoxulam (1.02% wv)+Cyhalofop-butyl w/w (5.1% ww) (5.0 wv)	135	15	3.49	2.49	39.27	455	4.25	6640
T_4	Bispyribac sodium (100g LSC)	35	15	3.8	3.05	25.61	428	4.04	5714
T_5	Two hand weeding	-	0 & 40	3.47	2.36	42.44	442	4.13	6266
T_6	Non weeded control	-	-	5.71	4.1		285	3.28	3831
SEm.(±)				0.23	0.13		14.55	0.13	303.8
LSD (P=0.05)				0.69	0.4		43.87	0.39	914.2

Original values of weed data is missing. Type of transformation followed is to be mentioned in the foot note.

RESULTS

The application of penoxulam (1.02% wv) + cyhalofop-butyl w/w (5.1% ww) 5.0 wv herbicide 135 g/ha at 15 DAT recorded higher grain yield (6640 kg/ha), lower number of weeds /m^2 (3.49/m^2), lower weed dry weight (2.49 g), followed by hand weeding twice at 20 & 40 DAT (3.47 /m^2 and 2.36 g) compared to the non weeded control (5.71/ m^2 and 4.1 g respectively). Weed control efficiency was higher in hand weeding at 20 and 40 DAT (42.44 %) followed by application of penoxulam (1.02% wv) + cyhalofop-butyl w/w (5.1% ww) 5.0 wv herbicide 135 g a.i/ ha at 15 DAT (39.27%) and the lowest was noticed with the application of butachlor 50 EC (20.98%). The findings of the present study are in accordance with those of Jadhav *et al.* (2008).

CONCLUSION

The study finally concluded that combined application of penoxulam + cyhalofop-butyl herbicide 135 g/ha at 15 DAT was found to be effective for control of the weeds in transplanted rice

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Efficiency of herbicide combinations for managing complex weed flora in transplanted rice

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Rice (*Oryza sativa* L.) is the world's most important food crop catering half of the world's population. Weeds in transplanted rice grow faster than and absorb available water, nutrient earlier than the rice and suppress rice growth. The use of herbicides offer selective and economical control of weeds right from the beginning, giving crop an advantage of good start and competitive superiority. Effective control of weeds had increased the grain yield by 85.5% (Mukherjee and Singh 2005). Single application of herbicide may provide effective control of weeds, but continuous use of such herbicides leads to the evolution of weeds resistant to several herbicides. Persistence of the herbicides in the field is only upto 30 DAT. Under such situations application of herbicide either as mixture or sequence may be useful for broad spectrum weed control in transplanted rice. Keeping this in view, a field experiment was carried out to evaluate the effect of herbicide applied in combination as well as in sequence for managing complex weed flora in transplanted rice.

METHODOLOGY

An experiment was conducted during *Rabi* 2012-13 at Agriculture College and Research Institute, Madurai to study the effect of herbicide applied in mixtures and sequence for managing complex weed flora in transplanted rice. A set of 15 treatments was laid out in random block design with three replications. The pre-emergence herbicides (butachlor, pretilachlor, pyrazosulfuron and pretilachlor + bensulfuron) were applied at 3 DAT. Post–emergence applications of bispyribac-Na, chlorimuron ethyl + metsulfuron methyl, ethoxysulfuron were done at 25 DAT. Combination and sequential application of pre and post emergence herbicide along with hand weeding were provided at an interval of 25DAT and 25 and 45 DAT respectively. Rice variety 'ADT 49' was transplanted at a spacing of 20 x 15 cm with recommended dose of 150 kg N, 50 kg P_2O_5 and 50 kg K_2O /ha.

RESULTS

The predominant weeds of the experimental plot were *Echinocloa crusgalli* and *Panicum repens* (among grasses), *Cyperus rotundus*, *Cyperus iria* and *Fimbristylis milliaceae* (among sedges) and *Sphenoclea zeylanica* and *Eclipta alba* (among broad-leaved weeds). All the weed control treatments caused significant reduction in total weed density and weed DMP when compared to unweeded control. Tank mixture application of bispyribac-Na and chlorimuron ethyl + metsulfuron methyl at 25 + 4 g /ha reduced the weed count upto 23.17 /m^2 and weed DMP to 51.53 kg/ ha and increased the WCE of 92% on 60 DAT. This was at par with the sequential application of pretilachlor fb chlorimuron ethyl + metsulfuron methyl 750 + 4 g /ha with the weed count of 27.15 /m^2, weed DMP (60.39 kg/ha) and WCE (91%) on 60 DAT (Table 1). This might be due to the fact that the use of two or more herbicides in combination provided broad spectrum weed control.

Table1. Weed growth, yield and economics of rice as influenced by different herbicide combinations.

Treatment	Weed density (No/m^2)	Weed dry matter (Kg/ha)	WCE (%)	Plant DMP (kg/ha)	Grain yield (t/ha)	B:C ratio
Pre-emergence butachlor alone on 3 DAT	10.27 (105.03)	15.29 (233.44)	66.2	2803	5.1	2.62
Pre-emergence pretilachlor alone on 3DAT	11.09 (122.52)	16.51 (272.29)	60.6	2745	5.0	2.54
Pre-emergence pyrazosulfuron alone on 3DAT	9.75 (94.71)	14.52 (210.52)	69.6	2989	5.2	2.7
Pre-emergence pretilachlor +bensulfuron (0.6 %) 6.6 % GR alone on 3DAT	7.97 (63.84)	11.86 (140.37)	79.7	3234	5.3	2.59
Post-emergence bispyribac-Na alone on 25 DAT	7.48 (55.54)	11.13 (123.45)	82.2	3542	5.6	2.73
Post- emergence chlorimuron ethyl + metsulfuron methyl alone on 25 DAT	6.95 (47.85)	10.33 (106.37)	84.6	3649	5.6	2.89
Pre-emergence bispyribac-Na +post-emergence chlorimuron ethyl + metsulfuron methyl on 25 DAT	4.86 (23.17)	7.21 (51.53)	92.6	4210	6.3	3.11
Post- emergence bispyribac-Na + ethoxysulfuron on 25 DAT	6.51 (41.99)	9.68 (93.35)	86.5	3428	5.4	2.61
Post-emergence pretilachlor + ethoxysulfuron on 25 DAT	6.35 (39.84)	9.43 (88.57)	87.2	3478	5.5	2.76
T10-Pre-emergence pretilachlor fb post-emergence chlorimuron ethyl + metsulfuron methyl on	5.25 (27.15)	7.80 (60.39)	91.3	3962	6.0	3.03
Pre-emergence butachlor fb post-emergence chlorimuron ethyl + metsulfuron methyl on 25 DAT	6.95 (47.86)	10.33 (106.40)	84.6	3357	5.4	2.72
Pre-emergence pyrazosulfuron fb manual weeding on 25 DAT	6.99 (48.39)	10.39 (107.56)	84.5	3708	5.6	2.69
Pre-emergence butachlor fb manual weeding on 25 DAT	6.62 (43.44)	9.85 (96.55)	86.0	3718.8	5.7	2.75
Hand weeding twice at 25 and 45 DAT	6.08 (36.53)	8.66 (74.54)	88.3	3932	5.8	2.46
Control	17.65 (311.23)	32.21 (1037.44)	-	2018	3.2	1.76
LSD (0.05)	0.20	0.17	-	119	124	-

*Values in parantheses are original. Data transformed to square root transformation

The increased grain yield clearly indicated the influence of weed free environment on grain production. Herbicide combination of bispyribac-Na and chlorimuron ethyl + metsulfuron methyl recorded higher grain yield of 6.3 t / ha. The effective control of weeds starting from the early growth stage might have resulted in better growth and yield of rice. The variation in grain yield (Table 1) under different treatments was the result of variation in weed density and weed biomass. This is in conformity with the findings of and Mukherjee and Maity (2011). Different weed control methods involved different amount of cost which affected the total cost of cultivation of transplanted rice. From the computation of weed control it was observed that the maximum cost of weed control was required for hand weeding twice at 25 and 45 DAT with a B:C ratio of 2.46, which was due to maximum labour requirement. It was revealed that application of herbicide mixture of bispyribac-Na and almix registered lower cost of cultivation with B:C ratio of 3.11.

CONCLUSION

Based on the study it was concluded that, application of herbicides in combination as mixtures was found to have effective broad spectrum control of complex weed flora in transplanted rice ecosystem. The tank mixture application of bispyribac-Na and chlorimuron ethyl + metsulfuron methyl on 25 DAT was found to be agronomically feasible and economically viable weed management practice for transplanted rice.

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Chemical weed management in transplanted rice using new molecules

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Unlike other cereal crops, rice suffers more from weed competition. Yield loss due to uncontrolled weed growth in transplanted rice ranges from 16-86% (Aurora and De Datta, 1992). In order to realize maximum benefit of applied monetary inputs, weed control at critical stage of crop-weed competition is inevitable. Hand weeding is commonly followed to control weeds in this crop. However, continuous rains during cropping season, scarcity and high wages of labour, particularly during peak period and early crop-weed competition make this operation difficult and uneconomic. Different herbicides are thus used alone or in combination to eliminate weeds but their efficiency differ because of their narrow spectrum of weed control. Application of herbicide mixtures is useful, particularly in the absence of an effective broads-spectrum herbicide in rice to control highly diverse population of weed flora, consisting of grasses, broad leaved weeds and sedges (Rao and Singh 1997).

Keeping this in view, a field experiment was conducted at Andhra Pradesh Rice Research Institute, Maruteru, West Godavari district, Andhra Pradesh during *Kharif* season for three consecutive years from 2011 to 2013 to develop easy and economic methods of chemical weed control by making use of new herbicides in transplanted rice. The experiment consisting of six treatments, *viz*. pre emergence application of butachlor (50 EC) 1500 g/ha at 5-7 days after transplanting and post emergence application of penoxsulam 1.02 w/v + cyhalofop –butyl 5.1% w/w (5.0 w/v) at 120 g/ha, penoxsulam 1.02 w/v + cyhalofop –butyl 5.1% w/w (5.0 w/v) at 135 g/ha at 15-20 days after transplanting *i.e.* 2-5 leaf stage, post emergence spraying of bispyribac sodium 35 g/ha at 15-20 days, Need based hand weeding and un-weeded control.

The three years of the study indicated that, all the herbicides tested in transplanted rice gave significantly higher grain yield over un-weeded check. The new herbicides penoxsulam + cyhalofop butyl at 2 doses (120 and 135 g/ha) controlled weeds effectively and recorded higher grain yield of 5.87 kg/ha and 6.02 t/ha respectively (3 years mean) over un-weeded check (4.52 t/ha) and were on par with bispyribac sodium 35 g/ha (5.71 t/ha) and need based hand weeding (6.01 t/ha). Data on weed dry weight indicated that spraying of herbicides significantly controlled the weeds and recorded less weed biomass of 54 and 53 g/m^2 at flowering stage of the paddy crop when penoxsulam+ cyhalofop butyl at 2 doses 120 and 135 g/ha respectively. This was followed by spraying of bispyribacsodium (59 g/m^2) and spraying of butachlor (65 g/sq m). Whereas, the weed dry weight was 31 g/ m^2 in need based hand weeding and 109 g/m^2 in unweeded control. All the herbicide treatments resulted in higher panicle number and panicle weight by virtue of more weed control efficiency.

Bio-efficacy and phytotoxicity of pyrazosulfuron-ethyl + pretilachlor of direct-seeded puddled rice

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Weed is as old as agriculture and from the very beginning farmers realized the interference of weed with crop productivity. The risk of yield loss from weeds in direct-seeded rice is greater than transplanted rice. Scientists working on weed management in direct seeded rice opined that ecosafe herbicide may be a sustainable alternative to hand weeding. Herbicide ready mixture recently shows more bioefficacy in controlling all types of weed flora in different field crops.

METHODOLOGY

The experiment was conducted during *Kharif*, 2012 and 2013 at Kalyani 'C' Block Farm, BCKV, West Bengal. The experimental soil was sandy loam with a soil pH of 6.79. Nine treatments in direct seeded puddled paddy (variety - IET 4786) were used (spacing of 25 cm x 20 cm in a plot size of 6 m x 3 m) in RBD replicated thrice. Recommended fertilizer dose of N:P:K 60:30:30 kg/ha were applied. The herbicide mixture pyrazosulfuron-ethyl 0.75% + pretilachlor 30% WG with different doses along with standard chlorimuron ethyl + metsulfuron methyl and sole pyrazosulfuron ethyl (PSE) were applied as POE. Pretilachlor 50 EC another standard check was applied as PE besides weedy check and farmers practice (Table 1). Weed biomass, density and weed control efficiency (WCE) were recorded at 7 and 30 DAA along with phytotoxicity on rice, yield parameters, biological yield and soil micro flora.

RESULTS

Among the treatments, the two higher doses of pyrazosulfuron-ethyl 0.75% + pretilachlor 30% WG 1.75 and 3.5 kg/ha showed better management of weed flora than the other treatments (Table 1). Pyrazosulfuron-ethyl 0.75% + pretilachlor 30% WG 3.5 and 1.0 kg/ha applied as POE recorded the highest (78.2%) and lowest (64.5%) WCE at 7 DAA respectively. Similar trends were also observed at 30 DAA. The maximum grain yield was recorded from pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG at 3.5 kg/ha (2.93 t/ha) while the minimum was from the untreated control (1.91 t/ha). The testing herbicide pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG applied at highest dose showed at par biological yield with farmers' practice. No phytotoxicity was observed against any of the testing or standard herbicide treatments. The population of soil micro flora did not show any harmful effect excepting at initial 3 weeks after herbicides application (Fig. 1). Similar results were obtained by Mahajan *et al.* 2009.

Table 1. Effect of treatments on weed control efficiency and yield of direct seeded rice during 2012-13.

Treatment	Formulated Dose/ha	Weed control efficiency (%)		Yield (t/ha)	
		7 DAA	30 DAA	Grain	Straw
Untreated Control	-	-	-	1.91	3.15
Pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG	1.00 kg	64.53	64.31	2.52	3.69
Pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG	1.50 kg	69.35	69.79	2.65	3.87
Pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG	1.75 kg	75.84	75.28	2.71	3.96
Pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG	3.50 kg	78.25	77.69	2.93	4.07
Pyrazosulfuron ethyl (PSE) 10 WP	300.00 g	74.05	72.79	2.83	4.05
Pretilachlor 50 EC	1500.00 ml	71.23	70.30	2.44	3.55
Standard Check - chlorimuron ethyl + metsulfuron methyl 20 WP	20.00 g	68.97	70.90	2.62	3.81
Farmers' practice - bispyribac sodium (BPS)10 SC + hand weeding at 40 DAT	250.00 g	69.60	68.93	2.92	4.11
LSDD (P=0.05)		-	-	0.05	0.07

CONCLUSION

It is concluded that pyrazosulfuron ethyl 0.75% + pretilachlor 30% WG applied at 3.5 kg/ha recorded significantly higher control of the weeds, weed control efficiency and grain yield of the direct seeded rice over other testing herbicides. No phytotoxicity in direct seeded rice plants was observed in any of the doses of the testing chemicals in their application.

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Rice roots are more plastic than barnyard grass to take up phosphorus and moisture when they are co-limited in the soil

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Weed competition affects growth and yield of rice (*Oryza sativa* L.). Increased abundance of grassy weeds would lead to limitations in water and phosphorous (P) availability, which are closely interrelated (Kleinig and Noble 1968). This study investigated the impact of P placement depth and different soil moisture regimes on competitive effects of barnyard grass [C_4 weed; *Echinochloa crusgalli* (L.) Beauv.] on early growth of rice.

METHODOLOGY

Two experiments were carried out in the glasshouse at the University of Peradeniya, Sri Lanka. The main experiment was conducted in cylindrical pots (15 cm diameter, 70 cm height) filled with P-deficient soil (Olsen-P 1.3 mg/kg) in a replacement series with different plant combinations, *i.e.* rice (R) and barnyard grass (BG) monocultures (four plants per pot; R-R or BG-BG), and a mixture of R+BG (two plants of each species per pot). The plant combinations were coupled with two P-placement depths (top soil: 0-5 cm and sub-soil: 15-20 cm from soil surface), and three moisture treatments namely, (1) continuous flooding (CF) - 3 cm water level above soil surface, (2) top soil drying (TSD) from anthesis – the middle soil layer of the pot kept moist through capillary action and (3) alternate wetting and drying (AWD) - continuous flooding was until tillering and then watered at 12 day intervals. The pots were maintained until crop maturity.

A rhizobox experiment supplemented the main experiment to study the root system plasticity to soil P-placement depths during initial growth stages of R and BG (*i.e.* 14 and 28 days after germination). Treatments were arranged in a three-factor factorial in the main experiment and two-factor factorial in the rhizobox in a complete randomized design (CRD) with three replicates. Shoot and root dry weights (DW), tissue P concentrations and P uptake per pot were measured.

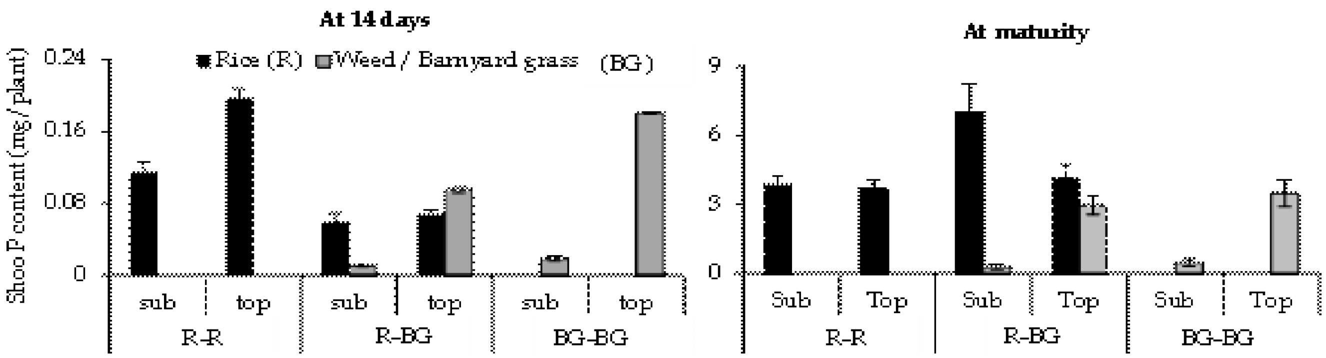

Fig. 1. Shoot P content at 14 days (rhizobox) and maturity (cylindrical pots) in rice (R - in black bars) and barnyard grass (BG - in gray bars) when grown in monocultures (R-R or BG-BG) or in mixture (R+BG) with application of P to sub (15-20 cm) or top (0-5 cm) soil. [Note: At maturity moisture treatments had no effect and hence marginal means are presented. Scale in the Y axis is different (mean± s.e., n=4)].

RESULTS

Weed competition is accelerated at high levels of P application (Kleinig and Noble 1968). In the rhizobox experiment, shoot and root DWs of BG were reduced by 70% and 45% at 14 days and by 85-91% and 60-75% at 28 days, respectively, when P was supplied to sub-soil than to top soil (Fig. 1). There was no significant impact on R. Similar response was observed in the main experiment. The root elongation of R increased from early growth stages when P was applied at 15-20 cm soil depth and reached the P-supplied soil layer. The specific root length (m/g) of R increased by more than 18% and fine root production (*i.e.* reduced diameter; < 0.4 mm) by 8% when P was applied in the sub-soil layer than to top soil. Even though root DW of R remained unchanged at sub-soil P application at AWD and CF moisture treatment combinations, in the TSD moisture condition it was increased by 20% than the top soil P applied condition.

The shoot P uptake by BG was reduced by 89 and 90% grown as R+BG and BG-BG combination, respectively and root P content was reduced by 85% in TSD and AWD moisture treatments. Moreover, the reduction of shoot and root P contents in rice was neglegible irrespective of the moisture treatment.

CONCLUSION

Rice can take the growth advantage over barnyard grass under sub-soil P placement in moisture limited soil conditions due to the presence of plastic root growth responses.

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Competitive effect of *Isachne globosa* on growth and yield of wet-seeded rice

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Weeds are the major biotic stress in rice production while act as a universal pest in agriculture. Weed management is the key factor towards achieving productivity in rice cultivation. It has been reported in Sri Lanka that 30-40% of rice yields are generally lost due to weed competition (Abeysekera and Anuruddhika 2001). Degree of loss due to weeds could be varied, depending on type of weed species, density, duration of crop weed interference, rice cultivar and cultural practices. Weeds grow quickly in direct seeded areas compared with weeds growth in wetland transplanted rice cultivation. *Isachne globosa* is one of the major noxious weed associated with the yield reduction of rice, across all agro ecological zones of the country. Even mere presence of *I. globosa* on rice field may not be economic to control and contemplate on herbicide spraying also depends on the density of weeds. Limited scientific studies have been conducted to find out the competitiveness of *I. globosa* and its effect on growth and yield of rice. Hence, the objective of this study was to find the effect of different densities of *I. globosa* on growth and yield of rice.

METHODOLOGY

A field experiment was conducted in an open ground at Rice Research and Development Institute, Batalagoda, Sri Lanka during minor season (*Yala*) from May to September 2013. Complete Randomized design (CRD) is followed with three replicates. The treatments consisted of seven different densities of *I. globosa* with a control. 90 days duration rice variety Bg 300 was used and sprouted seeds were sown with the spacing of 7.5 cm. *I. globosa* stems were planted surrounding the rice seedlings maintaining equal distance while maintaining the desired weed density. All the other agronomic and plant protection practices were adopted. Plant growth parameters were measured in two weeks interval and 56 days old weeds were uprooted to measure the dry weight. The number of panicles per square meter, number of grains per panicle, filled grain percentage, thousand grain weight and grain yield per square meter were recorded after harvest. The data were analyzed using the statistical package Minitab15. One way ANOVA, two way ANOVA and regression analysis were performed.

Table 1: Yield and yield components of rice under different weed densities

	Yield and yield components					
Weed density (weeds/ m^2)	No. of panicles / m^2	Grains/ panicle	Filled grain (%)	1000 grain weight ($*10^{-3}$kg)	Grain yield ($*10^{-3}$ kg/m^2)	% yield loss over control
0	624.33a	115.3a	94.32a	25.008a	1214.5a	0.00a
22	484.39ab	89.27ab	92.34ab	24.315a	999.7ab	17.69ab
43	419.81abc	80.07b	91.67ab	20.777ab	879.9bc	27.555bc
65	387.51abc	78.17b	90.44ab	20.971ab	821.5bc	32.358bc
86	312.16bc	69.57b	88.20ab	19.725b	798.8bc	34.228bc
108	312.16bc	68.93b	87.69ab	18.714b	777.5bc	35.983bc
129	236.81c	65.53b	84.70ab	18.72b	762.3bc	37.233bc
151	226.05c	66.27b	85.19b	17.513b	661.0c	45.573c

RESULTS

Height of rice plants showed significant (P=0.000) reduction with increase in weed densities at 4WAS. The least value observed under 151 weeds /m^2 and 43-151 weeds/m^2 showed a significant delay as per rice plant growth for the height parameter. Number of leaves and tillers were significantly (P=0.000) affected by weed competition. Weed density was significantly affected where density is above 43 plants/m^2. Growth parameters were significantly (P=0.000) affected for interaction effect of weed density and the time duration. The dry matter accumulation of weeds showed a significant (P=0.000) increase with increased weed competition.

Weed densities significantly (P=0.000) affected on the panicles/m^2 of rice. Consequently the inter-specific competition with weeds rendered the number of effective tillers. (Table 1) The number of grains per panicle and grain filling percentage was significantly (P=0.000) reduced due to the severe competitive effect of weeds. Grain yield of Bg 300 plants have showed a significant (P=0.000) negative effect with the *I. globosa* density. But increased weed density rendered the decrease rate of the yield due to interspecies competition of weeds. Weed density of *I. globosa* from 22 - 151 plants /m^2 reduces yield from 17.69-45.57% respectively.

CONCLUSION

The rice growth parameters and yield were significantly reduced at density of 22 plants/m^2 and reduction rate increases with increasing *I. globosa* densities.

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Effect of weed growth on different rice varieties in dry-seeded rice in Sri Lanka

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In Sri Lanka new local rice varieties were developed for commonly practiced wet seeded rice cultivation. Dry seeded rice establishment method is newly increasing trend among farmers due to shortage of water and reduced cost of cultivation. In dry seeded rice cultivation land is ploughed and leveled without wetting the surface, then rice is planted in seed drills. (Chauhan 2012). After planting irrigation was done and it is depending upon the availability of water. Although weeds are the major biotic stress in rice cultivation, are responsible for yield loss of >90% in dry seeded rice fields, because weeds and rice emerge simultaneously in dry-seeded systems (Chauhan *et al.* 2013). Hence the objective of this study is to evaluate the weed tolerance ability and yield loss due to weeds of the popular rice varieties under dry-seeded rice establishment method in Sri Lanka.

METHODOLOGY

A field trial was conducted at Rice Research and Development Institute, Batalagoda, Sri Lanka during 2011/12 Major and 2012 Minor seasons. Land preparation was done by one disk plough following two harrows in dry conditions. Phosphorus (50 kg P_2O_5 /ha) and potassium (22 kg K_2O /ha) were applied and incorporated in the soil. Plots were made with an area of 12 m^2. Dry seeds of six different rice varieties (Ld-365, Bg-357, Bg-352, Bg-358, Bg-366, At-362) of 105 days duration were planted at a rate of 100 kg/ha. The field was surface-irrigated after sowing. After seed germination constant standing water level of 2-3 cm was maintained. Herbicide pretilachlor + pyribenzoxim 300 + 20 g/l was sprayed 6 days after sowing (DAS) to weed free plots and they were strictly maintained without weeds by applying hand weeding when necessary. Field was arranged according to the split plot design with three replicates. Data on weed and rice plant growth, density, dry weight, yield and yield parameters were recorded.

RESULTS

Research field was dominated by grasses and sedges. Common grass species were *Leptochloa chinensis*, *Echinochloa crus-galli* and *Ischaemum rugosum*; sedge species were *Cyperus difformis*, *Cyperus iria*, and *Fimbristylis miliacea* and broadleaf weed species were *Monochoria vaginalis* and *Murdannia nudiflora.* Rice plant count and biomass was significantly affected by the weeds. In both the seasons plant count was significantly lower in weedy plots than weed free plots. Rice and weed dry biomass was taken at 42 DAS. According to rice plant biomass data, Bg-357 performed well under weedy conditions and gave high biomass of 334.92 g/m^2 (major) and 203.38 g/m^2 (minor). The 1000 grain weight was affected by weeds. Weeds are more capable of absorbing nutrients and water from soil and reduce their availability to the crop, resulting in half-filled seeds and empty seeds.

In 2011/12 major season total yield was low due to rough weather conditions and infection of diseases. With favorable weather conditions in 2012 minor season optimum yield was obtained in weed free plots (Table 1). At-362 gave the highest yield of 4.89 t/ha and 6.38 t/ha while Ld-365 gave lowest yields of 3.04 t/ha and 4.99 t/ha in weed free plots. At-362 was highly affected by the weeds and gave significantly low amount of yield of 0.56 t/ha and 0.80 t/ha in weedy plots during both the seasons.

Table 1. Rice plant dry weight 42 DAS and yield at harvest

Cultivar	Rice plant dry weight (g/m²)				Yield					
	2011/12 Major		2012 Minor		2011/12 Major			2012 Minor		
	Weedy	Weed free	Weedy	Weed free	Weedy (t/ha)	Weed free (t/ha)	Yield loss	Weedy (t/ha)	Weed free (t/ha)	Yield loss (%)
Ld-365	273.68	493.94	252.34	756.32	0.66	3.04	78.31	0.89	4.99	82.09
Bg-357	334.45	449.53	203.38	514.82	0.57	4.00	85.75	1.77	5.79	69.50
Bg-352	295.02	539.96	92.36	593.97	0.59	3.22	73.31	0.47	5.11	90.80
Bg-358	218.99	396.19	141.58	630.49	0.67	3.13	78.70	0.75	5.54	86.51
Bg-366	324.91	527.19	162.18	570.66	0.71	3.86	81.50	1.48	5.75	74.22
At-362	270.04	507.07	149.28	437.84	0.56	4.89	88.40	0.80	6.38	87.53
LSD (P=0.05)	184.75	159.34	191.8	372.28	0.74	1.19	-	1.45	0.83	-

According to the experimental results average yield loss due to weeds was nearly 80% in dry-seeded rice establishment systems.

CONCLUSION

All the selected varieties gave their optimum yield under weed free dry seeded conditions while At-362 gave the highest yield under weed free conditions and Bg-357 had the best weed competitive ability.

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Bio-efficacy of propyrisulfuron for wet-seeded rice in Sri Lanka

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Herbicides are the common weed control practice in Sri Lankan rice fields. Currently the broad spectrum herbicides are popular among farmers due to their weed control efficacy and low cost when compared to the previous used grass killer (propanil) followed by broadleaf and sedge killer (MCPA). After introduction of sulfonylurea herbicides; bispyribac-sodium has gain island wide acceptance among rice farmers within a short period due to the performance of early post emergence, broad spectrum weed controlling ability and outstanding selectivity for rice plants. However the continuous application of bispyribac-sodium in some areas has currently leads to the emergence of resistant biotypes of weeds.Propyrisulfuron reported to be a new sulfonylurea herbicide and to be effective on sulfonylurea resistant weed biotypes (Ikeda *et al*. 2011). Hence, recently developed sulfonylurea herbicide propyrisulfuron 10% SC was evaluated for its bio-efficacy in rice field.

METHODOLOGY

The experiments were conducted at the farmer field Sri Lanka, which is in the low country dry zone during 2012 major and minor seasons. Three continues seasons of bisphyribac-sodium applied and poorly weed controlled field was selected for the experiment. Propyrisulfuron was tested at the rate of 40, 50 g/ha applied at 7, 10, 15 days after sowing (DAS) of rice (var. *Bg-300*, 90 days duration). Rice was seeded at rate of 100 kg/ha. Bispyribac-sodium applied at 7, 10, 15 DAS used; control treatment together with hand weeding and no weeding treatments. Randomized Complete Block Design with three replicates were used. Other agronomic and plant protection activities followed DOA recommendations. Water was impounded to herbicide applied plots after 3 days. Grasses, broadleaved and sedges densities/dry weight were measured at 42 DAS. Visual phyto-toxicity, growth characters, yield and yield components of rice were recorded. The data were statistically analyzed using the SAS statistical software package. The treatment means were compared using the Duncan's new multiple range test at P=0.05

Table 1. Weed dry weight and yield of rice under different weed control treatments

Treatment	Grass weight (g/m^2)		Broadleaf weight (g/m^2)		Sedge weight (g/m^2)		Yield (t/ha)	
	2011/12 major	2012 minor	2011/12 major	2012 minor	2011/12 major	2012 minor	2011/12 major	2012 minor
Propyrisulfuron 40 g/ha 7 DAS	30.77bc	21.73c	13.80b	22.87b	0.87b	3.37b	2.66d	3.50bcde
Propyrisulfuron 40 g/ha 10 DAS	28.07bc	31.97b	20.70b	15.00bcd	3.47b	3.67b	3.23cd	3.10def
Propyrisulfuron 40 g /ha15 DAS	38.57b	20.63c	11.83b	4.37e	1.37b	2.57b	3.30cd	3.23cde
Propyrisulfuron 50 g/ha 7 DAS	8.10d	2.47f	2.13b	1.77e	2.23b	2.53b	4.13ab	4.13ab
Propyrisulfuron 50 g/ha 10 DAS	6.47d	2.57f	3.07b	2.30e	1.43b	1.43b	4.17ab	4.03abc
Propyrisulfuron 50 g/ha 15 DAS	7.53d	1.00f	1.30b	1.67e	1.40b	1.47b	4.17ab	4.00abc
Nominee® 30 g/ha 7 DAS	33.03bc	11.63de	11.57b	11.03cde	1.03b	2.23b	3.90bc	3.90abcd
Nominee® 30 g/ha 10 DAS	27.30c	15.37cd	14.43b	15.17bcd	1.70b	0.90b	3.80bc	3.33bcde
Nominee® 30 g/ha 15 DAS	36.67bc	18.13cd	20.00b	20.133bc	3.53b	0.77b	2.80d	3.00ef
Propanil 2700 g/ha, 7 DAS *fb* MCPA 1120 g/ha, 21 DAS	3.60d	6.73ef	5.37b	7.53de	3.37b	3.633b	4.63a	4.17ab
No Weeding	139.93a	72.33a	119.00a	90.50a	35.10a	29.50a	2.77d	2.30f
Hand Weeding	2.57d	2.23f	1.60b	3.57e	2.53b	2.07b	4.63a	4.40a

Within a column, means followed by the same letters are not significantly different by the DMRT at 5% probability level.

RESULTS

Grasses are the dominant weed flora in the experimental site in both seasons. No weeding treatment obtained the highest weed biomass in both seasons and it was highly significant from herbicide treated plots and hand weeded plots. In propyrisulfuron 50 g/ha treatments grass weed dry weight was not significantly different from propanil followed by MCPA and hand weeding treatment. Similar trend for broadleaf control was observed in propyrisulfuron 50 g/ha treatments. Sedges were controlled effectively in all the herbicide treated plots. Poor grass and sedge control was observed in bispyribac sodium applied at 10-15 DAS. It may due to increase in the emerging of bispyribac sodium resistant weeds. Further studies need to be confirmed. All herbicide treatments recorded significantly higher yield over the no weeding treatment, but not above hand weeding treatment.

CONCLUSION

Propyrisulfuron can be recommended as an effective broad spectrum herbicide to control weeds in wet seeded rice fields at the rate of 50 g/ha applied at 7-15 DAS without any adverse effect on growth and yield of rice.

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Bentazone Na salt for controlling weeds of transplanted rice

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India is the leading rice producing country in terms of area and is the second largest producer next to China. Rice is grown in 45 mha annually with a production of 90 million tonnes, contributing 45% to the total food grain production of the country. Weed competition is one of the prime yield-limiting biotic constraints in rice. Weed management is one of the major factors, which affect rice yield. Uncontrolled weeds cause grain yield reduction up to 76% under transplanted conditions (Singh *et al.* 2004). Therefore, timely weed control is imperative for realizing desired level of productivity. Accordingly, an efficient and economic weed management program is necessary to control different types of weeds throughout the cropping period. Hence it is necessary to test some high efficacy herbicides and sequential application of herbicides to control mixed weed flora in transplanted rice.

METHODOLOGY

The experiment was conducted during *Kharif* 2013 and 2014 at the "KVK FARM" (latitude: 22°93'E, longitude: 88°53'N and altitude: 9.75 m). The variety used in this experiment was Triguna. A set of 7 treatments was laid out in randomized block design with three replications. Twenty-three days old seedlings of Triguna rice variety were transplanted at a spacing of 20 cm × 15 cm. Each plot size was 5 m x 4 m. The test herbicide bentazone Na salt at 3 different dosages of 720, 960 and 1200 g/ha standards like ethoxysulfuron and oxydiargyl 15 and 80 g/ha respectively were sprayed as early post-emergence (2-3 leaf stage) and pretilachlor 500 g/ha sprayed as pre emergence to evaluate the efficacy of different doses of bentazone Na Salt in conjunction with other recommended herbicides for control of different weed flora in transplanted rice.

RESULTS

The major weeds found were *Echinochloa spp.*, *Cyperus irria, Alternanthera sessilis, Ammania baccifera, Monochoria vaginalis, Ludwigia purviflora.* Basagran at 1200 g/ha as early post-emergence herbicide reduced the weed count (7.0 /m^2) and weed DMP (6.69 g/m^2) and increased the WCE (80.13%) at 30 DAA as compared to lower doses followed by pre-emergence application of pretilachlor 50% EC and early post-emergence application of oxadiargyl 80% WP. In this study, greater weed infestation in the control plot (W_7), resulted in the lowest number of grains/panicle (70.07). The treatment W_3 produced the maximum number of grains/panicle (91.55) which was statistically superior to any other treatment mainly due to weed-free conditions in this treatment. 1000-grain weight was not significantly affected by weeding treatments. On an average, there was more than 43% reduction in the grain yield of rice due to competition with weeds in weedy plots. The highest grain yield of rice (3.96 t/ha) was obtained in W_3 treatment followed by W_6, W_2 and W_4 (3.63, 3.46, and 3.43 t/ha respectively). The highest straw yield (4.95 t/ha) was observed with W_3 which was statistically identical with W_4 (4.62 t /ha). Basagran 1200 g/ha gave higher yield of rice irrespective of their dose of application. Unweeded control registered the highest weed count /m^2 and weed DMP and lowest yield among the treatments.

Table 1. Weed dry matter and weed control efficiency and Yield as affected by different treatments (Pooled over two seasons)

Treatment	*Weed density (no./m^2)		*Weed dry matter production (g./m^2)		WCE (%)		No. of grains /panicle	1000-grain weight (g)	Yield (t/ha)	
	30 DAA	60 DAA	30 DAA	60 DAA	30 DAA	60 DAA			Grain	Straw
W_1: Bentazone Na salt 48 % 720 g/ha	4.74 (22)	5.24 (27)	3.91 (14.7)	7.81 (60.51)	56.13	43.47	82.39	20.68	3.37	4.01
W_2: Bentazone Na salt 48 % 960 g/ha	3.67 (13)	4.9 (24)	3.38 (10.9)	7.45 (55.08)	67.54	48.54	85.09	20.26	3.46	4.42
W_3: Bentazone Na salt 48 % 1200 g/ha	2.74 (7)	4.06 (16)	2.68 (6.69)	5.75 (32.58)	80.13	69.57	91.55	21.75	3.96	4.95
W_4: Ethoxysulfuron 15% 15 g/ha	4.06 (16)	5.24 (27)	3.86 (14.4)	7.99 (63.37)	57.11	40.79	83.67	20.19	3.43	4.62
W_5: Oxadiargyl 80% 80 g/ha	3.54 (12)	4.87 (23)	3.24 (9.98)	7.35 (53.03)	70.36	50.46	79.14	20.51	3.38	4.29
W_6 : Pretilachlor 50% 500 g/ha	3.24 (10)	4.57 (20)	3.05 (8.86)	6.13 (37.11)	73.69	65.33	84.36	20.29	3.63	4.48
W_7 : Control (no weeding)	6.52 (42)	8.76 (76)	5.85 (33.6)	10.37 (107.0)	-	-	70.07	19.75	1.77	3.32
LSD (P=0.05)	0.87	0.71	0.217	0.542	-	-	0.351	NS	0.536	0.493

*Data subjected to square root transformation; values in parentheses are original

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Management of mixed weed flora in transplanted basmati rice

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Himalayan foot hill plains fall in the Jammu region of Jammu and Kashmir State in India naturally endowed with peculiar climatic conditions congenial for the cultivation of world's best aromatic rice (*Oryza sativa* L.). Traditionally, the basmati rice crop is raised by transplanting method in the region. However, late onset of monsoon and occurrence of dry spells of varying lengths during the crop season, as experienced in the past couple of years, has resulted in to the resurgence of mixed weed flora in the rice fields. Therefore, even under transplanted conditions weeds have attained a status of major limiting factor in the production of basmati rice, if not properly managed can reduce the yield up to 30-70%. Farmers in Jammu region generally apply butachlor for controlling weeds in rice. Butachlor only controls grassy weeds and its efficacy greatly affected with the availability of water during and after its application. Pretilachlor and metsulfuron methyl are known to be effective against most of the annual grasses, sedges and broad-leaved weeds, respectively in rice. However, meager information is available about the application of pretilachlor as pre-emergence fb metsulfuron methyl at 25-30 days after transplanting (DAT) to manage mixed weed flora in rice in foot hill plains of Jammu region., hence the present investigation was undertaken.

METHODOLOGY

On Farm Trials (OFTs) were carried out during *Kharif* 2012 at five locations in the farmers fields in Kathua district of Jammu and Kashmir to test the efficacy of pretilachlor and metsulfuron methyl against mixed weed flora in transplanted basmati rice. Three treatments consisting of conventional herbicide butachlor (farmers practice) along with pretilachlor alone and pretilachlor fb metsulfuron methyl were arranged. The data from all the locations was collected and expressed as averaged data. Basmati rice variety '*Pusa-1121*' was transplanted in the farmers fields with recommended package of practices. Fertilizers were applied uniformly through urea, diammonium phosphate and muriate of potash 120 kg N, 60 kg P_2O_5 and 30 kg K_2O /ha, respectively. Data on weed growth, yield performance and economics were recorded.

RESULTS

Grassy weeds were predominant (55%), followed by broad-leaved (30%) and sedges (15%). *Echinochloa crusgalli* among the grassy weeds, *Caesulia axillaris* among the broad-leaved weeds and *Cyperus iria* among the annual sedges were more dominant. All the herbicidal treatments variedly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest weed density (6.0 /m^2) was observed under pretilachlor 0.75 kg/ha *fb* metsulfuron methyl 8 g/ha applied at 3 DAT and 35 DAT, respectively followed by pretilachlor 0.75 kg/ha alone (17 /m^2) (Table 1). The minimum weed dry weight was also recorded in these treatments, which was lower than butachlor 1.5 kg/ha (farmers practice). These results are in conformity with the findings of Gopinath *et al.* (2012).

Table 1. Weed growth, grain yield and straw yield of basmati rice as influenced by different herbicides

Treatment	Weed density* (no./m^2)	Weed dry matter* (g/m^2)	Grain yield* (t/ha)	Straw yield* (t/ha)
Butachlor 1.5 kg/ha (farmers practice)	58.0	14.5	2.85	4.00
Pretilachlor 0.75 kg/ha	17.0	5.3	3.53	5.03
Pretilachlor 0.75 kg/ha fb metsulfuron methyl 8 g/ha	6.0	0.4	4.0	5.50

*Data presented in the table is average of 5 locations.

The highest grain yield (4.0 t/ha) was recorded with pretilachlor 0.75 kg/ha fb metsulfuron methyl 8 g/ha and the lowest (2.85 t/ha) was under butachlor 1.5 kg/ha (farmers practice). The yield loss due to uncontrolled growth of weeds as compared to the treatment with pretilachlor 0.75 kg/ha *fb* metsulfuron methyl 8 g/ha was 40.4%. The maximum straw yield (5.50 t/ha) was recorded in pretilachlor 0.75 kg/ha *fb* metsulfuron methyl 8 g/ha and the lowest (4.0 t/ha) in butachlor 1.5 kg/ha (farmers practice).

CONCLUSION

It was concluded that pre-emergence application of pretilachlor 0.75 kg/ha at 3 DAT fb post-emergence application of metsulfuron methyl 8 g/ha at 35 DAT was most effective for controlling mixed weed flora and improving grain yield of transplanted basmati rice.

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Weed management in transplanted rice through broad-spectrum herbicides

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In Chhattisgarh, rice occupies average of 3.6 million ha with the productivity of the state ranging between 1.2-1.6 t/ha depending upon the rainfall. Weeds cause 28-55% yield losses in transplanted rice (Kumar *et al*. 2008, Yadav *et al* 2009). One of the major constraints in rice production is the poor management of weeds in transplanting rice. Therefore, the present investigation, weed management in transplanted rice (*Oryza sativa*) through broad-spectrum herbicides which kills weed or control of sedges, grasses and broad leaved weeds was undertaken.

METHODOLOGY

The field experiment was conducted during *Kharif* 2014 at the Research Farm, IGKV, RMD College of Agriculture and Research Station, Ambikapur, Surguja (C.G.). The experiment was laid out in randomized block design with three replication. Ten treatments consisted, *viz*. bispyribac sodium 25 g/ha post-em (20-25 DAT), azimsulfuron 35 g/ha post-em (20-25 DAT), penoxsulam 20 g/ha post-em (20-25 DAT), pyrazosulfuron 20 g/ha pre-em (0-3 DAT), pyrazosulfuron 20 g/ha pre-em (0-3 DAT) *fb* clorimuron + metsulfuron 4 g/ha post-em (20-25 DAT), pretilachlor + bensulfuron (G) 660 g/ha pre-em (0-5 DAT), fenoxaprop-p-ethyl + ethoxysulfuron (tank mix) 100 + 15 g/ha PoE (20-25 DAT), mechanical weeding at 20 and 40 DAT, hand weeding at 20 and 40 DAT and unweeded check. Rice variety pro-agro-6444 was transplanted on 24th July, 2014 with recommended agronomic and plant protection measures .

RESULTS

All the weed management practices at 30 and 60 DAP and at harvest significantly reduced the density and dry weight of weeds. Among the weed management practices, pre emergence application of pyrazosulfuron 20 g/ha *fb* clorimuron + metsulfuron 4 g/ha as a post-emergence was found to be the most effective weed management practice in reducing the density and dry weight of weeds with higher weed control efficiency, higher yield attributes and yield (5.80 t/ha) including benefit : cost ratio (2.60) but it was at par with two mechanical weeding at 20 and 40 days after transplanting , two hand weeding at 20 and 40 days after transplanting, pre emergence application of pretilachlor + bensulfuron 660 g/ha PE (0-5 DAT), pyrazosulfuron 20 g/ha or post-emergence application of bispyribac sodium 25 g/ha or penoxsulam 20 g/ha. The reduction in grain yield due to heavy weed infestation in unweeded check was 40% compared to best weed management practice. Post emergence application of azimsulfuron 35 g/ha was found effective in controlling sedges in transplanted rice.

Table 1. Weed control efficiency and grain yield in transplanted rice as influenced by weed management practices

Treatment		WCE %	Grain yield (t/ha)
1	Bispyribac sodium 25 g /ha post-em (20-25 DAT)	63.0	5.44
2	Azimsulfuron 35 g/ha post-em (20-25 DAT)	45.5	5.10
3	Penoxsulam 20 g /ha post-em (20-25 DAT)	58.8	5.55
4	Pyrazosulfuron 20 g/ha pre-em (0-3 DAT)	69.0	5.48
5	Pyrazosulfuron 20 g/ha pre-em (0-3 DAT) fb chlorimuron + metsulfuron 4 g/ha post-em (20-25 DAT)	84.0	6.30
6	Pretilachlor + bensulfuron (G) 660 g/ha pre-em (0-5 DAT)	68.0	5.48
7	Fenoxaprop-p-ethyl + ethoxysulfuron (tank mix) 100+15 g /ha post-em (20-25 DAT)	50.4	4.90
8	Mechanical weeding at 20 & 40 DAT	83.9	6.20
9	Hand weeding at 20 & 40 DAT	82.0	5.96
10	Unweeded check	-	4.49

CONCLUSION

Amongst the various weed management treatments, new herbicides at lower doses pyrazosulfuron 20 g/ha *fb* clorimuron + metsulfuron 4 g/ha was found to be the most effective weed management practice in reducing the density and dry weight of weeds with higher weed control efficiency, higher yield attributes and yield including benefit : cost ratio and pre emergence application of pretilachlor + bensulfuron 660 g/ha PE or pyrazosulfuron 20 g/ha or post emergence application of bispyribac sodium 25 g /ha or penoxsulam 20 g/ha is cost effective and sustainable for managing weeds in rice fields.

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Effect of different weed management practices in transplanted rice cultivation

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Rice is cultivated in India in a very wide range of ecosystems from irrigated to shallow lowlands, mid-deep lowlands, deep water to uplands. Transplanting is the major method of rice cultivation in India. Irrespective of the method of rice establishment, weeds are a major impediment to rice production through their ability to compete for resources and their impact on product quality. In transplanted rice bispyribac sodium is a suitable and economical herbicidal weed management (Veeraputhiran *et al.* 2013). With the view point of weed management this field experiment was conducted during the *Kharif* 2013-14 on sub-humid sub-tropical lateritic belt of Agricultural farm, Palli Siksha Bhavana (Institute of Agriculture) at Visva-Bharati, Sriniketan, India to test the effect of different weed management practices in transplanted rice cultivation.

METHODOLOGY

The experiment was conducted in the Randomised Block Design having three replications with the following nine treatments bispyribac sodium 20 g/ha at 25 DAT (T_1), bispyribac sodium 25 g/ha at 25 DAT (T_2), bispyribac sodium 30 g/ha at 25 DAT (T_3), cyhalofop-butyl 90 g/ha at 15 DAT followed by 2,4-D 1.0 kg/ha at 30 DAT (T_4) , cyhalofop-butyl 90 g/ha at 15 DAT followed by metsulphron-methyl + chlorimuron-ethyl 4 g/ha at 30 DAT(T_5) , butachlor 1.5 kg/ha at 3 DAT followed by 2,4-D 1.0 kg/ha at 30 DAT (T_6), butachlor 1.5 kg/ha at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g/ha at 30 DAT (T_7), farmer's practice (T_8), weedy check (T_9). Rice variety "*MTU-1010*" was transplanted in the experimental field with recommended package of practices.

RESULTS

From the field experiment it was observed that hand weeding at 20 and 40 DAT plot recorded the tallest plant which was followed by application of bispyribac sodium 30 g/ha at 25 DAT. Higher weed control efficiency (%) and lower weed index (%) values were obtained with the application of bispyribac sodium 30 g/ha at 25 DAT and bispyribac sodium 25 g/ha at 25 DAT among herbicide treated plots. Lowest sterility percentage of grains was recorded in hand weeding at 20 and 40 DAT plot and among herbicide treated plots lowest sterility percentage were obtained under sole application of bispyribac sodium 30 g/ha at 25 DAT. Highest grain yield was obtained with hand weeding twice at 20 and 40 DAT. Among herbicide treated plots, bispyribac sodium 30 g/ha at 25 DAT recorded the highest grain yield which was statistically at par with the grain yield of bispyribac sodium 25 g/ha at 25 DAT and bispyribac sodium 20 g /ha at 25 DAT .

Table 1. Effect of weed management on plant height, weed control efficiency, weed index, sterility percentage and grain yield in transplanted rice cultivation

Treatment	Plant height at harvest (cm)	Weed control efficiency (%)	Weed index (%)	Sterility (%)	Grain yield (kg/ ha)
Bispyribac sodium 20g/ha at 25 DAT	95.87	88.71	13.49	17.49	4998
Bispyribac sodium 25g/ha at 25 DAT	97.16	89.56	10.39	16.21	5176
Bispyribac sodium 30g/ha at 25 DAT	98.43	90.84	3.94	15.20	5549
Cyhalofop-butyl 90g/ha at 15 DAT followed by 2,4-D 1kg/ha at 30 DAT	91.58	84.83	24.25	20.32	3772
Cyhalofop-butyl 90g/ha at 15 DAT followed by metsulfuron-methyl + chlorimuron-ethyl 4g/ha at 30 DAT	94.77	86.21	34.71	19.62	4376
Butachlor 1.5kg/ha at 3 DAT followed by 2,4-D 1kg/ha at 30 DAT	87.69	78.31	34.97	24.87	3391
Butachlor 1.5kg/ha at 3 DAT followed by metsulfuron-methyl + chlorimuron-ethyl 4g/ha at 30 DAT	89.53	81.91	41.30	21.51	3757
Farmers parctice	102.43	97.82	-	10.56	6143
Weedy check	85.24	-	48.74	29.55	2961
LSD (P=0.05)	5.06	-	-	2.63	575.57

DAT- Days after transplanting

CONCLUSION

So it can be concluded that, the test herbicide bispyribac sodium being effective at both doses, it is economical to adopt the recommendation of lower dose of 25 g/ha at 25 DAT to the rice framers of red and lateritic zone of West Bengal for mixed weed flora management. Application of cyhalofop-butyl 90 g/ha at 15 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 30 DAT can be a promising alternative to bispyribac sodium 25 g/ha at 25 DAT.

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Performance of aerobic rice under integrated weed management practices in Telangana

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Aerobic rice (*Oryza sativa* L.) is a new concept wherein the crop is established *via* direct seeding in non-puddled, non-flooded fields and managed intensively as an upland crop and is one of the most promising approaches to water-saving However, aerobic rice systems are subject to greater weed pressure than conventional production systems due to early emergence and rapid growth of weeds along with initially slow growing crop seedlings results in severe crop-weed competition. Weeds are perceived to be the most severe constraint to upland and aerobic rice production A study was under taken with an objective to know the effect of integrated weed management practices in aerobic rice for weed control, yield and economics.

METHODOLOGY

The experiment was conducted at Regional Agricultural Research Station, Jagtial, Telangana on red sandy loams in rice fallows with the treatments indicated in Table.1 for two years. Azimsulfuran and 2,4-D were applied as post-emergence weedicide when weeds were in 2-3 leaf stage at 25-30 days after sowing (DAS). The treatments with plot size of 6 m x 4 m were replicated thrice in randomized block design. The rice (*Jagtiala Sannalu*) was sown during July in dry soil after 2-3 times ploughing with 300 seeds/m^2 (40 kg/ha) in 22.5 cm rows

RESULTS

The predominant weed flora observed in the experimental field were *Echinochloa colonum*, *E. crusgalli*, *Ageratum conyzoides*, *Commelina benghalensis*, *Portulaca oleracea* and *Cyperus rotundus* (sedge) as reported by Mishra and Singh (2007). Application of pendimethalin 3.3 l/ha as pre-emergence (PE) recorded significantly lower weed number and dry matter at 20 DAS than other treatments and was on par with pre emergence application of oxydiargyl 87.5 g/ha and resulted in higher weed control efficiency (Table 1). Application of azimsulfran 70 g/ha at 25-30 DAS in sequence with PE application of pendimethalin or oxydiargyl or pretilachlor recorded significantly lower weed number and dry matter at 55 DAS compared to application of 2,4-D 1.5 kg/ha and was on par with two hand weedings (at 20 and 35 DAS) and premergence weedicide followed by (*fb*) hand weeding at 35 DAS and resulted in higher weed control efficiency. Grain yield (4.53 t/ha) with application of pendinethalin 3.3 l/ha pre-emergence *fb* azimsulfuran 70 g/ha at 25-30 DAS recorded was comparable with that of application of pendinethalin 3.3 l/ha or oxydiargyl 87.5 g/ha as PE *fb* hand weeding at 35DAS (4151 and 4.11 t/ha) and was significantly higher than rest of the treatments (Table 1). Net returns and B:C ratio recorded with pre emergence application of pendinethalin 3.3 l/ha *fb* azimsulfuran 70 g/ha at 25-30 DAS was comparable with hand weeding at 20 and 35 DAS and was significantly higher than rest of the treatments (Bhurer *et al.* 2013).

Table 1. Performance of aerobic rice under different weed management practices during *Kharif* (mean of two years)

Treatment	Weed no./m^2	Weed dry weight (g/m^2)	WCE (%)	Grain yield (kg/ha)	Net returns (Rs./ha)
	55 DAS				
Pendimethalin at 3.3 L/ha Pre-E. *fb* Hand weeding (HW) at 35 DAS	5.9 (35.3)	3.4 (12.0)	93.2	4151	44376
Pendimethalin at 3.3 L/ha Pre-E. *fb* Azim. at 70 g/ha at 25-30 DAS*	6.2 (38.3)	3.1 (10.0)	94.3	4533	54699
Pendimethalin at 3.3 L/ha Pre-E. *fb* 2, 4-D at 1.5 kg/ ha 25-30 DAS*	10.3 (108.3)	5.8 (33.7)	80.9	3329	31956
Oxydiargyl at 87.5 g/ha Pre-E. *fb* HW at 35 DAS	7.2 (52.0)	3.3 (10.7)	94.0	4116	45084
Oxydiargyl at 87.5g/ ha Pre-E. *fb* Azim. at 70 g/ha at 25-30 DAS*	6.3 (40.0)	4.6 (21.7)	87.7	3929	42741
Oxydiargyl at 87.5 g/ha Pre-E. *fb* 2.4-D at 1.5 kg/ha 25-30 DAS*	10.7 (116.3)	5.6 (31.3)	82.2	2604	17723
Pretilachlor at 1.5 L/ha Pre-E. *fb* HW at 35 DAS *	6.5 (43.7)	3.3 (11.0)	93.8	4084	44408
Pretilachlor at 1.5 L/ha Pre-E. *fb* Azim. at 70g/ha at 25-30 DAS*	6.9 (48.3)	3.7 (14.0)	92.1	3591	35978
Pretilachlor at 1.5L/ha Pre-E. *fb* 2,4 – D at 1.5 kg/ha at 25-30 DAS*	8.7 (76.0)	6.7 (49.0)	72.2	2360	13053
Hand weeding at 20 and 35 DAS	7.1 (53.0)	3.2 (10.3)	94.1	4482	51089
Weedy check	17.9 (330.0)	13.2 (176.3)	0.0-	76	-31089
LSD (P=0.05)	2.5 (67.2)	1.9 (32.7)		422	8575

* Azimsulfuron and 2, 4-D were applied as post-emergence weedicide; fb – followed by; Azim.-Azimsulfuran; PreE- Pre emergence; PoE-post emergence; WCE weed control efficiency. Figures in parentheses are actual values and data subjected to square root transformation ("x+0.5)

CONCLUSION

Based on the results obtained, it can be concluded that application of pendinethalin 3.3 l/ha as pre emergence followed by application of azimsulfuran 70 g/ha at 25-30 DAS was found to be better for higher yield and economics of aerobic rice in Telangana.

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Bio-efficacy evaluation of oxyfluorfen in wet-seeded rice in Sri Lanka

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Herbicides are important component in modern rice production system. In late 90's sulfonylurea herbicides were introduced (Abeysekera 1999) and bispyribac-sodium gained island wide acceptance among rice farmers due to it's broad spectrum weed control efficacy and outstanding selectivity for rice crop. In Sri Lanka oxyfluorfen 480 g/l is only recommended for onion. However farmers are using oxyfluorfen 480 g/l for rice cultivation without any DOA recommendation. Therefore objective of this study is to evaluate bio-efficacy and phytotoxicity of oxyfluorfen 480 g/l in wet seeded rice cultivation.

METHODOLOGY

The experiments were conducted at two farmer field locations; Polonnaruwa (Po) and Rice Research & Development Institute, Batalagoda (Bg) in Sri Lanka during 2013-14. Each plot was demarcated by 30 cm wide bunds. Fertilizer and other management practices followed the DOA recommendations. Randomized complete block design with 3 replicates and four different times of applications of oxyfluorfen 480 g/l at the rate of 150 g/ha was used against pretilachlor 300 g/l at the rate of 480 g/ha, hand weeded and non-weeded treatments. Selected rice variety *Bg-300* (90 day old) was broadcasted uniformly at the rate of 100 kg/ha.

RESULTS

The weed flora in the experimental sites mainly dominated by sedges (*Cyperus iria* and *Cyperus difformis*) in both the locations. In Polonnaruwa site *Ischaemum rugosum* was the dominant grass species, while in Batalagoda *Lepotochloa chinensis* was dominant. Additionally in Batalagoda *Monochoria vaginalis* and *Marsilea quadrifoliata* were dominant broadleaf species. Oxyfluorfen 480 g/l applied at 0 days after sowing (DAS), 2.0 DAS observed severe phytotoxic symptoms of rice leaf tip wilting, hyponasty symptoms and reduced the germination count. oxyfluorfen 480 g/l applied at 3.0 DAS and 4.0 DAS showed very low phytotoxicity on rice, slight yellowing was observed and it recovered 7 days after application. It didn't affect the germination, yield and yield components.The herbicides treated plots in both locations showed significantly reduced weed density and weed dry biomass over the non-weeded plots. Oxyfluorfen 480 g/l applied at 0.0 DAS, 2.0 DAS higher weed control efficacy was observed but new weeds emerged vigorously in 14 DAS due to more space.

Table 1. Weed dry weight and yield of rice under different herbicide control treatments

Treatment	Grass weight (g/m^2)		Broadleaf weight (g/m^2)		Sedge weight (g/m^2)		Yield (t/ha)	
	Bg	Po	Bg	Po	Bg	Po	Bg	Po
oxyfluorfen 480 g/l SC (0DAS)	9.53b	15.13ab	21.30a	9.93b	16.73b	15.70b	2.60b	1.23c
oxyfluorfen 480 g/l SC (2DAS)	7.77b	8.20bc	14.53b	6.73c	15.00b	7.70c	2.17b	2.73b
oxyfluorfen 480 g/l SC (3DAS)	1.67c	3.30c	5.77c	5.97c	8.00b	4.33c	4.30a	4.47a
oxyfluorfen 480 g/l SC (4DAS)	2.47c	9.83abc	6.87c	3.10d	9.97b	4.57c	4.10a	4.97a
Pretilachlor (3DAS)	3.33c	2.10c	2.30c	3.10d	16.93b	4.07c	4.37a	5.10a
No weeding	13.57a	18.33a	21.07a	11.33a	36.77a	24.73a	1.03c	1.03c
Hand weeding	1.57c	3.43c	1.60c	1.10e	2.23b	2.10c	4.90a	5.30a

Within a column, means followed by same letters are not significantly different by DMRT at 5% probability level

Oxyfluorfen 480 g/l applied at 3.0 DAS, 4.0 DAS recorded minimum grass, broad-leaf and sedge population. Weed dry weight was not significantly different from pretilachlor treated plots. Similar trend of results were observed in both the experimental sites. In Polonnaruwa, oxyfluorfen 480 g/l SC effectively controled *Isachne globosa, Echinochloa spp. Cyperus difformis and Cyperus iria*, while *in* Batalagoda showed higher efficacy with *Leptochloa chinensis,Cyperus iria, Monochoria vaginalis* and *Marsilea quadrifolia.* The grain yield was significantly different ($p<0.05$) among treatments in all the locations. The untreated control recorded the lowest yield following oxyfluorfen 480 g/l at 0.0 DAS and 2.0 DAS treatments. oxyfluorfen 480 g/l treated at 3.0 DAS, 4.0 DAS and pretilachlor treated plots gave significantly higher yield.

CONCLUSION

Oxyfluorfen 480 g/l (GoalTender®) at the rate of 150 g/ha applied at 3.0 and 4.0 DAS controlled weeds effectively in wide range of weed in wet seeded rice cultivation without any negative effect to the yield and yield component

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A study on effect of pre- and post-emergence herbicides in drum-seeded wet rice

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Rice is the staple food crop of densely populated tropical Asia and Africa. It is grown in 114 countries across the world with an area of 150 mha with an annual production of about 600 million tonnes constituting nearly 11% of the world's cultivated land. Among the rice cultivation methods direct seeded rice culture is subjected to greater weed competition, because both weed and crop emerge at the same time and compete with each other from the germination itself, resulting in lesser grain yield. Uncontrolled weeds reduce yield by 96% and 61% in dry and wet direct-seeded rice, respectively (Saha 2005). There should be an appropriate weed management technology coupled with precise water management for controlling the weeds.

METHODOLOGY

A field investigation was conducted during *Rabi* 2012-13 at TNAU, Madurai with thirteen treatments comprising of pre emergence herbicides in combination with post emergence herbicides, hand weeding and weedy check were arranged in randomized block design and replicated thrice. Rice was grown in sandy clay loamy soil with pH and EC of 7.2 and 0.32 (dS/m), respectively. Variety *'ADT(R)-45'* seeds were sown by using drum seeder with spacing of 20 cm x 10 cm. Fertilizers were applied 150:50:50 kg NPK/ha, respectively. Data on weed dry weight and control efficiency on 60 DAS and yield were studied.

RESULTS

In this study, application of pyrazosulfuron ethyl as pre emergence (PE) on 8 DAS followed by (*fb*) bispyribac sodium as pre emergence (PoE) on 35 DAS resulted in greater reduction in dry weight (96.41 kg/ha) of weeds and it increased the weed control efficiency (WCE) to 86.98%. The use of two or more herbicides in sequence or in combination mainly to control the broad spectrum of weed flora, to reduce the production cost and to prevent the development of weed resistance to herbicides (Muthukrishnan *et al*. 2010). Similarly, application of pyrazosulfuron ethyl with one hand weeding recorded lesser weed dry weight and WCE.

Weed control treatments had a favourable effect on the yield of rice. Application of pyrazosulfuron ethyl fb bispyribac sodium registered higher grain (6.22 t/ha) and straw yield (7.61 t/ha). This might be due to higher WCE of the herbicide which ultimately reduced the nutrient depletion by weeds. Hence, nutrient availability to the crop was more and leads to higher rice yields. Saha (2005) reported that the application of pyrazosulfuron ethyl recorded higher grain and straw yield. This was followed by pyrazosulfuron ethyl with one hand weeding in which, pre emergence herbicide controlled weeds at earlier stage and supplementary hand weeding controlled the weeds at later stages of the crop growth which ultimately increased the yield of rice.

Table 1. Effect of weed control treatments on weed dry weight, WCE, grain and straw yield

Treatment	Dose (g/ha)	Application (DAS)	Weed dry weight (kg/ha)	WCE (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1-Pretilachlor with one hand weeding	500	8, 35	192.03	70.26	4589	5920
retilachlor + bensulfuron methyl with one hand weeding	660	8,35	167.92	73.37	4810	6250
T_3-Pyrazosulfuron ethyl with one hand weeding	20	8,35	103.67	85.04	5910	7310
T_4-Metsulfuron methyl + chlorimuron ethyl	4	35	258.98	61.33	3788	4940
T_5-Bispyribac sodium	25	35	254.87	61.88	3850	5054
retilachlor fb metsulfuron methyl + chlorimuron ethyl	500+4	8, 35	214.37	65.99	4250	5505
T_7-Pretilachlor fb bispyribac sodium	500+25	8,35	201.31	68.81	4420	5723
retilachlor + bensulfuron methyl fb metsulfuron methyl + chlorimuron ethyl	660+4	8,35	213.20	67.35	4356	5645
retilachlor + bensulfuron methyl fb bispyribac sodium	660+25	8, 35	159.43	75.03	4872	6334
Pyrazosulfuron ethyl fb metsulfuron methyl + chlorimuron ethyl	20+4	8,35	127.11	80.73	5400	6912
T_{11}-Pyrazosulfuron ethyl fb bispyribac sodium	20+25	8,35	96.41	86.98	6220	7610
T_{12}-Hand weeding twice	--	20,40	133.48	78.76	5280	6912
T_{13}-Unweeded check	--	--	714.40	0.00	2139	3250
LSD(P=0.05)	--	--	17.45	--	380	453

CONCLUSION

It was concluded that, PE application of pyrazosulfuron ethyl on 8.0 DAS *fb* PoE application of bispyribac sodium on 35 DAS is the efficient and economically viable weed management practice for drum seeded wet rice. In labour and water scarcity condition, drum seeded wet rice with above said weed management practice could be remunerative.

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Weed management practices in aerobic rice under different seeding methods

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Aerobic rice suffers more due to weed menace as the weeds and rice compete for growth factors together and weeds cause yield loss between 30 and 98 per cent (Oerke and Dehne 2004). Sequential application of herbicides along with one hand weeding was reported to be more effective than application of herbicides alone, hence the present investigation was undertaken to study the efficacy of sequential application of pre and post emergence herbicides in aerobic rice under direct seeding and broadcasting.

METHODOLOGY

Field experiment was carried out during *Kharif*, 2014 at Professor Jayashankar Telangana State Agricultural University, Hyderabad to evaluate the efficacy of sequential application of herbicides under different seeding methods in sandy loam soil. The experiment was conducted in factorial RBD with a plot size of 4 m x 4m with three replications. Factor 1 includes seeding methods, broadcasting **(S_1)** and line sowing **(S_2).** Factor II includes weed management practices, **T_1**- pretilachlor fb (metsulfuron methyl + chlorimuron ethyl) + cyhalofop butyl at 15-20 DAS, **T_2**- pretilachlor *fb* azimsulfuron + cyhalofop butyl 15-20 DAS, **T_3**- pretilachlor 0.75 kg/ha *fb* pyrazosulfuron ethyl + cyhalofop butyl at 15-20 DAS, **T_4**- bispyribac sodium 25 g/ha *fb* 2,4-D 0.5 kg/ha at 40 DAS, **T_5**-T_1 *fb* HW at 50 DAS, **T_6**- T_2 followed by HW at 50 DAS, **T_7**- T_3 *fb* HW at 50 DAS, **T_8**- T_4 followed by HW at 50 DAS, **T_9**- HW at 20, 40 and 60 DAS, **T_{10}**-unweeded control.

RESULTS

Herbicidal treatments significantly influenced the dry matter production of weeds as well as grain yield. Lowest weed dry matter (10.5) as well as higher WCE (95.5) was recorded with hand weeding thrice at 60 DAS which was at par with **T_6**- pretilachlor *fb* azimsulfuron + cyhalofop butyl 15- 20 DAS *fb* HW at 50 DAS with regard to WCE (95.3%) and grain yield (3.21 t/ha) indicating that weeds are controlled efficiently with sequential application of herbicides resulted in higher grain yield. Grain yield was influenced by the interaction effect of both seeding methods and weed management practices. Hand weeding recorded significantly higher yield under line sowing method. Among seeding methods the higher grain yield was recorded with line sowing (S_2) (3.16 t/ha) than the broadcasting (S_1) (2.36 t/ha) method which might be due to the maintenance of less weed population and higher weed control efficiency.

Table1. Effect of weed management practices on aerobic rice under different seeding methods.

	Weed management practices	Weed dry weight (g /m^2)			WCE	Grain yield (kg/ ha)		
		S_1	S_2	Mean	(%)	S_1	S_2	Mean
T_1	Pretilachlor fb (metsulfuron methyl + chlorimuron ethyl) + cyhalofop butyl at 15-20 DAS.	11.74 (136.9)	11.61 (133.9)	11.67(135.4)	43.2	2357	2978	2668
T_2	Pretilachlor fb azimsulfuron + cyhalofop butyl 15-20 DAS.	11.77 (137.6)	11.52 (131.9)	11.65 (134.7)	43.5	2630	3135	2883
T_3	Pretilachlor fb pyrazosulfuron ethyl + cyhalofop butyl at 15-20 DAS.	11.78 (138.0)	11.60 (133.6)	11.69 (135.8)	43.0	2330	3245	2787
T_4	Bispyribac sodium fb 2-4-D at 40 DAS.	11.82 (139.0)	11.64 (134.6)	11.73 (136.8)	42.6	2217	2978	2598
T_5	T_1 fb HW at 50 DAS.	3.78(13.3)	3.32(10.1)	3.55(11.7)	95.0	2658	3643	3150
T_6	T_2 fb HW at 50 DAS.	3.68(12.5)	3.29(9.8)	3.48(11.2)	95.3	2701	3735	3218
T_7	T_3 fb HW at 50 DAS.	3.80(13.5)	3.30(10.2)	3.55(11.8)	94.9	2546	3622	3084
T_8	T_4 fb HW at 50 DAS.	3.84(13.8)	3.39(10.5)	3.61(12.1)	94.8	2557	3449	3003
T_9	HW at 20, 40, 60 DAS	3.53(11.5)	3.23)(9.5)	3.38(10.5)	95.5	2989	4064	3526
T_{10}	Unweeded control	15.5(240.6)	15.4)(236.4)	15.47(238.5)	0	958	1051	1005
	Mean	85.6	82.0			2366	3161	
		SEm±	CD (0.05%)			SEm±	CD	
	F1	0.65	1.88			44.73	128.1	
	F2	1.47	4.21			100.0	286.4	
	F1×F2	2.08	NS			141.4	405.0	

CONCLUSION

Sequential application of pre and post-emergence herbicides, *viz.* azimsulfuron or pyrazosulfuron ethyl, chlorimuron ethyl+ metsulfuron methyl, bispyribac sodium or 2,4-D along with one hand weeding was found to be efficient weed control practice for getting more grain yield while it was with line sowing as suitable seeding method for getting higher grain yield in aerobic rice.

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Integrated weed management in direct-seeded rice in lateritic soil of West Bengal

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Rice is the main staple food in Asia and Pacific region, providing almost 39% of calories (Yaduraju and Rao 2013). In India, it is mainly grown by transplanting which requires more water, labour, energy over direct seeded rice (DSR). But DSR has limitation of higher infestation of weeds. The productivity of the DSR is often reported to be lower, mainly due to problems associated with weed management. Aerobic soil conditions and dry-tillage practices, besides alternate wetting and drying conditions, are conducive for germination and growth of highly competitive weeds, which cause grain yield losses of 50–91% (Naresh *et al.* 2011, Mathew *et al.* 2013). Herbicides are considered to be a viable and effective alternative to hand weeding. But no single method of weed management is effective and sustainable. With this background the present experiment was conducted to study the effect of integrated weed management practices on weed growth, productivity and economics in DSR.

METHODOLOGY

A field experiment was conducted during *Kharif* 2014 at Agriculture farm, Institute of Agriculture, Visva- Bharati, Sriniketan, West Bengal with rice variety *MTU-1010* to study the effect of integrated weed management on population dynamics and growth of weeds, productivity and economics of direct seeded rice. The experiment comprising of ten treatments, *viz.* pendimethalin at 0.75 kg/ha + one hand weeding at 35 DAS (T_1), pendimethalin at 0.75 kg/ha + mulching with *Saccharum spontaneum* (T_2), pendimethalin at 0.75 kg/ha + mulching with water hyacinth (T_3), pendimethalin at 0.75 kg/ha and S*ebania* + 2,4-D sodium salt at 400 g/ha (T_4), bispyribac-Na at 25 g/ha (T_5), pendimethalin at 0.75 kg/ha followed by bispyribac-Na at 25 g/ha (T_6), closer spacing (20 cm row to row) + pendimethalin at 0.75 kg/ha followed by bispyribac-Na at 25 g/ha (T_7), closer spacing (20 cm row to row) + pendimethalin at 0.75 kg/ha (T_8), hand weeding at 15, 30 and 45 DAS (T_9) and unweeded control (T_{10}) was laid out in a randomized block design with three replications. The crop was fertilized with 60 kg N, 30 kg each of P_2O_5 and K_2O /ha. All other recommended agronomic practices and plant protection measures were adopted to raise the crop. Data on weed population dynamics, dry weed biomass and yield attributes were recorded during the growth period. Weed control efficiency (%) was computed using the dry weed biomass of weeds.

RESULTS

The total number of weed species in the experimental field was 21 out of which *Cynodon dactylon*, *Echinochloa colona* among grasses, *Cyperus iria*, *Fimbristylis miliacea* among sedges and *Ludwigia parviflora*, *Melochia chorchorifolia*, *Spilanthes acmella*, *Commelina benghalensis* and *Cynotis axilaris* among broadleaved were predominant. The highest density and dry weed biomass of all the weed species at 45 DAS were recorded in unweeded control (Table 1). The lowest density and dry weed biomass at 45 DAS were observed with hand weeding at 15, 30 and 45 DAS. Among the other treatments closer spacing (20 cm row to row) + pendimethalin at 0.75 kg/ha followed by bispyribac-Na at 25 g/ha recorded lower density and dry weight of weeds which was at par with pendimethalin at 0.75 kg/ha followed by bispyribac-Na at 25 g/ ha. All the treatments recorded more than 90 % WCE except closer spacing (20 cm row to row) + pendimethalin at 0.75 kg/ ha. Weed infestation caused about 53% yield reduction in direct seeded rice. The highest plant height at harvest was recorded in pendimethalin at 0.75 kg/ha + mulching with water hyacinth which was statistically at par with three hand weeding at 15, 30 and 45 DAS. The highest number of panicles /m^2 was recorded with pendimethalin at 0.75 kg/ha+ mulching with water hyacinth which was at par with all other treatments except closer spacing (20 cm row to row) + pendimethalin at 0.75 kg/ha and unweeded control. Test weight of rice did not vary significantly. The treatment pendimethalin at 0.75 kg/ha + mulching with water hyacinth recorded the highest grain yield (4.61 t/ha) which was statistically at par with pendimethalin at 0.75 kg/ha and *Sesbania* + 2,4-D-Na salt , pendimethalin at 0.75 kg/ha *fb* bispyribac-sodium at 25g/ha at 20 DAS, closer spacing (20 cm row to row)+ pendimethalin at 0.75 kg/ha *fb* bispyribac-sodium at 25g/ha and three HW at 15, 30 and 45 DAS. Pendimethalin at 0.75 kg/ha+ mulching with water hyacinth also recorded the highest gross and net return (Table 1). Higher weed control efficiency in these treatments facilitated better availability of space, light and nutrients resulting in higher values of growth attributes, more number of panicles, grains/panicle ultimately higher yield and net return.

Table1. Effect of treatments on density and dry weed biomass, weed control efficiency, plant height, yield components, yield, gross and net return of direct seeded rice

Treatment		Weed density (no. /m^2) at 45 DAS	Dry weed biomass (g/m^2) at 45 DAS	Weed control efficiency (%) at 45 DAS	No. of panicles /m^2	Grain yield (t/ha)	Gross return (Rs./ha)	Net return (Rs./ha)
T_1	Pendimethalin at 0.75 kg/ha +1 HW at 35 DAS	5.87 (34.33)	2.72 (6.89)	97.25	277	3.54	43480	22092
T_2	Pendimethalin at 0.75 kg/ha + mulching with *Saccharum spontaneum*	10.18 (103.67)	4.70 (21.65)	91.37	274	3.92	49750	29552
T_3	Pendimethalin at 0.75 kg/ha + mulching with water hyacinth	6.23 (38.33)	3.12 (9.21)	96.33	303	4.61	56330	36132
T_4	Pendimethalin at 0.75 kg/ha and *Sesbania* + 2,4-D-Na salt	5.21 (26.67)	3.11 (9.15)	96.35	290	4.17	50850	31382
T_5	Bispyribac- sodium at 25 g/ha at 20 DAS	3.79 (14.00)	2.13 (4.04)	98.39	288	3.66	44850	25702
T_6	PMT at 0.75 kg/ha fb bispyribac-sodium at 25 g/ha at 20 DAS	2.90 (8.00)	1.81 (2.78)	98.89	301	4.27	52110	31622
T_7	Closer-spacing (20 cm)+ pendimethalin at 0.75 kg/ha fb bispyribac-sodium at 25 g/ha	2.47 (5.67)	1.66 (2.29)	99.09	301	4.20	51380	30892
T_8	Closer-spacing (20 cm)+ pendimethalin at 0.75 kg/ha	13.04 (169.67)	8.33 (69.28)	72.43	267	3.49	42900	25082
T_9	Three hand weeding at 15, 30 and 45 DAS	0.71 (0)	0.71 (0)	100.0	301	4.53	55160	27642
T_{10}	Unweeded control	20.20 (367.7)	15.86 (251.2)	0	208	2.13	27800	11322
LSD (P=0.5)		0.74	0.46	-	31.3	0.59	-	-

Figures in parentheses are the original values. The data was transformed to SQRT (x + 0.5) before analysis.

CONCLUSION

It may be concluded that pre-emergence application of pendimethalin at 0.75 kg/ha + mulching with water hyacinth or pendimethalin at 0.75 kg/ha followed by bispyribac sodium at 25 g/ha appeared to be promising weed management practices for higher weed control efficiency, yield and net return of direct seeded rice in lateritic soil of West Bengal.

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Nutrient depletion by weeds, yield and economics of rice as influenced by weed management

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In order to achieve enhanced crop production and higher benefits from applied inputs, weeds must be kept under check by safe and effective means. Infestation of weeds mine nutrients from the soil thus, adversely affects the production of the crops. Effective weed management practices are essential to reduce the cost of cultivation and to protect the applied and natural resources.

METHODOLOGY

A field experiment was conducted at Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *Kharif*, 2014 to study the effect of different weed management practices on weed dynamics, nutrient depletion by weeds, yield and economics of transplanted rice. The experiment was laid out in randomised block design with three replications on sandy clay loam soil. The weed management practices tested were different doses of bispyribac sodium at 10, 20, 30, 40 and 60 g/ha as post emergence at 20 DAT; bensulfuron methyl + pretilachlor 60 + 600 g/ha; pretilachlor 600 g/ha at 5 DAT; hand weeding twice at 20 and 40 DAT and unweeded check.

RESULTS

The dominating weed flora in the experimental field at 30 DAT were *Echinochloa crusgalli* (42.1%), *Cyperus rotundus* (20.2%), *Dactyloctenium aegyptium* (13.9%), *Commelina bengalensis* (5.1%) and *Eclipta alba* (3.2%) with other weeds (9.5%). At 60DAT, the relative density of *E. crusgalli* (7.8%), *C. rotunduss* (10.2%) and other weeds (6.2%) were reduced to great extent. The total weed density was found to be lowest with hand weeding at 20 and 40 DAT. Application of bispyribac sodium 30, 40 and 60 g/ha registered significantly lower total weed density and weed biomass compared to other treatments at both 30 and 60 DAT.

Bispyribac sodium was effective in controlling of broad leaved weeds, grasses and sedge to some extent due to its broad spectrum action. Different weed management practices recorded weed control efficiency ranging from 31.2 to 89.6 per cent at 30 DAT and 34.4 to 92.9% at 60 DAT. Though slightly higher WCE was recorded with bispyribac sodium 40 and 60 g/ha at 30 and 60 DAT it was on par with bispyribac sodium 30 g/ha and bensulfuron methyl + pretilachlor 60 + 600 g/ha. All weed control treatments were significantly superior to weedy check in decreasing N, P and K removal by weeds both at 30 DAT (data not reported) and 60 days after transplanting. Among weed control treatments, N, P and K removal by weeds was lowest with hand weeding at 30 and 60 DAT. Bispyribac sodium 30, 40 and 60 g/ha and bensulfuron methyl + pretilachlor 60 + 600 g/ha also resulted in significantly lower nitrogen (62.9-73.7%), phosphorus (56-74%) and potassium (57.1-61.1%) removal by weeds over unweeded check due to better weed control efficiency as a result of lowered weed dry matter.

Table 1. Effect of weed management practices on weed dynamics, weed control efficiency, nutrient removal by weeds, yield and economics of rice.

Treatment	Weed density (no/m^2)		Weed dry matter (g/m^2)		WCE (%)		Nutrient Removal by weeds (kg/ ha) at 60 DAT			Grain Yield (t/ha)	Net Returns (Rs/ha)	B:C Ratio
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	N	P	K			
Bis. Na at 10g/ha	6.22	6.55	30.2	52.9	31.2	34.4	8.3	1.5	16.5	3563	17084	0.50
Bis. Na at 20g/ha	4.58	5.83	22.0	42.5	49.7	46.3	7.0	1.5	11.7	4045	30635	0.96
Bis. Na at 30g/ha	4.09	5.25	12.6	31.2	70.9	60.3	5.8	1.0	8.6	4347	34912	1.10
Bis. Na at 40g/ha	3.91	5.16	11.5	28.6	73.7	63.2	5.0	0.9	8.7	4365	34880	1.10
Bis. Na at 60g/ha	3.81	4.83	10.8	24.8	75.2	68.6	4.6	0.7	7.9	4378	34872	1.10
Pretilachlor at 600g/ha	5.77	7.02	25.9	57.2	40.7	27.6	12.0	1.9	11.2	3708	25725	0.89
Ben. methyl + Pretila. at 60+ 600 g/ha	4.04	5.45	12.3	33.9	71.9	57.2	6.5	1.2	8.8	4085	29768	0.92
Hand weeding at 20, 40 DAT	2.57	2.76	4.5	5.8	89.6	92.9	1.2	0.2	1.5	4935	38110	1.00
Weedy Check	7.49	7.70	44.4	80.5	0.0	0.0	17.5	2.7	20.3	2821	13925	0.51
LSD (P=0.05)	0.45	0.62	5.21	10.7	6.5	11.5	3.3	0.2	1.9	351	4846	0.16

Highest and significantly superior productivity of rice was recorded with hand weeding. Among the chemicals, application of early post emergence herbicide bispyribac sodium 30, 40 and 60 g/ha and bensulfuron methyl + pretilachlor 60 + 600 g/ha recorded statistically on par grain yield. Highest net returns (Rs 34,912) and maximum B:C ratio (1.10) was recorded by application of bispyribac sodium 30 g ai/ha. Veeraputhiran and Balasubramanian (2013) also reported the broad spectrum action of bispyribac sodium 25 g/ha in rice. Due to heavy competition of weeds for nutrients, space, water and light severe yield reduction to a tune of 63.5% was recorded in weedy check.

CONCLUSION

Bispyribac sodium at 30 g/ha as early post emergence herbicide was found to be an effective and alternative post emergence herbicide for better weed control, higher grain yield and economic returns in transplanted lowland rice.

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Effect of herbicides and their combinations on weed control efficiency in rice-based cropping system

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Rice is the most important and extensively grown staple food crop, accounting for 43% of the total food grain in the country. Weed infestation in transplanted rice is a critical factor that reduced the yield to the extent of 15-45% (Chopra and Chopra 2003). Rice-rice is the major cropping system in southern Karnataka where in long duration varieties of rice adopted by the farmers leave less time for field preparation between rice harvest during summer and sowing in rainy season as result weed infestation was more and existing pre-emergence herbicides are less effective against weeds like *Echinochloa* spp., *Panicum repens*, *Cyperus* spp etc. Keeping these points in view, the present investigation was under taken.

METHODOLOGY

The field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka to test the efficacy of herbicides and their combination on rice based cropping system. The experiment consisted of 08 treatments laid out in Randomized Complete Block Design with three replications. The treatments were T_1:glyphosate (0.75 kg/ha) applied 15 days before transplanting, T_2: butachlor (1.5 kg/ha) applied at 0-5 DAT, T_3: bensulfuron methyl + pretilachlor (0.06 + 0.6 kg/ha) applied at 5 DAT, T_4: glyphosate (0.75 kg/ha) applied at 15 days before transplanting + butachlor (1.5 kg/ha) applied at 0-5 DAT, T_5: glyphosate (0.75 kg/ha) applied at 15 days before transplanting + bensulfuron methyl + pretilachlor (0.06 + 0.6 kg/ha) applied at 5 DAT, T_6: hand weeded twice (20 and 40 DAT), T_7: use of cono-weeder and T_8: non-weeded control. Agronomic practices were followed for raising crop.

RESULTS

The efficacy of herbicides on the basis of weed biomass indicated that application of glyphosate (15 days prior to transplanting 0.75 kg/ha) in combination with bensulfuron methyl + pretilachlor applied at 5.0 DAT was most effective with a weed control efficiency of 64.97% *fb* use of cono weeder at 20 and 40 DAT (60.47%) and rice field treated with butachlor 50 EC 1.5 kg/ha applied at 5.0 DAT was least effective (40.44%). Among the different weed management practices, the pooled data (2 years) indicated that the application of glyphosate (15 days prior to transplanting 0.75 kg/ha) in combination with bensulfuron methyl + pretilachlor applied at 5.0 DAT recorded significantly higher grain yield (7.02 t/ha) followed by bensulfuron methyl + pretilachlor applied at 5 DAT (6.73 t/ha) and found superior than other treatments in the study. The lowest was observed with non-weeded control (4.49 t/ha). Higher yield might be due to more number of panicle/m^2 (406). All the weedicide treatments showed significantly higher grain yield over the unweeded check. This was due to the fact that the less competition for moisture, light and nutrient uptake by the crop plants by reduced weed population. The higher assimilation of photosynthesis in weedicide treated plots may be the reason for higher yield.

Table 1. Weed dry weight, WCE and yield as influenced by different weed control treatments

Treatment		Weed dry weight (g/m^2) at 60 DAT	WCE (%) at 60 DAT	Panicle number /m^2			Grain yield (kg/ ha)		
				2011	2011	2011	2011	2012	mean
T_1	Glyphosate	16.97	36.03	371	293	332	6038	5951	5995
T_2	Butachlor	19.43	26.76	378	315	347	6261	6319	6290
T_3	Bensulfuron-methyl + pretilachlor (6.6 GR)	13.2	50.25	395	326	361	6662	6803	6733
T_4	Glyphosate + butachlor	13.53	49.00	388	380	384	6506	6602	6554
T_5	Glyphosate + DAT- Days after transplanting bensulfuron-methyl + pretilachlor (6.6 GR)	10.3	61.18	415	396	406	6885	7155	7020
T_6	Hand weeded twice	11.97	54.88	395	313	354	6640	6402	6521
T_7	Use of conoweeder	11.67	56.01	380	384	382	6239	6936	6588
T_8	Non weeded control	26.53		310	265	288	4479	4514	4497
LSD (P=0.05)		5.96		15.3	21.2	18.23	289.9	326.0	307.9

CONCLUSION

It was concluded that application of glyphosate (15 days prior to transplanting 0.75 kg/ha) in combination with bensulfuron methyl + pretilachlor applied at 5.0 DAT was most effective to control weeds in rice based cropping system.

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Long-term effect of continuous use of herbicides on shift in weed flora in rice-wheat sequence

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Rice-wheat is the predominant cropping system in India occupying around 10.5 mha. The farmers realize much of their food security from this cropping system. Weeds are serious constraints in rice-wheat cropping system. Of the total losses caused by pests, weeds have a major share (30%). They reduce the crop yield and deteriorate the quality of produce and hence reduce the market value of the turn out (Arif *et al.* 2006).

METHODOLOGY

A long-term experiment was conducted on rice-wheat cropping system during *Rabi* 2000 to 2014 at Palampur. The soil of the test site was silty clay loam in texture, acidic in reaction, low in available N, P and K with CEC of 11.5 mol ($P^{\pm}$). Nine treatments viz. farmers' practice (T_1), continuous use of herbicides (butachlor + 2,4-D) with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continuous (isoproturon + 2,4-D; T_2 and T_4) and rotational (clodinafop/isoproturon; T_3 and T_5) use of herbicides in wheat and rotational use of herbicides (butachlor/pretilachlor (cyhalofop-butyl) in later years) + 2,4-D) with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continuous (isoproturon + 2,4-D; T_6 and T_8) and rotational (clodinafop/ isoproturon; T_7 and T_9) use of herbicides in wheat were tested in rice – wheat cropping system from rabi 2000 to 2013-14.

RESULTS

During *Rabi* 2000, *Phalaris minor*, *Avena ludoviciana*, *Vicia sativa*, *Anagallis arvensis* and *Coronopus didymus* were dominant weeds. Population density of all these weeds decreased in later years. *Coronopus didymus* was not observed after 2009-10. After 3-4 years, *Poa*, *Lolium* and *Ranunculus* appeared. *Poa* and *Lolium* had alarming proportion in the later years while *Ranunculus* disappeared after 2-3 years. From 2005-06, *Polygonum* and *Alopecurus* were the new invaders. In the later years, *Trifolium*, *Stellaria*, *Lathyrus*, *Plantago* and *Daucus carota* had little infestation in the experimental field. In rice, *Echinochloa crusgalli*, *Panicum dichotomiflorum* and *Cyperus iria* were the main weeds initially. The population of these weeds decreased over the years. Lately *Digitaria* (2002 and 2003), *Eschaemum* (2004 and 2005), *Aeschynomene* (2004-10), *Commelina* (2005), *Paspalum* (2005), *Ammannia* (2007-14), *Eriocolon* (2009-14), and *Monochoria* (2010-2014) appeared in the experimental field. The population of *Monochoria* and *Ammannia* was in the decreasing trend while that of *Ericolon* showed increasing trend.

Yield of wheat was higher during the middle years followed by later and former years. All weed control treatments were superior to farmers' practice in increasing wheat grain yield. Based on fourteen years pooled data, T_9 and T_7 remaining at par with T_5 resulted in significantly higher wheat grain yield over other treatments. T_9 had highest wheat sustainable yield index (0.743). Rice grain yield showed increasing trend over the years. T_4 remaining at par with T_3 had highest sustainable rice yield index (0.782). These were followed by T_8, T_9 and T_5. T_9 where rotational use of herbicides was practiced in both the crops along with 25% N substitution through *Lantana* in rice had highest sustainable yield index (0.763) with highest total grain productivity of rice and wheat. On an average, T_9 increased total grain productivity by 17% over the farmers practice.

Table 1. Effect of treatments on grain yield of rice wheat and sustainability

	Treatment		Grain yield (kg/ha)			Sustainable yield index (SYI)		
	Rice	Wheat	Rice	Wheat	Rice + wheat	Rice	Wheat	Rice + wheat
T_1	Farmers' practice	Farmers' practice	2684	2991	5675	0.584	0.731	0.695
T_2	Butachlor fb 2,4 DEE	Isoproturon + 2,4-D	2768	2818	5586	0.593	0.637	0.653
T_3	Butachlor fb 2,4 DEE	Clodinafop /isoproturon* +2,4-D	3048	3270	6318	0.638	0.775	0.748
T_4	Butachlor fb 2,4-DEE + 25% N through *Lantana*	Isoproturon +2,4-D	3217	3363	6579	0.663	0.782	0.765
T_5	Butachlor fb 2,4-DEE + 25% N through *Lantana*	Clodinafop /isoproturon +2,4-D	3426	3113	6538	0.714	0.735	0.777
T_6	Pretilachlor /Butachlor*	Isoproturon +2,4-D	2999	3073	6073	0.623	0.686	0.691
T_7	Pretilachlor /Butachlor	Clodinafop /isoproturon +2,4-D	3361	2842	6203	0.703	0.644	0.734
T_8	Pretilachlor /Butachlor + 25% N Lantana	Isoproturon +2,4-D	3171	3275	6447	0.647	0.729	0.720
T_9	Pretilachlor /Butachlor + 25% N Lantana	Clodinafop /isoproturon +2,4-D	3486	3157	6642	0.743	0.684	0.763
LSD (P=0.05)			151	117	231	0.584	0.731	0.695

Butachlor 1.5 kg/ha; pretilachlor 0.75 kg/ha; * Herbicides were used in rotation; from *kharif* 2007 cyhalofop-butyl 90 g/ha replaced pretilachlor; isoproturon 1.0 kg/ha; clodinafop 75 g/ha; 2,4-D 0.75 kg/ha

CONCLUSION

The findings of the present investigation conclusively inferred that weeds are dynamic in nature and their populations are largely influenced by cropping systems and management strategies adopted. There is no chance of the development of herbicidal resistance in weeds even with continuous use of herbicidal weed control if the management techniques are suitably designed based on a system's perspective.

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Bioefficacy of herbicide combinations for the control of complex weed flora in direct-seeded rainfed rice under mid hill conditions of Himachal Pradesh

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Weeds pose major problem in rice production due to the prevalence of congenial atmosphere during rainy season. The uncontrolled weeds compete with direct seeded rice and reduce yield upto 80% (Sunil *et al.* 2010). Several herbicides like butachlor, pendimethalin, oxidiazon and oxyfluorfen have been used and reported to provide fair degree of weed control in this system of rice cultivation (Moorthy and Manna 1993). Keeping in view the facts, the present study was carried out at Palampur to study the bio-efficiency of combination of herbicides against weed complex in direct seeded upland rice.

METHODOLOGY

A field experiment was conducted at Palampur (HP) during *Kharif* 2013 and 2014 in randomized block design with 10 treatments (Table 1) and three replications. The soil of the experimental site was silty clay loam in texture, acidic in reaction (pH 5.6), medium in available nitrogen (320 kg/ha), phosphorus (9.5 kg/ha) and high in available potassium (285 kg/ha). Rice variety '*HPR-1156*' was sown during the first week of June in both the years with recommended package of practices except the treatments. Herbicides were applied with power sprayer using 750 l water per hectare. Data on on total weed density and dry weight of weeds were recorded at harvest of the crop.

RESULTS

The major weeds of the experimental field were *Echinochloa colona, Digitaria sanguinalis, Panicum dichotomiflorum, Commelina benghalensis, Aeschynomene indica, Ageratum conyzoides* and *Cyperus iria*. A perusal of the data presented in Table 1 revealed that total weed count and total weed dry weight were significantly influenced by different weed control treatments. All the weed control treatments except three mechanical weeding with cono/rotary weeder resulted in significantly lower total weed count and total weed dry weight. Different treatments influenced the plant height, panicle length, number of effective tillers and spikelets/panicle significantly. All the weed control treatments resulted in taller rice plants, length of panicle and more number of spikelets/panicle. Weeds in unweeded check reduced the grain yield of paddy by 66.4% over pendimethalin fb bispyribac *fb* manual weeding 1000 *fb* 25g/ha (0-2 *fb* 20 DAS *fb* 45 DAS). Pendimethalin *fb* bispyribac *fb* manual weeding (0-2 *fb* 20 DAS *fb* 45 DAS) resulted in highest grain yield of direct seeded rice. However, it was statistically at par with pendimethalin/oxadiargyl *fb* bispyribac during 2013.

Table 1. Effect of different treatments on total weed count (no/m^2) and dry weight (g/m^2) at harvest grain yield of direct seeded rice

Treatment	Total weed count (no./m^2)		Total Weed weight (g/m^2)		Grain yield (kg/ha)	
Rice	2013	2014	2013	2014	2013	2014
Bispyribac 25g/ha (20 DAS)	4.82(22.3)	4.82(22.3)	6.54(41.9)	2.58(5.70)	2793	2677
Pendimethalin *fb* bispyribac 1000 *fb* 25g/ha (0-2 fb 25 DAS)	4.77(21.8)	4.61(20.3)	5.45(28.8)	3.08(9.50)	3025	2799
Oxadiargyl *fb* bispyribac 100 fb 25g (0-2 fb25 DAS)	4.2(16.6)	3.83(13.7)	5.85(33.3)	3.40(8.25)	3089	3068
Pyrazosulfum *fb* bispyribac 20 fb 25g/ha (0-3 fb 25 DAS)	4.4(18.8)	4.25(17.1)	5.54(29.7)	2.50(5.30)	2795	2806
Pendimethalin *fb* bispyribac *fb* manual weeding 1000 *fb* 25g/ha (0-2 *fb* 20 DAS *fb* 45 DAS)	3.9(13.9)	3.24(9.5)	5.64(30.8)	1.87 (2.50)	3147	3384
Pendimethalin *fb* manual weeding1000g/ha (0-2 *fb* 25-30 DAS)	5.71(31.7)	5.29(27.0)	6.70(43.9)	2.76(6.30)	1960	2207
Bispyribac + (chlorimuron + metsulfuron methyl) 20+ 4g/ha (20 DAS)	3.83(13.7)	5.28(26.9)	5.81(32.8)	2.59(5.70)	2650	2600
Three mechanical weedings (cono / rotary weeder)	5.31(27.3)	4.17(16.4)	7.63(57.3)	3.40(10.6)	2230	2404
Weed free	4.8(22.4)	4.06(15.5)	6.0(35.0)	2.34(4.50)	2799	2810
Weedy check	7.14(50.0)	6.60(43.6)	9.76(94.4)	7.52(55.7)	1116	1077
LSD (P=0.05)	1.96	2.13	2.33	1.00	371	314

Values given in the parentheses are the original means, DAS= after sowing, *fb*= followed by

CONCLUSION

The present investigation conclusively inferred that weeds are a major hurdle and application of pendimethalin 1.0 kg/ha *fb* bispyribac 25 g/ha *fb* hand weeding was an effective treatment to reduce significantly the weed competition in direct seeded rice.

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Physiological studies of weeds in long-term experiment on IPNS in rice-wheat cropping system

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Rice and wheat are the main staple foods which account for about 60% of world's human food and contribute more than 70% of the total cereal production in India and thus form the backbone of food security (Lathwal *et al.* 2010). Integrated nutrient management, the managerial aspect of IPNS (Integrated Plant Nutrition System) is more vital in sustaining increased productivity (Yadav and Kumar 2009). Studying the weed dynamics is helpful to understand the dominance or absence of a particular species in cropping system, devise means and ways to reduce their population, find out ways to delay or avoid the development of resistance by them against a herbicide, identify suitable crops for crop diversification and modify agronomic practices in favour of healthy crop growth.

METHODOLGY

The present study was carried out in long-term experiment on IPNS in rice – wheat cropping system at the Bhadiarkhar farm of the University. There were 12 treatment combinations, *viz*. T_1 - control (no fertilizer, no manure), T_2 - 50% NPK to both rice and wheat, T_3 - 50% NPK to rice and 100% NPK to wheat, T_4 - 75% NPK to both rice and wheat, T_5 - 100% NPK to both rice and wheat, T_6 - 50% NPK + 50% N (FYM) to rice and 100% NPK to wheat, T_7 - 75% NPK + 25% N (FYM) to rice and 75% NPK to wheat, T_8 - 50% NPK + 50% N (wheat cut straw) to rice and 100% NPK to wheat, T_9 - 75% NPK + 25% N (wheat cut straw) to rice and 75% NPK to wheat, T_{10} - 50% NPK + 50% N (green manure) to rice and 100% NPK to wheat, T_{11} - 75% NPK + 25% N (green manure) to rice and 75% NPK to wheat and T_{12} -farmers' practice (40% NPK and FYM 5 t/ha to both the crops) were evaluated in a randomized block design with four replications.

RESULTS

Ammania baccifera was the most dominant weed constituting 57% of the total weed flora during *Kharif*. This was followed by *Monochoria vaginalis* (23%), *Brassica* sp. (10%), *Eleocharis* sp. (4%), *Scirpus* sp. (3%) and *Cyperus sp.* (*3.0%*). Phytosociological analysis further indicated that *Amania baccifera* was the most important weed having highest IVI (important value index), SDR (summed dominance ratio), SI (Similarity index) and SDI (Shimpson Diversity index) in all the treatments except T_6 during *Kharif*. The *Ammania baccifera* was followed by *Monochoria vaginalis* in all the treatments except T_1. In *rabi* season, *Phalaris minor* constituted 85% of total weed flora. It had highest IVI, SDR, SI and SDI irrespective of the treatments. T_8 had maximum count of *Amania baccifera* whereas T_2 had minimum. T_1 remaining at par with T_4 and T_{10} resulted in significantly lower count of *Monochoria vaginallis* than other treatments. T_6 being at par with T_5, T_{11} and T_{12} had significantly higher count of *Monochoria* over other treatments. T_{10} resulted in significantly lower count of *Cyperus* sp than T_{12}, T_8, T_1. However, it was at par with the other treatments. Its count was significantly higher under T_1, T_6 and T_8 remaining at par with T_7, T_9, T_{10} and T_{11}, resulted in significantly lower count of *Eleocharis* sp. over other treatments. T_2 resulted in highest count of *Eleocharis* sp. T_2 remaining at par to T_3, T_5, T_6, T_7, T_{10}, T_{11} gave significantly lower count of this weed over other treatments. T_1 remaining at par to T_8 and T_4 resulted in significantly higher count of *Scirpus* sp. over other treatments. Total weed count in rice was highest under T_8 and lowest under T_{10}. Farmers' practice resulted in highest count of *Phalaris minor*. T_1 resulted in highest count of *Vicia sativa*. T_2 and T_4 remaining at par with each other resulted in significantly higher count of *Polygonum hydropiper* over the other treatments. The other treatments did not vary significantly among each other. In wheat, T_4 resulted in lowest total weed count followed by T_{10}, T_{11} and T_3. The highest total weed count was recorded in the treatment T_{12} (farmers' practice). Fertility treatments brought about significant variation in the total weed dry weight at 30 DAT rice. T_2 remaining at with T_1, T_3, T_4, T_7, T_9, T_{10} and T_{11}, resulted in significantly lower total weed dry weight. T_{12} being at par to T_8, T_5 and T_6 had significantly higher total weed dry weight. Fertility treatments could not significantly influence total weed dry weight in wheat, at any of the stage.

CONCLUSION

There was greater weeds floristic diversity (14 weed species, eight in rice and six in wheat) found in rice-wheat cropping systems. The weed flora largely varied with the nutrient management treatments. Weeds inflict huge yield and nutrient losses thereby depriving the crops for want of nutrients. Weeds cannot be eliminated/ eradicated. Therefore, strong management strategy has to be designed based on the prevalent species and the management practices followed.

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Bioefficacy and phytotoxicity of 2,4-D ethyl ester for weed control in transplanted rice

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Rice (*Oryza sativa* L.) is the most important staple food for more than 60% of the world's population. There are several reasons for low productivity of rice and the one due to weed is most important. Uncontrolled weeds reduced the grain yield by 62.6% under transplanted rice (Singh *et al*. 2005). Chemical weed management appears to be the best low cost alternative but still it needs more eco-safe. New herbicides are introducing in a regular manner but their eco-safe low cost efficiency needs to be investigated. In view of above, the present experiment was undertaken to study the efficacy on weed growth and yield in transplanted rice.

METHODOLOGY

A field experiment was carried out during *Kharif* 2013 at Regional Research Sub-Station of New Alluvial Zone (NAZ), Chakdaha, West-Bengal to evaluate the bio-efficacy and phytotoxicity of 2,4-D ethyl ester for weed control in transplanted rice. The experiment was laid out in randomized block design (RBD) with 9 treatments (Table 1) replicated thrice in a sandy loam soil. The variety '*IET-4886 (Satabdi)*' were sown during last week of June in 5 m x 4 m plots with a spacing 20 cm (R-R) x 20 cm (P-P). Tested herbicides with different doses were sprayed as pre-emergence at 3 DAT.

RESULTS

The predominant weed species were *Echinochloa colona, Echinochloa crusgalli* and *Ischaemum rugosum* among grasses; *Cyperus difformis, Cyperus iria and Fimbristylis miliacea* among sedge and *Eclipta alba, Ludwigia parviflora, Monochoria vaginalis, Marselia quadrifoliata and Alternanthera philoxeroides* among broad leaves. Herbicidal treatments significantly influenced the weed population and dry matter production of weeds (Table 1). Among the herbicidal treatments, 2,4-D EE at 3.40 kg/ha recorded highest WCE (71.47%), lowest weed population and dry weight at 30 DAS and highest grain yield (5.66 t/ha) (Fig. 1) followed by 2,4-D EE 3.40 kg/ha (with 67.39% WCE and 5.56 t/ha grain yield), whereas control plot (weedy check) showed the worst performance (grain yield 2.67 t /ha). The testing herbicide 2,4-D EE 3.40 kg/ha and 2,4-D EE 3.40 kg/ha recorded at par grain yield with farmers' practice which are significantly higher than standard butachlor 1.0 kg/ha. The straw yield also showed similar variations. No phytotoxicity symptoms were observed on rice crop after 5, 15 and 30 DAA.

Table1. Weed dry weight, weed population and weed control efficiency at 30 DAS

Treatment	Formulation dose (L/ha)	Weed dry weight (g/ m^2) at 30 DAS			Weed population (No./m^2) at 30 DAS			WCE % at 30 DAS
		Broad leaved	Grasses	Sedges	Broad leaved	Grasses	Sedges	
T_1 : 2,4-D EE 38 % EC 0.85 kg /ha	2.24	9.85	11.67	4.25	30.56	28.67	13.01	59.67
T_2 : 2,4-D EE 38 % EC 1.70 kg / ha	4.47	8.97	10.97	5.00	24.84	28.00	11.50	60.97
T_3 : 2,4-D EE 38 % EC 3.40 kg/ ha	8.95	7.95	9.00	3.89	20097	25.67	10.25	67.39
T_4 : 2,4-D EE 80 % EC 0.85 kg./ ha	1.06	9.05	11.00	5.66	28.97	28.33	12.40	59.77
T_5 : 2,4-D EE 80 % EC 1.70 kg./ ha	2.125	8.25	9.25	4.00	22.50	25.88	10.57	66.35
T_6 : 2,4-D EE 80 % EC 3.40 kg./ ha	4.25	7.00	7.56	3.67	18.70	22.56	9.56	71.47
T_7 : Butachlor 50% EC 1.00 kg. /ha	2.00	8.87	10.66	4.67	23.60	27.97	11.00	62.13
T_8 : Farmers' practice	-	8.56	10.26	4.00	22.56	27.67	10.98	64.29
T_9 : Weedy check	-	25.67	30.56	7.67	50.78	56.33	18.90	0
LSD (P=0.05)	-	0.264	0.675	0.026	0.434	1.029	0.085	1.129

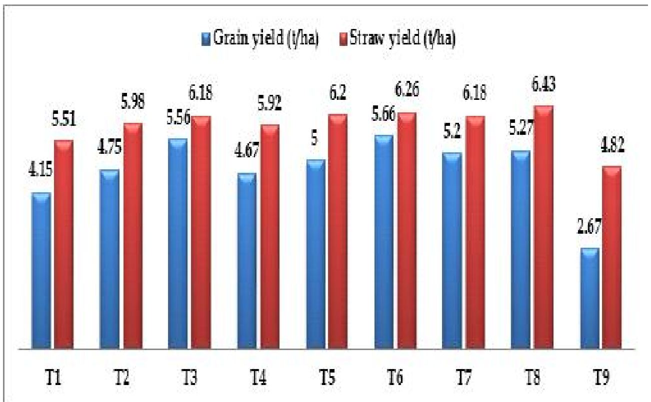

Fig.1. Effect of treatments on grain and straw yield of transplanted rice

CONCLUSION

The results revealed that 2,4-D EE 3.40 kg/ha showed better performance in managing all types of weed flora and increasing the yield of rice, also resulted in no phytotoxicity to rice as well as gave more benefit. The testing and standard herbicides did not show any detrimental effect on soil physio-chemical properties and micro-flora status excepting some reduction up to three weeks after application.

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Weed management and economics of basmati rice under different establishment methods in central Punjab

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Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum*) are grown in a sequence on an area about 2.7 million hectares in Punjab and contribute 80% in the total food pool of the state. The total water requirement for rice-wheat system is estimated to vary between 1,382-1,838 mm of which more than 80% is used by rice alone (Jat *et al.* 2006). In India, rice is mainly grown using a system known as puddling transplanting (PT). Basmati rice (scented rice) fetches a hefty price in the national as well as international markets due to its excellent cooking and eating qualities. Traditionally, basmati rice is grown by transplanting the seedlings in puddled field, which is very cumbersome, labour intensive and water exhaustive practice. This technique requires continuous ponding of water during the initial 15 days of seedling establishment and in turn leads to nutrient losses through leaching, besides causing high evapotranspiration losses during the hot summer months. Further, the rising labour cost and lowering of underground water table have compelled to shift from the traditional flooded transplanted to direct seeding of basmati rice. As compared to transplanting, direct seeding of rice reduces water consumption up to 13%, labour cost by 50%, matures about 15 days earlier and is conducive for mechanization. Therefore, the present investigation was undertaken to evaluate the performance of direct seeded basmati rice in comparison to other establishment methods and herbicides effective for controlling weeds in direct seeded crop.

METHODOLOGY

Field experiments were conducted at farmers' fields during *Kharif* 2013 and 2014 in Moga District of Punjab. Two establishment methods viz. mechanical transplanting with Kubota walk behind transplanter and direct dry seeding of basmati rice with the inclined seed plate drill were compared with farmers' practice i.e. puddled transplanting of basmati rice. For mechanical transplanting mat type nursery was grown and direct seeding of basmati rice was done when soil was at field capacity. For puddled transplanted basmati rice and mechanical transplanted basmati rice conventional herbicide formulation pretilachlor 1200 ml/ha was applied in standing water with 2 days of transplanting. Whereas in case of direct seeding weeds were controlled by application of pendimethalin 2.5 l/ha within 2 days of sowing which was followed by post-emergence application of bispyribac sodium 250 ml/ha at 20-25 days after sowing. The data on weed population, grain yield, water productivity and economics was recorded.

RESULTS

From the perusal of the data (Table 1) it was observed that herbicides used in case of different establishment methods were effective in controlling weeds. Weed population was on higher side in case of farmers' practice because farmers delayed the herbicide application i.e. they did not applied herbicide within 2 days of transplanting. In case of direct seeding of basmati rice human labour and tractor hours required were lesser as compared to farmers' practice and mechanical transplanting of basmati rice. The direct seed basmati crop reached maturity 10-15 days earlier as compared to other two establishment methods. The number of irrigations required by direct seeded crop were 14-17 as compared to 20-25 in other establishment methods. Though grain yield in case of direct seeded crop was less (7.52 t/ha) as compared to farmers' practice (7.56 t/ha) and mechanical transplanting (7.62 t/ha) but it gave higher net returns and benefit cost ratio because of saving in labour. Direct seeding of basmati also resulted in 4.20% and 6.25% saving in irrigation water as compared to farmers' practice and mechanical transplanting and also gave higher water productivity. The results obtained are in conformity with the results obtained by Brar *et al.* (2012)

Table 1. Weed population, grain yield, water productivity and economics under different establishment methods in Basmati rice (Average of 2 years)

Parameter	Treatments		
	Farmers' practice	Mechanical transplanting	Direct seeding
Weed population/m^2 (60 days after transplanting/seeding)	15.6	7.2	6.8
Human hours for establishment	55-60	50-55	35-40
Tractor hours for establishment	10-12	12-14	5-6
Crop duration (days)	140-150	140-145	130-140
Number of irrigations	20-25	20-25	14-17
Global warming potential	2.0-4.5	2.0-3.0	1.3-3.0
Grain yield (t/ha)	7.56	7.62	7.52
Gross returns (Rs./ha)	113400	114300	112800
Variable Cost (Rs./ha)	72960	72410	69515
Net returns (Rs./ha)	40440	41890	43285
B:C Ratio	1.55	1.58	1.62
Water used (m^3/ha)	18720	18320	17550
Water productivity (kg grain/m^3)	0.40	0.42	0.43

CONCLUSION

From the results of two year experiment, it may be concluded that the weeds can be effectively controlled in direct seeded basmati rice and it resulted in saving of irrigation water and was more economical as compared to puddled and mechanically transplanted basmati rice.

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Evaluation of post-emergence herbicides in transplanted rice

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Rice is the most important staple food crop of India. In transplanted rice, weed infestations not only reduce the grain yield up to 45% but also quality of grain is impaired. The share of weed management cost is higher than other operations in transplanted rice. Increasing problem of labour availability for rice cultivation, use of post-emergence herbicide has greater potential for effective weed management and higher yield. In this context, present study was carried out to evaluate efficacy of popular post emergence herbicides in transplanted rice.

METHODOLOGY

Field experiments were conducted at College Farm, PJTSAU, Rajendranagar to evaluate popular post emergence herbicides in transplanted rice (*MTU-1010*) on yield and weed control efficiency in transplanted rice during *Kharif* 2014. Five post emergence herbicides, bispyribac sodium 10 % SC 25 g/ha applied at 15 DAT, azimsulfuron 35 g/ha applied at 2-4 leaf stage of weeds, pyrazosulfuron ethyl 15-20 g/ha applied at 5 DAT, ethoxysulfuron 15% WDG 15 g/ha applied at 15 DAT and combination of bensulfuron methyl + pretilachlor 60 + 600 g/ha applied at 5.0 DAT were tested against hand weeding at 25 and 50 DAT and weedy check in a randomized block design and replicated three times. Soil of the experimental site was a sandy clay loam, slightly alkaline in nature, low in available nitrogen and medium available phosphorus and potassium.

RESULTS

Weed density recorded at 30, 45 and 60 DAT showed no significant difference among the herbicide treatments. However hand weeding at 25 and 50 DAT showed significantly low weed density than other treatments. Similar results were obtained with respect to weed dry matter with hand weeding at 25 and 50 DAT recording significantly least weed dry matter at 30, 45 and 60 DAT. Regarding WCE, there was gradual decrease in the efficacy of the herbicides as the crop duration increased and ranged from 59.8% to 66.0% at 60 DAT. All the post emergence herbicides tested recorded similar WCE and were on par with each other. Significantly highest WCE of 85.4 % was recorded by hand weeding at 25 and 50 DAT. Similar results were obtained by Yadav *et al*. 2009.

Table 1. Weed density, weed dry matter, weed control efficiency at various growth stages and grain yield of transplanted rice as influenced by weed control treatments

Treatment	Weed density (no./m^2)			Weed dry matter (g/m^2)			Weed control efficiency (%)			Grain Yield (t/ha)
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	
Bispyribac sodium 10% SC 25 g/ha	7 (2.83)	13 (3.74)	17 (4.24)	6.8	15.9	23.2	72.9	68.2	66.0	4.85
Azimsulfuron 50% DF 35 g/ha	8 (3.00)	14 (3.87)	20 (4.58)	7.5	17.5	25.0	69.8	65.0	63.5	4.78
Pyrazosulfuron ethyl 10% WP 20 g/ha	9 (3.16)	14 (3.86)	20 (4.57)	8.0	16.8	24.0	67.9	66.4	64.9	4.45
Ethoxysulfuron 15% WDG 15 g/ha	11 (3.46)	16 (4.12)	22 (4.79)	8.0	18.5	27.5	68.2	63.1	59.8	4.43
Bensulfuron-methyl (0.6) + pretilachlor (6%) GR 60 + 600 g/ha	8 (3.00)	12 (3.60)	21 (4.68)	7.3	15.1	26.5	70.7	68.6	61.3	4.62
Hand weeding at 25 and 50 DAT	1 (1.41)	9 (3.15)	8 (2.99)	0.9	11.3	10.0	96.4	77.5	85.4	5.52
Untreated control	20 (4.58)	36 (6.08)	44 (6.71)	25.0	50.0	68.4	--	--	--	2.63
LSD (P=0.05)	2.2 (0.29)	2.2 (0.39)	4.3 (0.47)	2.1	3.9	4.8	7.3	5.6	6.8	0.61

* Values in parenthesis are data transformed to square root transformation.

Grain yield followed similar trend as that of WCE with herbicide treatments recording similar yields (4.43 to 4.80 t/ha) and hand weeding registering significantly highest grain yield (5.52 t/ha). Results indicated that all the post emergence herbicides tested were equally effective in transplanted rice.

CONCLUSION

All the post emergence herbicides tested recorded similar weed control efficiency and yield and were equally efficient. Owing to severe scarcity of agricultural labour in future days weed control through post emergence herbicides is a viable option.

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Weed management in direct-seeded rice

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Rice (*Oryza sativa* L.), a staple food crop in India, is grown on 42.5 mha, which is the largest area among rice growing countries and provides 29% of the caloric requirement in India. Worldwide, it feeds about 50% of the population and provides 19% of the global calorie intake. Therefore, sustaining and improving the production of rice is essential for global food security. Weeds are one of the limiting factors in direct- seeded rice, which reduce the yield up to 50-100%.

METHODOLOGY

A field experiment was conducted during *Kharif* 2014 at Bihar Agricultural College Farm, Sabour to find out the cost-effective weed management practice for controlling weeds, growth and yield of direct seeded rice. The experiment consisted of twelve weed control treatments laid out in randomized complete block design with three replications. Rice variety Susk Samrat was taken in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha, respectively. Data on weed growth, yield performance and economics were recorded.

RESULTS

The relative density of grasses, broad leaved weeds and sedges were 34.2, 28.4 and 36.1% at 60 DAS. The maximum weed dry matter was recorded in weedy check at all stages of crop growth. Among the weed control treatments, minimum weed dry matter was recorded with treatment T_{12} pendimethalin *fb* bispyribac sodium + 1.0 HW followed by T_{11} penoxsulam + cyhalofop at 60 DAS of crop growth stages. However, total weed density of grassy weeds was minimum in T_{12} pendimethalin *fb* bispyribac sodium with one hand weeding (1.95) and T_{11} penoxysulam + cyhalofop T_{11} (2.02) which was significantly lower over rest of the treatments These treatments had greater reduction in total weed density and dry matter accumulation than other herbicidal treatments, hence they led to record higher weed control efficiency of 88.0 and 86.9% in T_{12} and T_{11}, respectively. This could be attributed to greater reduction of dry weight of weeds by the combined effect of herbicides and hand weeding at later stage. Similar finding was reported by Subbaiah and Sreedevi (2005)

Table 1. Weed growth, yield and economics of rice as influenced by different weed control treatments

Treatment	Weed dry matter (g/m^2)	Weed control efficiency (%)	Grain yield (t/ha)	B:C ratio
T_1 -Weedy check	11.94 (142.1)	0.0	3.81	1.67
T_2- Weed free	0.71(0.00)	100.00	5.42	2.31
T_3 - Pendimethalin 1.0 kg/ha as PE	8.56 (72.70)	48.12	3.84	2.21
T_4 - Bispyribac-sodium 30 g./ha as PoE	5.14 (26.0)	81.08	4.25	2.44
T_5- Pendimethalin 1.0 kg/ha *fb* bispyribac- sodium 25 g/ha as PoE	4.73 (21.90)	82.95	454	2.42
T_6- Pendimethalin 1.0 kg/ha *fb* ethoxysulfuron 18.5 g/ha as PoE	5.32 (27.80)	82.01	4.66	2.55
T_7 -Pendimethalin 1.0 kg/ha as PE *fb* penoxsulam 22.5 g/ha as PoE,	4.63 (20.9)	85.22	4.73	2.60
T_8- Pendimethalin 1.0 kg/ha *fb* pyrazosulfuron + bispyribac- sodium 20+20 g/ha as post-emergence	4.84 (22.90)	83.35	4.82	2.56
T_9 –Pendimethalin *fb* azimsulfuron + bispyribac- sodium 1.0 kg/ha Pre-emergence *fb* at 12.5+20 g/ha Post-emergence,	4.53 (20.0)	85.75	4.80	2.57
T_{10} – Bispyribac sodium at 25 g/ha + fenoxaprop (with safener) 60 g/ha as post-emergence	4.72 (21.80)	84.75	4.93	2.70
T_{11} - Penoxsulam + cyhalofop (RM) at 150 g/ha as post-emergence	4.14 (16.60)	86.97	5.05	2.86
T_{12} - Pendimethalin 1.0 kg/ha as pre-emergence *fb* bispyribac-sodium at 25 g/ha as post-emergence + 1HW	4.27 (17.80)	88.06	5.39	2.56
LSD (P= 0.05)	0.07	1.12	0.56	0.31

Grain yield differed significantly owing to different weed control treatments. Significantly higher grain yield was recorded in weed free plot (5.42 t/ha). The higher yield in weed free plot was mainly due to the complete elimination of weeds throughout the crop growth which enabled minimum competition and causing better plant growth along with higher values of yield attributing characters. Among the herbicidal treatments, pendimethalin *fb* bispyribac sodium with one hand weeding produced at par grain yield (53.9q) with penoxsulam+ cyhalofop (5.05 t/ha) and bispyribac sodium + fenoxaprop with safener (4.93 t/ha) and significantly higher grain yield over rest of the treatment. Herbicidal treatments resulted in considerably lower cost of cultivation as compared to the treatment T_{12}. However, higher benefit cost ratio (2.86) was observed with T_{11} penoxsulam + cyhalofop (RM).

CONCLUSION

It was concluded that post-emergence application of penoxsulam + cyhalofop (RM) 150 g/ha was most effective for controlling weeds, improving grain yield and profitability of direct-seeded rice.

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Weed controlling efficacy of profoxydim in direct-seeded rice in Sri Lanka

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Rice is being the staple food in Sri Lanka since ancient times and which has been recorded more than hundreds of local traditional rice cultivars from the ancient written history. With the increase of population rice productivity become a major factor in food security. As a result development of new improved varieties made the new era of rice cultivation in early 1950s and introduction of rice herbicides in early 1970s accelerated the productivity of new improved paddy varieties up to present self sufficiency in rice. In 2000's rice farmers experienced less efficacy in bispyribac herbicide and sulfonylurea based herbicides in weed control and the ban of propanil based herbicides in 2012 highly effected on control of weeds in rice cultivation Island wide.

The chemical weed control seems to be a competitive and most efficient way to control weeds at initial stages of crop growth. Selection of proper herbicides is essential for successful weed management in all crop production systems. Therefore, proper weed management is essential for satisfactory rice production. The present study was undertaken to evaluate bio efficacy of new herbicides on yield and weed control efficiency in direct seeded rice. Among these *Ischaemum rugosum* and *Leptochloa chinensis* have become a major issue in Sri Lankan paddy farming, especially in dry and intermediate zones. This study was conducted to analyze the bio-efficacy of profoxydim 75 g/l on *Ischaemum rugosum* and *Leptochloa chinensis* in direct seeded rice in Sri Lanka.

METHODOLOGY

The study was conducted in intermediate zone at major and minor paddy seasons in 2013/2014 respectively. Land preparation, water management and pest & disease management carried out under the recommendation of Department of Agriculture (DOA). The blocks designed for experimental treatment, reference treatment, hand weeded and control treatment which were demarcated separately with two replicates. '*BG-300*' sprouted paddy seeds broadcasted uniformly at a rate of 100 kg/ha. Two replicates of profoxydim 75 g/l at rate of 1.0 l/ha followed by MCPA 60 1.8 l/ha was applied 20 and 24 days after broadcasting respectively. As the reference treatment metamifop 100 g/l EC applied at the rate of 1.2 l/ha *fb* MCPA 60 1.8 l/ha at 9 and 24 days after broadcasting respectively. Two replicates of hand weeding and no weeding treatments were included in each season.The field flooded as per the DOA recommendations and the weed population density, dry weight measured separately using 50 cm x 50 cm quadrate at 7 and 9 weeks after sowing. Finally the yield of each treatment was measured separately.

Table 1. Weed dry weight and yield of rice under different herbicide control treatments during 2013-14 major and minor season

Treatment	Grass Weight (g/m^2)		Broadleaf Weight (g/m^2)		Sedge Weight (g/m^2)		Yield (t/ha)	
	major	minor	major	minor	major	minor	major	minor
Profoxydim 75g/l *followed by* MCPA 60%	1.08bc	3.34bc	5.27bc	0.01b	0.04b	2.03b	5.45a	4.26a
Metamifop 100 g/l EC *followed by* MCPA 60%	0.01c	2.04c	9.07bc	0.01b	0.34b	1.05b	5.48a	4.87a
No weeding	8.51a	26.00a	19.68a	54.65a	20.15a	51.35a	2.60b	1.64b
Hand weeding	0.01c	0.26c	0.01d	0.01b	0.01b	0.02b	5.19a	4.57a

***** Within a column, means followed by same letters are not significantly different by DMRT at 5% probability level

RESULTS

The experimental site mainly dominated by *Ischaemum rugosum, Lepotochloa chinensis, Echinochloa crusgali, Cyperus iria, monochoria vaginalis* and *Marsilea quadrifolia.* After 4 - 3 days of profoxidim 75 g/l application, slight yellowing of rice plants were observed and which is recovered 8 days after application without any effect to the yield.

Profoxydim 75 g/l EC has shown comparable weed controlling efficacy with metamifop 100 g/l EC.

Compared to the un-weeded plots both treatments resulted in lower density and dry weight of weeds. Weed controlling efficacy (WCE) of profoxydim 75 g/l EC for grassy weeds were 87% in both seasons. Profoxydim 75 g/l EC effectively controlled *Ischaemum rugosum* and *Leptochloa chinensis* with equal efficacy to metamifop 100 g/l EC compared to the no weeding treatment.

CONCLUSION

It was concluded that application of profoxydim 75g/l EC is effective in controlling weeds, especially *Ischaemum rugosum* and *Leptochloa chinensis* in direct seeded rice.

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Integrated weed management in dry-sown direct-seeded rice in Tripura

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Rice (*Oryza sativa* L.) is the major food crop of Tripura. It is predominantly grown by transplanting in the State. But due to water and labor scarcity, farmers are shifting to direct seeded method of rice establishment. However, weeds are one of the limiting factors in direct- seeded rice, which reduce the yield to the tune of 50-100% (Mishra and Singh 2007). Development of effective and integrated weed management practices are essential for sustainable rice cultivation. Keeping these points in view, present investigation was carried out to find out suitable integrated weed management practices for the direct seeded rice in Tripura.

METHODOLOGY

A field experiment was conducted at Krishi Vigyan Kendra, South Tripura during the *Kharif* (wet) season of 2013 using rice variety '*NDR-97*' to evaluate the efficacy of different weed management practices on weed growth and productivity of upland direct seeded rice. Twelve treatments *viz.* pendimethalin at 1.0 kg/ha at 2 DAS (T1), pendimethalin at 1.0 kg/ha + one manual weeding at 30 DAS (T2), pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac sodium at 25 g/ha at 20 DAS (T3), fenoxaprop at 60 g/ha + metsulfuron-methyl and chlorimuron-ethyl at 4 g/ha at 15 DAS(T4), bispyribac sodium at 25 g/ha at 20 DAS (T5), metsulfuron-methyl and chlorimuron ethyl at 4 g/ha at 10 DAS followed by bispyribac sodium at 20 g/ha at 20 DAS (T6), pyrazosulfuron ethyl at 25 g/ha at 3 DAS followed by bispyribac sodium at 20 g/ha at 20 DAS (T7), stale seed bed + smother crop (cowpea) (T8), stale seed bed + one hand weeding at 30 DAS (T9), Sesbania (broadcast) + 2,4-D at 500 g/ha at 25 DAS (T10), three hand weedings at 20, 30 and 45 DAS (T11) and unweeded control (T12) were assigned in a randomized block design replicated thrice. Recommended package of practices were followed in raising the crop.

RESULTS

Weed flora present in the experimental field were *Amaranthus viridis, Oldenlandia corymbosa, Spilanthes acmella, Ludwigia parviflora, Cleome rutidosperma, Malvestrum coromondalianeum* among the broad leaf weed, *Digitaria sanguinalis* among grasses and *Cyperus iria* among sedges. The lowest weed density and dry weight at 60 DAS were registered with hand weeding thrice at 20, 30 and 45 DAS which was statistically at par with pendimethalin + bispyribac sodium (T3) and pendimethalin + one manual weeding (T2). Similar result was also reported by Bhurer *et al.* (2013) in direct seeded rice. Hand weeding at 20, 30 and 40 DAS (T11) registered the highest weed control efficiency closely followed by pendimethalin + bispyribac sodium (T3) and pendimethalin + one manual weeding (T2). The highest no. of panicles/plant, no. of grains per panicle and grain yield were recorded with hand weeding thrice at 20, 30 and 45 DAS which was statistically at par with pendimethalin + bispyribac sodium (T3) and pendimethalin + one manual weeding (T2). The test weight of rice did not vary significantly. Effective and timely weed management under these treatments reduced the density as well as dry weight of weeds which facilitated the crop to have sufficient space, light, nutrient and moisture and thus the number of panicles per plant, number of grains per panicle and finally the yield was increased.

Table 1.Effect of treatments on density and dry weight of weeds , weed control efficiency, yield components and yield of direct seeded rice

Treatment	Weed density (no./m^2) at 60 DAS	Weed dry wt. (g/m^2) at 60 DAS	Weed control efficiency (%) at 60 DAS	No. of panicles /plant	No. of grains / panicle	Test weight (g)	Grain yield (t/ha)
Pendimethalin at 1.0 kg/ha at 2 DAS	78.33	148	41.17	9	72	23.26	2.24
Pendimethalin at 1.0 kg/ha + one manual weeding at 3s0 DAS	25.33	41.33	83.57	16	116	23.45	3.44
Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac sodium at 25 g/ ha at 20 DAS	22.67	35.83	85.76	16	120	23.19	3.80
Fenoxaprop at 60 g /ha + metsulfuron-methyl and chlorimuron-ethyl at 4 g /ha at 15 DAS	55.67	108.96	56.69	9	89	23.20	2.79
Bispyribac sodium at 25 g /ha at 20 DAS	55.00	118.84	52.76	10	84	23.28	2.66
Metsulfuron-methyl and chlorimuron at 4 g /ha at 10 DAS followed by bispyribac sodium at 20 g /ha at 20 DAS	55.33	111.03	55.87	9	85	23.59	2.72
Pyrazosulfuron ethyl at 25 g /ha at 3 DAS followed by bispyribac sodium at 20 g /ha at 20 DAS	49.00	102.87	59.11	12	97	22.87	2.84
Stale seed bed + smother crop (cowpea)	60.00	115.57	54.06	12	90	23.34	2.65
Stale seed bed + one hand weeding at 30 DAS	66.00	128.6	48.88	10	87	23.51	2.51
Sesbania (broadcast) + 2,4-D at 500 g /ha at 25 DAS	77.00	140.08	44.32	11	83	23.42	2.29
Three hand weedings at 20, 30 and 45 DAS	19.33	29.02	88.46	17	120	23.28	3.95
unweeded control	112.33	251.57	0	6	63	23.07	1.08
LSD (P=0.05)	6.46	13.47	-	2.33	4.93	NS	0.16

CONCLUSION

Thus it may be concluded that pre-emergence application of pendimethalin at 1.0 kg/ha + bispyribac sodium at 25 g/ha at 20 DAS appeared to be most effective for higher weed control efficiency and obtaining higher yield in direct seeded rice in Tripura.

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Effect of herbicide combinations on weed, yield and growth attributes in dry direct-seeded rice

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Weed management in dry direct seeded rice seeks a good combination of herbicides for control of broad spectrum of weeds during crop growth stages. Dry direct seeding have several benefits over puddled transplanting, except weeds. Many herbicides are available, but still a good combination of herbicides is most needed for effective control of perennial grasses, sedges and broad leaved weeds in zero-till rice. Herbicides are more effective in controlling the weeds as well as reducing the total energy requirement for rice cultivation. Besides, only the use of chemicals other agronomic practices like, crop establishment by zero tillage with residue retention may play an important role in weed suppression and improving the yield (Singh *et al*. 2013). Therefore, the present investigation was undertaken to evaluate the different herbicide combinations in presence of anchored residue under zero till dry direct seeded rice.

METHODOLOGY

A field experiment was carried out during *Kharif* 2014 at Borlaug Institute for South Asia, Jabalpur (M.P.) to study the efficacy of different weed management practices. Eight weed management treatments, *viz*. T1- weedy, T2- weed free, T3- bispyribac (25 gm) + pyrazosulfuron (25), T4- bispyribac (25 gm) *fb* 2, 4-D EE (500 gm), T5- with safener (56 gm) + ethoxysulfuron (18 gm), T6- metsulfuron+cholorimuron (4 gm) + bispyribac (25 gm), T7- fenoxaprop with safener(56 gm) + chlorimuron (2gm), T8- bispyribac (25 gm) were arranged in a randomised block design with three replications. Rice cv. '*PB 1121*' of 115-125 days duration was used as test variety. Dry seed of rice at 15 kg/ha was used for seeding by zero-till dril fitted with inclined plates. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash 120 kg N, 60 kg $P_2O_5$and 40 kg K_2O/ha, respectively. Data on weed biomass and dry weight, yield and growth attributes were recorded.

Table 1. Effect of different weed management methods on weed growth, yield and growth attributes

Treatment	Grain Yield (t/ha)	Tillers (m/row)	Plant height (cm)	Weed population (m^2)	Weed dry matter (g/m^2)
weedy	2.90	142	115	10.44 (109.67)	15.84 (250.61)
Weed free	5.30	190	117	0.71	0.71
Bispyribac (25 gm) + pyrazosulfuron (25)	5.07	177	112	6.22 (38.34)	6.63 (43.65)
Bispyribac (25 gm) *fb* 2, 4-D EE (500 gm)	4.77	160	115	8.97 (83.33)	8.95 (79.56)
Fenoxaprop with safener (56 gm) + ethoxysulfuron (18 gm)	4.67	169	110	8.63 (76.67)	9.64 (92.3)
metsulfuron+cholorimuron (4 gm) + bispyribac (25 gm)	4.60	154	111	9.11 (88)	7.73 (59.2)
Fenoxaprop with safener(56 gm) + chlorimuron (2gm)	4.70	155	111	10.5 (100.34)	12.04 (144.51)
Bispyribac (25 gm)	3.90	151	114	8.68 (78.67)	13.52 (182.6)
LSD (P=0.05)	0.43	20.03	4.54	2.75	0.48

Data are subjected to square root transformation ("x+0.5). Data given in parentheses are original values.

RESULTS

Experimental field was infested with grassy (*Echinocloa colona*, *E. crusgalli*, *Paspalum* spp., *Cynodon dactylon*), sedges (*Cyperus rotundus* and *Cyperus iria*), and broad-leaved weed (*Caexulia auxillaries*). Grassy weeds were predominant (55%), followed by broad-leaved (25%) and sedges (20%). Among the weed management treatments, the lowest weed density (6.2 /m^2) was observed under bispyribac (25 gm) + pyrazosulfuron (25) at 18 DAS, followed by fenoxaprop with safener (56 gm) + ethoxysulfuron (18 gm) (8.63 /m^2) (Table 1). The minimum weed dry weight was also recorded in bispyribac (25 gm) + pyrazosulfuron (25) at 18 DAS which was significantly lower than the other treatments. Both weed biomass and weed dry weight were recorded significantly lesser than due to proper control of weeds. The highest grain yield (5.3 t/ha) was recorded under weed free treatment and closely followed by (5.07 t/ha) bispyribac (25 gm) + pyrazosulfuron (25) at 18 DAS and the lowest (2.9 t/ha) was under weedy. High grain yield resulted after proper management of weeds in these treatments. Plant height and tillers were higher in weed free and bispyribac (25 gm) + pyrazosulfuron (25) at 18 DAS and lowest in weedy.

CONCLUSION

It was concluded that post emergence herbicides bispyribac (25 gm) + pyrazosulfuron (25) at 18 DAS was found to be most effective methods for controlling weeds, improving grain yield and growth attributes.

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Promising herbicides for effective weed management in direct-seeded rice

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'Rice is life'! This has become a worldwide mantra since the International Year of Rice in 2004. Rice being a major food crop of Madhya Pradesh is cultivated on 1.78 mha area with production of 1.65 mt. Weeds are one of the limiting factors in direct seeded rice which reduced the yield upto 50-80% in rainfed uplands (Singh *et al.* 1996). Yield reduction is even higher *i.e.* upto 97% due to competition of *Echinochloa crussgalli* (Kurchania *et al.* 1992).

METHODOLOGY

A field experiment was conducted during *Kharif* 2010 at Breeder seed production farm, Adhartal, JNKVV, Jabalpur to study the efficacy of bispyribac sodium and other herbicides against weeds in drilled rice. The experimental field was infested with major grassy weeds *Echinochloa colona*, *Dinebra retroflexa*, *Cyperus iria*, *Eclipta alba* and *Phyllanthus niruri.*

RESULTS

Among the herbicidal treatments, the lowest weed density was observed under bispyribac sodium 80 g/ha at 15 DAS, followed by bispyribac sodium 40 g/ha. The minimum weed dry weight was recorded in two hand weeding at (20 and 40 DAS) and proved significantly superior over all weed control treatments. Also the lowest weed dry weight and weed index was observed under bispyribac sodium 80 g/ha. The maximum grain yield was recorded in hand weeding and lowest under weedy check. The yield loss due to uncontrolled growth of weeds as compared to hand weeding was 67.55%. Among the herbicidal treatments bispyribac-Na 80 g/ha recorded maximum grain yield which was at par with other herbicidal treatment of bispyribac-Na except 10 g/ha and significantly higher as compared to cyhalofop-butyl and butachlor that produced 11.37% and 9.31% less grain yield compared to bispyribac-Na 20 g/ha respectively. The minimum cost of cultivation was registered under control plot. However it was maximum under hand weeding. All the treatments received post-emergence application of bispyribac-sodium 10-80 g/ha, cyhalofop-butyl (75 g/ha) and butachlor (1500 g/ha) needed less variable cost over hand weeding. Thus, use of herbicides for control of weeds seems to be cheaper. The application of bispyribac-sodium 20 g/ha was more remunerative than rest of the treatments including weed free treatment. While weedy check was not advantageous as there was loss of almost 100 paisa per rupee investment.

Table 1. Weed density, weed dry weight, weed index and yield of rice as influenced by different weed control treatments

Treatment	Dry matter (g/m^2)	Weed density/m^2	Weed index (%)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (Rs. /ha)	B:C ratio
Bispyribac-Na 10 g/ha	4.58 (20.48)	8.77 (76.33)	30.82	3.35	4.85	17868	2.04
Bispyribac-Na 20 g/ha	3.52 (11.87)	6.20 (38.00)	7.28	4.49	6.08	18468	2.63
Bispyribac-Na 30 g/ha	2.97 (8.30)	4.67 (21.33)	6.97	4.51	6.13	19068	2.56
Bispyribac-Na 40 g/ha	2.29 (4.74)	3.94 (15.00)	5.88	4.56	6.15	19668	2.51
Bispyribac-Na 80 g/ha	0.95 (0.41)	2.74 (7.00)	5.26	4.59	6.23	22068	2.25
Bispyribac-Na 20 g/ha + 2,4-D 500 g/ha	2.92 (8.00)	4.82 (22.77)	8.19	4.45	6.43	18868	2.56
Cyhalofop -butyl75 g/ha	4.05 (15.87)	7.45 (55.00)	17.59	3.99	5.83	18278	2.38
Butachlor 1500 g/ha	5.29 (27.43)	8.69 (75.00)	17.38	4.00	5.93	18018	2.42
Hand weeding	0.71 (0.00)	0.71 (0.00)	0.00	4.85	6.53	25428	2.06
Control	7.93 (62.35)	15.02 (225.00)	66.49	1.62	3.05	17028	1.06
LSD (P=0.05)	0.36	0.70	-	1.81	3.90	-	-

Values in paranthesis are original values.

CONCLUSION

The efficacy of bispyribac sodium as post emergence was significantly superior when applied at 80 g/ha over other herbicides. However, the application of bispyribac-sodium 20 g/ha was more remunerative.

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Bioefficacy of chlorimuron-ethyl against weeds in transplanted rice

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Rice (*Oryza sativa* L.) is one of the predominant food crops of the world. It is the king crop of Asia because 90% of the rice is being produced and consumed in Asia alone. In general rice is preferably transplanted under irrigated agro-ecosystem. Transplanted rice has diverse types of weed flora. Weed control becomes an immensely important practice to avoid yield losses. The problem of extensive weed incidence during early stages of rice crop growth can not be determined which competes with crop plants for moisture, nutrients, light, space and other growth factors. This crop competition leads to significant yield losses to the tune of 35-55% in transplanted rice (Gautam and Mishra 1995). Post-emergence herbicide is becoming need of the day due to emergence of weeds at later growth stage of crop. Use of herbicide offers economic and efficient control of weeds providing the crop better establishment and competitive ability.

METHODOLOGY

The experiment was conducted at the product testing unit, Department of Agronomy, JNKVV, Jabalpur during *Kharif* 2013. The soil of the experimental field was sandy clay loam in texture, low in organic carbon (0.61%) and available nitrogen (238.6 kg/ha) and medium in available phosphorus (21.0 kg/ha) and available potassium (273.2 kg/ha). It was neutral in soil reaction (7.3pH) and normal in electrical conductivity (0.32 ds/m). The experiment was laid out in randomized block design with seven treatments replicated thrice, *viz.* chlorimuron ethyl 3, 6, 9, 12 and 24 g/ha, hand weeding and weedy check. Rice seedlings (variety IR-64) were transplanted in field manually at the planting geometry of 25 cm x 25 cm in all the plots. Chlorimuron ethyl was sprayed as per treatments 3, 6, 9, 12 and 24 g/ha at 13 days after transplanting with the help of knapsack sprayer using a flat–fan nozzle.

Table 1. Effect of different weed control treatments on grain yield, straw yield, harvest index, weed index and weed control efficiency

Treatments	Dose (g./ha)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Weed index (%)	WCE at harvest
T1-Chlorimuron ethyl 25% WP	3	3.14	5.60	35.92	31.65	90.39
T2-Chlorimuron ethyl 25% WP	6	3.44	6.08	36.13	25.52	94.03
T3-Chlorimuron ethyl 25% WP	9	3.83	6.45	37.25	16.70	94.86
T4-Chlorimuron ethyl 25% WP	12	3.89	6.89	36.10	15.30	95.63
T5-Chlorimuron ethyl 25% WP	24	3.79	6.43	37.09	17.57	96.60
T6-Hand weeding twice (20 and 40 DAT)	-	4.60	7.16	39.09	0.00	100.00
T7-Weedy check	-	2.92	5.20	35.96	36.52	0.00
SEm±		0.09	0.24	-	-	-
CD at 5%		0.27	0.75	-	-	-

RESULTS

Among the weeds, *Caesulia axillaris* was the most dominant weed (38.11/m^2 (density) and 20.77% (relative density)) at 15 DAA. But the dominancy was shifted to *Echinochloa colona* at 30, 45, 60 DAA and harvest. This was followed by *Eclipta alba* and *Alternanthera sessilis*. All these weeds were controlled effectively with the application of chlorimuron ethyl 24 g/ha. Yield attributes, grain and straw yields were significantly higher under hand weeding twice followed by chlorimuron ethyl 12 g/ha. Weed index was minimum under hand weeding twice followed by chlorimuron ethyl 12 g/ha. While the weed control efficiency was maximum under hand weeding twice. Chlorimuron ethyl 12 g/ha was the economically viable treatment among all the weed control treatments.

CONCLUSION

Application of chlorimuron ethyl 24 g/ha was found more effective in reducing the density and dry weight of broad leaved weeds but application of chlorimuron ethyl 12 g/ha was found more remunarative and productive.

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Effect of initial weeding, interval and frequency of weeder on weed control and yield of wet-seeded rice

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The need for greater food production at prices affordable by consumers and profitable to farmers has been a concern for all. Competition from weeds is a major constraint to the productivity of wet seeded rice. Weeds have been reported to reduce the yield of wet seeded rice by 15-70%. It may become more popular if an effective weed control system is developed. The key for successful direct seeding on a large scale lies in the way that farmers manage their weed and crop. Hence, the present investigation was undertaken with a view to study the best weed control method through mechanical, chemical and manual means of weed management in direct wet seeder rice.

METHODOLOGY

Field experiments were conducted to evaluate the weed control methods through mechanical, chemical and manual means of weed management in direct wet seeded rice at Regional Research Station, Paiyur, in dry and wet seasons, 2007 in randomized block design with three replications. The mechanical weeding was done initially from 5 DAS to 25 DAS (5 days interval) up to period of 50 DAS at 15-25 days interval at weeding frequency of two or three times compared against the herbicide application and farmers practice in nine treatments. The 8 - row drum seeder (20 cm line spacing) was used and the test variety was ADT 43. The nine treatments consisted of mechanical weeding on 5, 20 and 35 DAS (T1), 10, 25 and 40 DAS (T2), 15, 30 and 45 DAS (T3), 20, 35 and 50 DAS (T4), 25, 40 and 55 DAS (T5), 25 (seedling stage) and 50 DAS (maximum tillering phase) (T6), hand weeding on 25 and 50 DAS (Farmer's practice - T7), pre-emergence herbicide application of pretilchlor on 8 DAS *fb* hand weeding on 30 DAS (T8), and post emergence herbicide application of chlorimuron ethyl + metsulfuron methyl on 20 DAS *fb* hand weeding on 50 DAS (T9).

RESULTS

The major weed flora of the experimental site included sedges, *viz*. *Cyperus rotundus* (44.9%), broad leaved weeds, *viz. Parthenium hysterophorus* (23.0%), *Portulaca oleraceae* (8.0%) and *Trianthema portulacastrum* (5.3%) and grassy weeds, *viz. Dactyloctenium aegyptium* (6.4%), *Brachiaria mutica* (3.0%) *Chloris barbata* (1.3%),

The weed population and dry weight per unit area was lower when weeding and soil stirring was done through mechanical weeders at an early stage of the crop ie 5-10 days and also when weeds are small and less thus registered significantly more number of tillers and panicles per unit area. The pooled grain yield, net income and BC ratio was maximum in mechanical weeding done thrice at a interval of 15 days started from 10 DAS (6.34 t, Rs. 31,125 /ha and 3.41) than other weed management practices. The findings of research is in conformity with the Mrunalini and Ganesh (2008) and Remesan *et al.* (2007)

Table 1. Effect of weed control method and practices on yield attributes, yield and economics of direct seeded puddled rice (pooled analysis, Samba 2007 + Navarai 2007-08, var ADT 43)

Treatment		Grain yield Kg/ha	Straw yield kg/ha	Gross income Rs/ha	Net income Rs/ha	B:C ratio
T1	Mechanical weeding on 5,20 and 35 DAS	6251	5780	43287	30378	3.35
T2	Mechanical weeding on 10, 25 and 40 DAS	6342	5980	44034	31125	3.41
T3	Mechanical weeding on 15, 30 and 45 DAS	6300	5989	43787	30878	3.39
T4	Mechanical weeding on 20, 35 and 50 DAS	6039	5464	41697	28788	3.23
T5	Mechanical weeding on 25, 40 and 55 DAS	6039	5493	41726	28817	3.23
T6	Mechanical weeding on 25 (seedling stage) and 50 DAS (maximum tillering phase)	5638	5131	38957	26748	3.19
T7	Hand weeding on 25 and 50 DAS (Farmer's practice)	5694	5182	39345	26136	2.98
T8	Pre-emergence herbicide application of pretilchlor on 8 DAS fb hand weeding on 30 DAS	5651	5395	39300	26901	3.17
T9	Post emergence herbicide application of Almix on 20 DAS *fb* hand weeding on 50 DAS	5562	5048	38422	25788	3.04
LSD (P=0.05)		342	476	NA	NA	NA

DAS: Days after sowing, fb: followed by, NA : Not analyzed

CONCLUSION

The results revealed that the weeding and soil stirring through mechanical weeders must be done initially at 10 DAS and subsequent weeding and stirring can be done at a interval of 15 days to control the weeds effectively and to maximize the productivity and profitability of direct wet seeded rice.

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Effect of chemical and non-chemical weed management practices in direct drum-seeded rice

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Rice (*Oryza sativa* L.) is the most important and widely cultivated crop in the world. Weeds have been reported to reduce the yield by 50-60% in direct seeded rice. To avoid this wasteful loss, control of weeds in time is imperative. Although manual weeding, control weeds effectively, it is difficult, time consuming and costly. Therefore, the present investigation was undertaken with a view to study the effect of chemical and non chemical method of weed control individually and combination in direct (drum)seeded rice under low land irrigated condition.

METHODOLOGY

The field experiments were conducted to study the effect of chemical and non- chemical weed control in direct (drum) seeded rice under lowland irrigated condition at Regional Research Station, Tamil Nadu Agricultural University, Paiyur 635 112, Tamil Nadu, India in wet and dry seasons of 2012 and 2013 respectively in randomized block design with three replications. The treatments are pre and post emergence application of pyrazosulfuron ethyl 20 g/ha on 3 DAS and bispyribac sodium 25 g/ha on 20 DAS respectively and in combination with mechanical weeding (cono weeder) on 10 and 25 DAS. Hand weeding on 15 and 30 DAS and in combination with mechanical weeding on 10 and 30 DAS alongwith weedy check (control). The eight row drum seeder (20 cm line spacing) was used and the test variety was ADT 39 (135 days).

RESULTS

The dominant weed flora of the experimental fields are *Echinochola colonum* among the grasses, *Cyperus difformis* among the sedges and *Ammannia baccifera*, *Bergia capensis*, *Marsilia quadrifolia*, *Eclipta alba* among the broad leaved weeds. Among the treatments, application of pre-emergence herbicide pyrazosulfuron ethyl 20 g/ha on 3 DAS + mechanical weeding on 25 DAS (T_5) recorded the lowest weed number of 101.7 /m^2 and 86.2 /m^2 at 30 DAS, which was significantly lower than other treatments along with higher WCE of 96.5% on 60 DAS .The pooled analysis was done for grain, straw yield and economics for Navarai 2012 and Samba 2013. Regarding yield, application of pre-emergence herbicide pyrazosulfuron ethyl 20 g/ha on 3 DAS + mechanical weeding on 25 DAS (T_5) recorded the higher grain and straw yield of 6.45 t/ha and 7.38 t/ha, respectively. This treatment recorded 56% higher grain yield over control (weedy check) (T_{10}) and 14% higher yield over pre-emergence herbicide on 3 DAS (pyrazosulfuron ethyl 20 g/ha) (T_1). These results are in conformity with the findings of Chopra and Chopra (2003) and Pal *et al.* (2012). With regard to economics, application of pre-emergence herbicide pyrazosulfuron ethyl 20 g/ha on 3 DAS + mechanical weeding on 25 DAS (T_5) recorded the higher gross income of Rs. 82669/-, net income of Rs. 48767/- with the B:C ratio of 2.45.

Table 1. Effect of different weed control treatments on weed control efficiency, yield and economics of drum seeded rice

Treatment	Total no. of weeds/m^2 at 30 DAS	WCE (%)	Grain yield (kg/ ha)	Gross income (Rs/ha)	Net income (Rs /ha)	B:C ratio
T1 – PEH on 3 DAS (pyrazosulfuron ethyl 10% WP @ 20 g/ha	25.10^b (644.0)	83.0	5666	73987	41960	2.31
T2 – Po EH on 20 DAS (bispyribac sodium10% EC 25 g /ha)	25.4^b (644.3)	79.3	5604	73302	40350	2.23
T3 - Mechanical weeding on 10 DAS and 25 DAS (cono weeder)	10.6^a (111.0)	94.5	6195	81046	46264	2.33
T4 - PEH. on 3 DAS + Po EH. on 20 DAS	11.01^a (120.3)	92.3	5917	77335	43481	2.30
T5 - PEH. on 3 DAS+ Mech. weed on 25 DAS	10.1^a (101.7)	96.5	6450	82669	48767	2.45
T6 - Mechanical weeding. on 10 DAS + Po EH.on 20 DAS	11.6 a (132.7)	94.7	5755	75463	40636	2.17
T7 - Hand Weeding on 15 and 30 DAS	11.1^a (121.3)	94.4	5917	77482	39250	2.03
T8 - Hand Weeding on 15 DAS + mechanical weeding on 25 DAS	13.3^a (175.3)	90.9	5782	75541	39034	2.07
T9 - Mechanical weeding. on 10 DAS + hand weeding on 30 DAS	12.3^a (150.3)	89.9	5799	74919	38412	2.05
T10 - Control (weedy check)	42.5^c (1808.3)	-	4138	54387	23316	1.75
LSD (P=0.05)	3.5	-	334	NA	NA	NA

*Figures in parentheses are original values, PEH - Pre emergence herbicide, PoE – Post emergence

CONCLUSION

The results revealed that, application of pre-emergence herbicide pyrazosulfuron ethyl 20 g/ha on 3 DAS followed by mechanical (cono weeder) weeding on 25 DAS recorded higher weed control efficiency (WCE) of 94% and higher grain yield of 6.45 t/ha with the B:C ratio of 2.45. Hence, it was concluded that considering the weed control efficiency, yield and economics, pre-emergence application of pyrazosulfuron ethyl 20 g/ha on 3 DAS followed by mechanical (cono weeder) weeding on 25 DAS is recommended for weed management in direct seeded puddled rice to meet the challenges against labour scarcity and weed infestation.

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Bioefficacy of azimsulfuron against sedges in transplanted rice as post-emergence application

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Rice is grown in about 45 mha with production of 96 mt contributing 45% to the total food grain production of India. Weed competition is one of the prime yield limiting biotic constraints resulting into yield reduction of 28-45% in rice (Singh *et al*. 2003). Pre-emergence herbicides are most commonly used against grassy weeds in transplanted rice. But post-emergence herbicides are becoming need of the day due to emergence of sedges and broad leaf weeds at later growth stages of crop. Azimsulfuron is a recently introduced post-emergence sulfonylurea herbicide useful for controlling weeds in rice fields (Valle *et al*. 2006). The present investigation was undertaken to study the bio-efficacy of azimsulfuron for the control of sedges in transplanted rice.

METHODOLOGY

A field trial was conducted during *Kharif* season of 2013-14 and 2014-15 to at N. E. Borlaug Crop Research Center, G. B. Pant University of Agriculture and Technology, Pantnagar to evaluate the bio-efficacy of azimsulfuron developed by M/s E.I. DuPont India Ltd. Experiment consisted of nine treatments with three doses of azimsulfuron with or without surfactant 17.5 , 26.25 and 35 g/ ha including bispyribac sodium 25 g/ha as standard check as well as weed free and untreated check. The herbicidal treatments were applied as post emergence at 24 days after transplanting (2-4 leaf stage of weeds) of the rice crop. Herbicides were applied by using a Knapsack sprayer fitted with flat fan nozzle using water volume of 300 l/ha.

RESULTS

The experiment field was infested mainly with *Scirpus roylei*, *Cyperus iria*, *Cyperus difformis* and *Fimbristylis miliacea* as sedges in the rice crop. Application of azimsulfuron 17.5, 26.25 and 35 g/ha with 0.2% surfactant and 35 g/ha without surfactant provided complete control of *Scirpus roylei*, *Cyperus iria* and *Cyperus difformis* during 2013-14 and 2014-15 respectively. The decrease in dry weight of weeds in these treatments was mainly due to effective control of weeds. Azimsulfuron controlled the weeds by inhibiting biosynthesis of the essential amino acids valine and isoleucine, hence stopping cell division and plant growth. Among herbicidal treatments, the highest grain yield (6.01 and 6.11 t/ha) was found in azimsulfuron + surfactant 26.25 g /ha which was found significantly similar to its higher dose 35 g / ha, azimsulfuron + surfactant 17.5 g/ha and azimsulfuron 35 g /ha without surfactant.

Table 1. Azimsulfuron 50DF + 0.2% surf on total weed density, dry weight, weed control efficiency and grain yield of transplanted rice

Treatment	Dose (g/ ha)	Total weed dry weight at 45 DAA /m^2				Grain yield (kg/ha)	
		2013-15	WCE %	2014-15	WCE %	2013-14	2014-15
Azimsulfuron 50DF + 0.2% surf	17.5	1.8 (3.3)	99.4	1.7 (2.8)	97.63	5900	6010
Azimsulfuron 50DF + 0.2% surf	26.25	1.0 (0.0)	100.0	1.0 (0.0)	100.0	6012	6115
Azimsulfuron 50DF + 0.2% surf	35	1.0 (0.0)	100.0	1.0 (0.0)	100.0	5950	6092
Azimsulfuron 50DF	17.5	6.7(44.6)	92.3	3.1 (9.4)	92.05	5622	5708
Azimsulfuron 50DF	26.25	5.2(26.2)	95.4	2.7 (7.3)	93.82	5730	5850
Azimsulfuron 50DF	35	1.0(0.0)	100.0	1.0 (0.0)	100.0	5900	6070
Bispyribac sodium	25	12.9(166.9)	71.1	6.1 (37.9)	68.1	4950	5040
Weed Free	-	1.0(0.0)	100.0	1.0 (0.0)	100.0	5990	6095
Untreated Check		24.0(579.1)	0.0	10.9 (118.3)	0.0	2333	2074
CD at 5 %		0.85		1.45	-	130	124

Values within parentheses are original. Data are subjected to square root transformation(Öx+1)

CONCLUSION

On the basis of field study, it can be concluded that azimsulfuron + surfactant 17.5 g/ha could be the standard dose for post emergence application in rice to achieve effective control of *Scirpus roylei*, *Cyperus iria*, *Cyperus difformis* and *Fimbristylis miliacea.* This treatment also produced higher grain yield of rice due to effective control these weeds.

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Integration of nitrogen fertilizer timing and weed management practices affects weed dynamics and competition in dry-seeded rice

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Direct-dry seeded rice has been the predominant rice (*Oryza sativa* L.) cultivation system in upland rain-fed rice ecosystem. However, farmers in many Asian countries, including India, are shifting their rice production system from traditional puddle–transplanted rice to direct-seeded either wet or dry-seeded rice cultivation system. Such shift is driven by labour and ever increasing water scarcity. The aerobic soil conditions and dry-tillage practices, besides alternate wetting and drying conditions, are not only conducive for germination and growth of highly competitive weeds, but also causes serious N losses which reduces grain yields ranging between 50-91% in DSR. Nitrogen fertilizer has been reported to break dormancy of certain weed species and thus may affect weed infestation (Agenbag and Villiers 1989). Not only can weed reduce the amount of N available to crop, but also growth of many weed species is promoted by higher soil N levels (Morales-Payan *et al.* 1998) Therefore, knowledge of effects timing of N fertilization on weeds and crops grown in competitive mixture may be a promising cultural approach to integrate with herbicide based weed management. A field study was undertaken to determine the response of weeds and rice to various timing of N application and weed management in dry-seeded rice system. Information generated in the study will help in developing integrated and cost-effective weed management strategy in dry-seeded rice system.

METHODOLOGY

A field experiment was conducted during rainy (*Kharif*) season of 2012 and 2013 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. A combination of 24 treatments consisting of 4 nitrogen application time (main plot) and 6 weed management treatments (sub-plot) were evaluated in a split-plot design (Table 1). Rice variety '*HUR-1O5*' was dry-seeded at seed rate of 40 kg/ha in 20 cm spaced rows. A uniform dose of 120 kg N/ha, 60 kg P_2O_5/ha and 40 kg K_2O/ha were applied in all the plots. Full dose of P and K were applied as basal application and nitrogen was applied as per timing of N application under treatments. Data on weeds growth parameters and weed control efficiency were recorded at 60 days after sowing. Rice yield attributes and yields were also recorded during the course of investigation.

RESULTS

Crop was severely infested with weeds, *viz. Echinochloa colona, Echinochloa crusgalli* (among grasses). *Cyperus rotundus, Cyperus iria, Fimbristylis miliacea (among sedges), Eclipta alba, Ammannia baccifera, Caesulia axillaris* and *Phyllanthus niruri* (among broad-leaf weeds).

Table 1. Effect of nitrogen application time and herbicides on weed growth, yield attributes and grain yield of direct-seeded rice (pooled over 2 years)

Treatment	Total weed density* (m^2)				Total weed dry weight* (g/m^2)				Grain yield (t/ha)			
	N_1	N_2	N_3	N_4	N_1	N_2	N_3	N_4	N_1	N_2	N_3	N_4
Weedy check	19.6 (387.3)	16.8 (282.8)	16.0 (255.6)	18.5 (22.0)	17.9 (342.1)	15.4 (240.5)	14.9 (224.5)	17.7 (314.0)	1.25	1.56	1.77	1.41
Weed free	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	4.93	5.15	5.23	4.87
Pendimethalin 1 kg/ha	16.1 (261.4)	13.6 (187.2)	13.2 (175.2)	15.6 (243.6)	14.5 (212.0)	12.5 (158.0)	11.4 (131.4)	14.3 (207.2)	2.65	3.68	3.21	3.09
Pendimethalin 1 kg/ha *fb* metsulfuron-methyl + chlorimuron (2 + 2 g/ha)	12.2 (149.7)	10.5 (110.4)	9.7 (94.2)	11.6 (135.1)	11.8 (139.3)	9.5 (91.7)	8.7 (76.5)	11.4 (130.8)	3.47	4.45	4.32	3.89
Pendimethalin 1 kg/ha bispyribac + carfentrazone (25 + 20g /ha)	9.8 (95.7)	8.5 (76.1)	8.2 (67.9)	9.3 (86.7)	8.2 (67.8)	5.0 (25.7)	5.2 (27.4)	7.6 (58.9)	4.09	4.74	5.09	4.54
Pendimethalin 1 kg/ha *fb* bispyribac + ethoxy -sulfuron (25 + 18 g/ha)	10.2 (105.2)	9.0 (84.2)	9.0 (81.2)	10.0 (101.2)	9.4 (90.0)	6.0 (37.1)	5.4 (30.1)	8.7 (76.9)	4.07	4.74	4.91	4.40
	SEm±		LSD (P=0.05)		SEm±		LSD (P=0.05)		SEm±		LSD (P=0.05)	
W at same N	0.26		0.74		0.36		1.02		0.11		0.31	
N at same W	0.27		0.78		0.37		1.06		0.12		0.35	

* Observations recorded at 60 DAS; Figures in parentheses are the original values, Data analysed using square root transformation (x + 0.5); **Note:** N_1-¼ basal + ¾ at 4 week after sowing (WS), N_2- ⅓ 2 WS +⅓ 4WS +⅓ 6 WS, N_3- ¼ 2 WS + ¼ 4WS + ¼ 6 WS + ¼ 8 WS, N_4- ¼ basal + 1/2 4WS + ¼ 6 WS, *fb*- followed by

Integration of nitrogen application time with herbicides treatment caused significant reduction in total weed density and dry weight at 60 days after sowing and increased number of panicle/m row length and grain yield of rice (Table1). Pendimethalin 1.0 kg/ha *fb* bispyribac + carfentrazone (25 g + 20 g/ha) under nitrogen application at ¼ 2 WS + ¼ 4 WS + ¼ 6 WS+ ¼ 8WS was most effective in reducing the weed density and weed dry weight and found at par with pendimethalin 1.0 kg / ha *fb* bispyribac + ethoxysulfuron (25 g + 18 g)/ha and recorded significantly less weed indices over other herbicidal treatments.

Treatment combination of ¼ 2WS + ¼ 4WS + ¼ 6WS + ¼ 8WS and pendimethalin 1.0 kg/ha fb bispyribac sodium + carfentrazone (25 + 20 g/ha) produced significantly more number of panicles per row length and recorded maximum grain yield than all the other treatment combinations, but was comparable to pendimethalin 1.0 kg/ha *fb* bispyribac-sodium + ethoxysulfuron (25 + 18 g/ha). The minimum grain yield was recorded under weedy check at all the time of nitrogen application.

CONCLUSION

It was concluded that skipping the nitrogen application at sowing and applying at ¼ 2 WS + ¼ 4 WS + ¼ 6 WS+ ¼ 8 WS and sequential application of pendimethalin 1.0 kg / ha *fb* bispyribac + carfentrazone (25 g + 20 g/ha) was the most effective treatment combination to manage weeds and realize higher grain yield in dry-seeded rice.

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Integrated weed management in machine-planted rice

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Manual transplanting of rice, done usually by hired labour, is increasingly becoming a difficult proposition due to shortage of labour during the peak periods of operation and escalating labour wages. Machine transplanting is one of the methods of crop establishment which may ensure optimum plant population and less reliance on labour with higher yield and profits compared to conventional practice of manual transplanting, and is gaining popularity among farmers. Weeds were reported to reduce rice yields by 12-98%, depending on method of rice establishment. Significant variation occurs in the dominance of the weed species with crop establishment and weed control methods (Singh *et al.* 2005). Identifying suitable weed management practice is one of the steps for getting higher yields under machine planting as weed problem is more due to maintenance of saturation during initial 2-3 weeks for better establishment of younger seedlings particularly during *Kharif* season.

METHODOLOGY

A field experiment was conducted during two consecutive *Kharif* seasons of 2013 and 2014 at Agricultural Research Station, Ragolu, Srikakulam District of Andhra Pradesh on sandy clay loam soil with nine weed management treatments, *viz.* T_1- hand weeding at 20 and 40 DAT, T_2- weed free check, T_3- pre-emergence (PE) application of oxadiargyl 70 g/ha + conoweeding thrice T_4- PE oxadiargyl 70 g/ha + post-emergence application (PoE) of bispyribac-sodium at 25 g/ha + conoweeding twice, T_5- power weeding every 10 days from 15- 55 DAT, T6- POE cyhalofop-butyl at 100 g/ha + 2,4–D at 1.0 kg/ha, T7- POE bispyribac-sodium at 25 g/ha + + 2,4-D at 1.0 kg/ha, T_8- POE pyrazosulfuron-ethyl at 20 g/ha at 4-7 DAT + power weeding twice at 30 and 40 DAT, and T_9- weedy check. The trial was laid out in randomised block design with three replications and test variety was '*RGL-2332*' ('*Srikurma*'). Fifteen days old seedlings raised in trays were planted with Yanmar rice and transplanted at a spacing of 30 cm x 18 cm. Recommended package of practices for transplanted rice was followed for this crop except for weed control.

RESULTS

Results of the two years study revealed that pre emergence application of oxadiargyl 70 g/ha + post-emergence application of bispyribac-sodium at 25 g/ha + cono-weeding twice controlled the weeds effectively, recorded the lowest weed count at 30 DAS and at 50 DAS, lowest weed dry weight at 30 DAS and at 50 DAS with the highest weed control efficiency at 50 DAS and recorded higher grain yield. Post-emergence application of pyrazosulfuron-ethyl at 20 g/ha at 4-7 DAT + power weeding twice at 30 and 40 DAT was found to be next best treatment for weed suppression and yield realization and economics and these two weed managements practices were found at par to weed free check. Saha (2006) found that the sulfonylurea urea herbicides were superior in arresting total weed density and dry matter production in transplanted rice. Yield attributes like panicles/m^2 also followed the same trend of grain yield.

Table 1. Effect of weed control treatments on weed growth, yield and yield parameters in machine-planted rice

Treatment	Weed count/m^2		Weed dry weight (g)		Weed control efficiency (%)	Panicles/ m^2	Grain yield (t/ha)
	30 DAT	50 DAT	30 DAT	50 DAT			
T_1- Hand weeding at 20 and 40 DAS	5.34	8.04	1.27	1.87	83.7	396	4.90
T_2- Weed free check	1.17	0.97	0.32	0.30	98.2	439	5547
T_3- PE oxadiargyl 70g ai/ha + conoweeding thrice	12.31	17.10	2.84	3.85	63.3	383	5.21
T_4- PE oxadiargyl 70 g/ha + POE bispyribac-sodium at 25 g/ha + conoweeding twice	7.58	9.14	1.81	2.16	80.8	404	5.52
T_5- Power weeding every 10 days from 15-55 DAS	14.70	20.91	3.35	4.68	54.6	375	4.90
T_6- POE cyhalofop-butyl at 100 g/ha + 2,4–D at 1 kg/ha	16.04	22.99	4.08	5.41	48.8	375	4.47
T_7- POE Bispyribac sodium at 25 g/ha + 2,4 –D at 1 kg/ha	11.65	14.735	2.67	3.32	69.7	381	5.23
T_8- POE pyrazosulfuron-ethyl at 10 WP at 20 g/ha at 4-7 DAS + power weeding twice at30 and 40 DAS	9.88	16.04	2.27	3.58	69.7	407	5.35
T_9- weedy check	31.39	45.59	6.80	9.76	0	301	3.83
LSD (0.05)	4.84	17.97	1.14	3.30	-	57	0.58

CONCLUSION

Pre-emergence application of oxadiargyl 70 g/ha + post-emergence application of bispyribac-sodium at 25 g/ha + cono-weeding twice was found to be the best weed management practice for machine planted rice.

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Evaluation of different weed management practices in aerobic rice in coastal areas of Karaikal

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Increasing scarcity of fresh water for agriculture particularly for rice cultivation due to the demand of water by industries and other sectors has threatened the sustainability of the irrigated rice ecosystem (Tuong and Bouman 2003). Aerobic rice cultivation offers an opportunity to produce rice with less water. This way of growing rice saves water by eliminating continuous seepage and percolation, land preparation and reducing evaporation (Bouman *et al.* 2002). However, direct seeded aerobic rice is subject to more severe weed infestation than transplanted lowland rice, because in aerobic rice systems weeds germinate simultaneously with rice, and there is no water layer to suppress the weed growth. This necessitates the evaluation of new herbicides and weed management practices for controlling weeds in aerobic rice systems. Considering the above facts, a field experiment was undertaken to evaluate different weed management practices in aerobic rice in the coastal areas of Karaikal.

METHODOLODY

A field experiment was conducted during *Kharif* 2011 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The soil of the experimental site was loamy sand in texture and low in available N (78.4 kg/ha) and P (16.2 kg/ha), and medium in available K (138 kg/ha). Soil pH was slightly acidic (6.1). The organic C content was medium (0.76%). An early-maturing (107-117 days) rice cv. '*PMK(R)-3*' with medium fine grain quality was sown at a spacing of 20 cm × 10 cm. The experiment consisting of ten treatments (Table 1) was laid out in a randomized block design with three replications. Pre-emergence application of herbicides was done at three days after sowing while early post-emergence application of herbicides was done at twelve days after sowing. The growth parameters and yield were recorded and statistically analysed. The economics was worked out based on the prevailing costs of inputs and output.

RESULTS

The predominant weed flora in the experimental field were: *Echinochloa colona*, *Cynodon dactylon* and *Panicum repens*among grasses, *Trianthema portulacastrum, Cleome viscosa, Aeschynomene indica* and *Eclipta alba* among broad leaved weeds and *Cyperus rotundus* among sedges. When weeds were left unchecked, the rice grain yield was reduced by 90.3% (Table 1). The results revealed that application of pendimethalin 0.75 kg/ha + hand hoeing at 40 DAS recorded higher growth and yield parameters which in turn resulted in significantly higher grain and straw yields (1.53 and 2.74 t/ha). The economic evaluation also indicated that higher gross returns (Rs. 22,669 /ha), net returns (4,449 / ha) and B:C ratio (1.25) were obtained with pendimethalin 0.75 kg/ha + hand hoeing at 40 DAS. Application of anilofos 0.40 kg/ha + hand hoeing at 40 DAS was the next best treatment.

Table 1. Growth parameters, yield, weed index and economics of aerobic rice production as influenced by different weed control treatments

Treatment	Leaf area index	Grain yield (t/ha)	Weed index	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Pendimethalin 0.75 kg/ha + hand hoeing at 40 DAS	7.25	1.53	-	22,669	4,499	1.25
Cyhalofop 0.10 kg/ha + hand hoeing at 40 DAS	6.16	0.96	37.2	14,297	-3,626	0.80
Pretilachlor safener 0.50 kg/ha + hand hoeing at 40 DAS	5.55	0.98	36.0	14,531	-3,513	0.81
Pyrazosulfuron-ethyl 0.20 kg/ha + hand hoeing at 40 DAS	6.01	1.09	28.7	16,320	-2,059	0.89
Butachlor 1.00 kg/ha + hand hoeing at 40 DAS	5.45	1.21	21.0	17,706	-73	1.00
Anilophos 0.40 kg/ha + hand hoeing at 40 DAS	6.53	1.47	4.1	21,888	4,070	1.23
Metamifop 0.075 kg/ha + hand hoeing at 40 DAS	4.52	0.87	43.2	12,921	-4,983	0.72
Metamifop 0.100 kg/ha + hand hoeing at 40 DAS	5.04	0.81	47.1	11,958	-6,121	0.66
Hand hoeing at 20 and 40 DAS	6.85	1.18	22.7	17,794	-1,185	0.94
Unweeded control	4.40	0.14	90.3	2,739	-13,240	0.17
LSD (P=0.05)	1.13	0.16				

NA -Data statistically not analysed

CONCLUSION

Pre-emergence application of pendimethalin 0.75 kg/ha followed by hand hoeing at 40 DAS is found to be a suitable weed management practice for achieving higher productivity and economic returns in aerobic rice in Karaikal region.

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Weed management practices in aerobic rice under different seeding methods

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*A*erobic rice suffers more due to weed menace as the weeds and rice compete for growth factors together and weeds cause yield loss between 30 and 98% (Oerke and Dehne 2004). Pretilachlor as pre-emergence herbicide, is not effective against grasses and sedges while azimsulfuron, the new selective post-emergence herbicide was found to be efficient against sedges and broadleaf weeds and less effective against grasses. However, sequential application of herbicides along with one hand weeding was reported to be more effective than application of herbicides alone, hence the present investigation was undertaken to study the efficacy of sequential application of pre- and post-emergence herbicides in aerobic rice under direct seeding and broadcasting.

METHODOLOGY

Field experiment was carried out during *Kharif*, 2014 at Professor Jayashankar Telangana State Agricultural University, Hyderabad to evaluate the efficacy of sequential application of herbicides under different seeding methods in sandy loam soil. The experiment was conducted in factorial RBD with a plot size of 4 m x 4 m with three replications. Factor 1 includes seeding methods, broadcasting (S_1) and line sowing (S_2) Factor II includes weed management practices, T_1 - pretilachlor 0.75 kg/ha *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g/ha + cyhalofop-butyl 75 g/ha at 15-20 DAS, T_2 - pretilachlor *fb* azimsulfuron + cyhalofop-butyl 15-20 DAS, T_3 - pretilachlor 0.75 kg/ha *fb* pyrazosulfuron-ethyl + cyhalofop-butyl at 15-20 DAS, T_4 - bispyribac-sodium 25 g/ha *fb* 2-4-D 0.5 kg/ha at 40 DAS, T_5 - T_1 followed by HW at 50 DAS, T_6 - T_2 followed by HW at 50 DAS, T_7 - T_3 followed by HW at 50 DAS, T_8 - T_4 followed by HW at 50 DAS, T_9 - HW at 20, 40 and 60 DAS, T_{10} - unweeded control. The recommended fertilizer dose was applied at 100-60-40 kg of N, P_2O_5 and K_2O/ha, respectively.

RESULTS

Major weed flora were: *Echinocloa colonam* L., *Cynodon dactylon* L., *Eleusine indica* (among the grasses); *Cyperus rotundus* L (among the sedges), *Eclipta alba* L., *Commelina bengalensis* L., *Ipomoea purpurea, Alternanthera sessillis, Physalis minima, Bacopa monnieri, Cyanotis cristata, Corchorus, Phyllanthus niruri, Ageratum conyzoides* (among the broad-leaved weeds). Herbicidal treatments significantly influenced the yield parameters as well as grain yield. Significantly higher number of panicles and test weight were recorded with hand weeding thrice which was at par with pretilachlor *fb* azimsulfuron + cyhalofop-butyl 15- 20 DAS *fb* HW at 50 DAS with regard to higher WCE and grain yield, indicating that weeds are controlled efficiently with sequential application of herbicides resulted in higher grain yield. Number of panicles and grain yield was influenced by the interaction effect of both seeding methods and weed management practices. Hand weeding recorded significantly higher number of panicles and yield under line sowing method. Among seeding methods, higher grain yield was recorded with line sowing (S_2) than the broadcasting (S_1) method which might be due to the maintenance of less weed population and higher weed control efficiency.

Table 1. Effect of weed management practices on aerobic rice under different seeding methods

Weed management	WCE	No. of panicles/m²			Grain yield (t/ha)		
	(%)	S_1	S_2	Mean	S_1	S_2	Mean
Pretilachlor fb metsulfuron-methyl + chlorimuron-ethyl + cyhalofop-butyl at 15-20 DAS	43.2	254.6	246.3	250.5	2.35	2.97	2.66
Pretilachlor *fb* azimsulfuron + cyhalofop-butyl 15-20 DAS	43.5	280.0	258.3	269.1	2.63	3.13	2.88
Pretilachlor *fb* pyrazosulfuron-ethyl + cyhalofop-butyl at 15-20 DAS	43.0	243.6	254.3	249.0	2.33	3.24	2.78
Bispyribac-sodium *fb* 2-4-D at 40 DAS	42.6	246.6	250.6	248.6	2.21	2.97	2.59
T_1 *fb* HW at 50 DAS	95.0	229.6	285.3	257.5	2.65	3.64	3.15
T_2 *fb* HW at 50 DAS	95.3	236.6	287.3	262.0	2.70	3.73	3.21
T_3 *fb* HW at 50 DAS	94.9	225.6	283.3	254.5	2.54	3.62	3.08
T_4 *fb* HW at 50 DAS	94.8	230.0	282.0	256.0	2.55	3.44	3.00
HW at 20, 40, 60 DAS	95.5	251.3	288.0	269.6	2.98	4.06	3.52
Unweeded control	0	149.6	134.3	142.0	0.95	1.05	1.00
Mean		234.8	257.0		2.36	3.16	
		SEm ±	LSD (P=0.05)		SEm ±	LSD (P=0.05)	
F1		2.5	7.2		0.44	1.28	
F2		5.6	16.1		1.00	2.86	
F1×F2		7.9	22.8		1.41	4.05	

CONCLUSION

Sequential application of pre- and post-emergence herbicides, *viz.* azimsulfuron or pyrazosulfuron-ethyl, chlorimuron-ethyl + metsulfuron-methyl, bispyribac-sodium or 2,4-D along with one hand weeding was found to be efficient weed control practice for getting more grain yield, while it was with line sowing as suitable seeding method for getting higher grain yield in aerobic rice.

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Effect of post-emergence herbicides on yield and economics of direct wet-seeded rice

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The weed flora of wet direct-seeded rice crop is entirely different from that of transplanted crop due to maintenance of saturation moisture at sowing and shallow depth of water up to three weeks after sowing. The establishment of rice crop through drum seeding technique by using sprouted rice seed on puddled soil is confronted with the problem of profuse growth of weeds. Infestation of heterogeneous weed flora becomes the biggest biological constraint and yield losses even up to 90% have been reported (Bhat *et al.* 2011). Role of efficient weed management practices in wet-seeded rice is an important phenomenon and the success of direct wet-seeded rice is dependent upon efficient and effective weed control practices. Thus the present study was undertaken to explore the possibility of use of different high efficacy herbicides for efficient and effective weed management in direct wet-seeded rice sown through drum seeder.

METHODOLOGY

A field experiment was conducted during *Kharif* season 2012 in sandy clay loam at the College farm, college of agriculture, Acharya N.G. Ranga agricultural university, Rajendranagar, Hyderabad. Eight weed control treatments were laid out in randomized block design with three replications. The sowing was done through 8 row drum seeder by using sprouted seeds under puddled condition with a row to row spacing of 20 cm. A uniform fertilizer dose of 120-60-60-25 kg N-P-K-Zn /ha was applied. Rice '*MTU-1010*' of 110-120 days duration was used as test variety. Pre-germinated seed at 38 kg/ha was used for wet drum seeding of rice. The total rainfall received during crop season was 579.8 mm. Pre-emergence and post-emergence herbicides were applied with the help of a sand mixture and hand-operated knapsack sprayer fitted with flat-fan nozzle respectively. Data on weed growth, yield performance and economic were recorded.

RESULTS

The result indicated that all the weed control treatments brought out a significant effect on yield of direct wet seeded rice as compared to unweeded plot (Table 1). Highest grain yield and straw yields were recorded in weed free treatment (5.80 and 7.00 t/ha respectively). Among the weed control treatments , bispyribac-sodium (at 25 g/ha) at 25 DAS as PoE recorded the highest grain yield and straw yield (5.37 and 6.50 t/ha) which was on par with cyhalofop-butyl (100 g/ha) + chlorimuron-ethyl + metsulfuron-methyl (at 4 g/ha)) at 15 days after seeding as PoE, pretilachlor + safener (0.4 kg/ha) at 3 days after seeding) + Hand weeding at 40 DAS and two hand weeding at 20 and 40 DAS. The higher grain and straw yield were mainly due to the favourable condition created through the efficient weed control resulted in lesser weeds competition to the crop by reducing weed density, weed dry matter and better weed control efficiency, which favoured crop to produce more plant dry matter, increased productive tillers over unweeded check.

Adoption of different weed management practices also influenced the gross returns, net returns and B: C ratio. The highest net returns and BCR were obtained with bispyribac-sodium at 25 g/ha) at 25 DAS as PoE and were higher as compared to other treatments (Table 1). The weed free check recorded maximum gross return, but it was not recorded the maximum net return and B : C ratio. The increased cost incurred to keep the plot weed free had reduced the net return and B : C ratio. Next to these treatments cyhalofop-butyl at 100 g/ha) + chlorimuron-ethyl + metsulfuron-methyl@4/ha at 15 DAS as PoE, pretilachlor + safener at 0.4 kg/ha at 3 DAS + Hand weeding at 40 DAS, has given the better performance in wet drum-seeded rice. The two hand weedings at 20 and 40 DAS also gave the better result.

Table 1. Effect of weed management practices on grain and straw yields and economics of wet direct-seeded rice sown through drum seeder

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Gross returns ($x10^3$ Rs/ha)	Net returns ($x10^3$ Rs/ha)	B:C ratio
T_1 – Weed free check (repeated hand weeding at 10 days intervals)	5.80	7.00	86.50	36.09	1.72
T_2 – Unweeded check	2.37	3.50	36.72	4.76	1.15
T_3 – Two hand weedings at 20 and 40 DAS	5.00	6.10	74.70	38.64	2.07
T_4 – Metamifop 100 g/ha at 3 leaf stage) as POE	3.47	4.53	52.38	19.72	1.60
T_5 – Pretilachlor + safener 0.4 kg/ha at 3 DAS as PE	3.91	4.99	58.84	26.22	1.80
T_6 – Bispyribac-sodium 25 g/ha at 25 DAS as POE	5.37	6.50	80.08	44.80	2.27
T_7 – Cyhalofop-butyl 100 g/ha + chlorimuron-ethyl + metsulfuron-methyl at 4 g at 15 DAS as POE	5.23	6.33	78.07	43.29	2.24
T_8 – Pretilachlor + safener 0.4 kg/ha at 3 DAS + hand weeding at 40 DAS	5.10	6.20	76.15	41.47	2.2
LSD (P=0.05)	0.41	0.49			

PE - Pre-emergence, PoE – Post-emergence, DAS - Days after sowing; Price of grain: Rs. 12.50/kg and Price of straw: Rs. 2.00/kg

CONCLUSION

Application of bispyribac-sodium@25 g/ha at 25 DAS as PoE has recorded the highest grain yield, net returns, and B:C ratio followed by cyhalofop-butyl@100 g/ha + (chlorimuron-ethyl + metsulfuron-methyl)@4 g/ha) at 15 DAS as PoE and were found to be economically beneficial weed control practices in wet drum seeded rice under situations where weed control measures could not be taken up in early stages of crop growth.

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Weed management options under different methods of establishment in summer rice

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Rice (*Oryza sativa* L.) is an important staple crop in India and its productivity is declining due to many constraints. Weeds are a major impediment to rice production, causing differential yield losses under varying methods of establishment. Manual or mechanical method does not ensure timely and effective weed management because of many limitations. Due to higher wages and unavailability of labor, herbicides find greater acceptance by the farmers (Yaduraju 2012). New chemical herbicides appear to be the suitable alternatives under all situations. Hence, the present study was carried out to study the efficacy of mew herbicides in rice under different establishment methods.

METHODOLOGY

A field experiment was carried out during dry (*Boro*) season of 2011-12 and 2012-13 at Rice Research Station, Chinsurah, Hooghly, West Bengal to evaluate the bio-efficacy of new herbicides under different methods of rice establishment. The soil of the experimental field was a typical Gangetic Alluvium (Entisol) with clay-loam texture, good water holding capacity and moderate soil fertility. Three establishment methods in main plots and eight weed management treatments in sub-plots were assigned in split-plot design with three replications. Establishment methods included System of Rice Intensification (SRI), drum seeding of rice (DSR) in puddled (wet) soil and conventional transplanting of rice (CTR), whereas weed management treatments comprised of pyrazosulfuron-ethyl at 25 g/ha at 10 days after sowing (DAS) / transplanting (DAT) + cono weeding (CW) at 25 DAS/DAT, bispyribac-sodium at 25 g/ha (15 DAS/DAT) + CW (25 DAS/DAT), azimsulfuron at 35 g/ha (15 DAS/DAT) + CW (25 DAS/DAT), penoxsulam at 25 g/ha (10 DAS/DAT) + CW (25 DAS/DAT), metsulfuron-ethyl + chlorimuron-ethyl at 4 g/ha (10 DAS/DAT) + CW (25 DAS/DAT), one CW (25 DAS/DAT), two hand weeding (20 and 40 DAS/DAT) and weedy check. Rice variety '*Khitish (IET 4094)*' was raised with recommended package of practices. Herbicides were sprayed using knapsack sprayer fitted with a flat fan nozzle at a spray volume of 500 l/ha. Data were recorded on weed growth (density and biomass) at 75 DAS/DAT and grain yield at harvest.

RESULTS

Weed flora in unweeded plots mostly consisted of *Echinochloa colona*, *E. crusgalli* (grasses); *Cyperus difformis*, *C. iria*, *C. rotundus* (sedges); *Eclipta alba*, *Euphorbia hirta*, *Marsilea quadrifoliata* and *Monochoria vaginalis* (broadleaved). Weed management treatments involving herbicide use were found more effective in SRI and DSR (wet) than CTR. All the establishment methods as well as weed management treatments significantly influenced the density and biomass of weeds. Among the weed management treatments, lower weed density as well as biomass were recorded under bispyribac-sodium + cono weeding, azimsulfuron + conoweeding, metsulfuron-ethyl + chlorimuron-ethyl + cono weeding and two rounds of hand weeding, which remained at par. Chauhan and Yadav (2013) reported these herbicides to be effective for direct seeded rice (Table 1). Better performance of these treatments was obviously due to broader spectrum of weed management, compared with the others. Among establishment methods, SRI was found more promising, irrespective of weed management levels, whereas DSR (wet) and CTR were at par with each other. The lowest grain yield was recorded in weedy check plots due to the fact that weeds robbed off different growth-limiting resources meant for rice crop.

Table 1. Effect of treatments on weed growth and grain yield of summer rice

Treatment	Weed density (no./m^2)		Weed biomass (g/m^2)		Grain yield (t/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Establishment methods						
SRI	52.6	73.1	44.1	35.2	5.62	5.75
DSR (wet)	55.7	84.8	47.5	42.3	5.27	5.37
CTR	57.4	80.3	50.2	40.8	5.20	5.34
LSD (P=0.05)			2.6	2.1	0.23	0.29
Weed management						
Pyrazosulfuron-ethyl + Cono weeding	48.3	72.4	41.4	34.6	5.41	5.44
Bispyribac-sodium + Cono weeding	21.9	34.8	17.2	17.4	5.71	5.75
Azimsulfuron + cono weeding	22.9	33.1	18.3	16.7	5.65	5.80
Penoxsulam + cono weeding	27.8	44.5	24.0	21.0	5.56	5.62
Metsulfuron-ethyl + chlorimuron-ethyl + cono weeding	47.4	68.0	41.1	33.2	5.43	5.50
CW once	99.2	135.2	88.3	68.2	4.95	5.20
Hand weeding twice	26.1	38.7	14.9	17.4	5.82	5.89
Weedy check	148.4	208.4	133.1	107.1	4.33	4.71
LSD (P=0.05)	7.5	8.0	5.8	7.4	0.36	0.27

CONCLUSION

It might be concluded that post-emergence application of bispyribac-sodium, azimsulfuron or metsulfuron-ethyl + chlorimuron-ethyl in combination with one cono weeding would be an effective tool for weed management in different methods of summer rice culture.

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Weed management practices in aerobic rice under sodic soil condition

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Rice (*Oryza sativa* L.) is a major food crop of India in terms of area, production and consumer preference. The water scarcity is the emerging problem in rice growing areas in Tamil Nadu. The aerobic rice is improved upland rice in terms of yield potential and improved lowland rice in terms of drought tolerance. Rice is unique in the sense that transplanted paddy requires lot of water for land preparation. Aerobic cultivation has more benefits as compared to traditional transplanting. However, weeds are one of the limiting factors in aerobic rice cultivation, which reduce the yield up to 82% (Thimmegowda 2006). Chemical weeding is the vital tool for effective and cost efficient weed control in aerobic rice. However, the information on weed management practices for aerobic rice is not available sufficient, hence the present investigation was undertaken.

METHODOLOGY

A field experiment was carried out during *samba* season of 2013-14 (September 2013-January 2014) at Anbil Dharmalingam Agricultural College and Research Institute, Trichy to evolve an efficient and economic weed management practice for aerobic rice. Ten treatments consisting of pretilachlor at 600 g/ha as pre-emergence herbicide on 3 DAS (T_1), metsulfuron-methyl 10% + chlorimuron-ethyl at 20 g/ha as post-emergence herbicide on 20 DAS (T_2), pyrazosulfuron-ethyl at 25 g/ha as pre-emergence herbicide on 3 DAS (T3), $T_4 = T_1 + T_2$, metsulfuron-methyl 10% + chlorimuron-ethyl at 20 g/ha as pre emergence herbicide on 8 DAS and post-emergence on 20 DAS (T_5), pyrazosulfuron-ethyl at 25 g/ha as pre-emergence herbicide on 3 DAS + metsulfuron-methyl + chlorimuron-ethyl at 20 g/ha as post-emergence herbicide on 20 DAS (T_6), pretilachlor at 600 g/ha as pre-emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post-emergence herbicide on 20 DAS (T_7), pyrazosulfuron-ethyl at 25 g/ha as pre-emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post-emergence herbicide on 20 DAS (T_8), bispyribac-sodium at 20 g/ha as post-emergence herbicide on 20 DAS (T_9), Hand weeding twice at 20 and 40 DAS (T_{10}) and unweeded check (T_{11}) were arranged in a randomised block design with three replications. Rice variety 'TRY 1' was sown as aerobic condition with these treatments. Data on weed growth, yield performance and economics were recorded.

RESULTS

Among the grassy weeds *Echinochloa colona* was dominant followed *Cynodon dactylon.* In case of sedges, *Cyperus rotundus* was dominant sedge followed by *Cyperus iria. Ammania baccifera, Ludwigia parviflora* and *Eclipta alba* were more dominant among broad-leaved weeds. Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest weed density of 41.6, 32.0, 23.0 and 16.3 no./m^2 at 30 DAS, 60 DAS, 90 DAS and at harvest, respectively was observed under pretilachlor at 600 g/ha as pre-emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post-emergence herbicide on 20 DAS (Table 1). The higher weed density was recorded in unweeded check. Herbicidal treatments resulted in considerably lower cost of cultivation compared with hand weeding. The similar trend was also observed in total weed dry weight. The maximum weed control efficiency of 74.6, 83.8, 79.1 and 77.2% were recorded at 30, 60, 90 DAS and at harvest, respectively. Minimum weed control efficiency of 34.6% at 30 DAS was recorded in bispyribac-sodium at 20 g/ha as post-emergence herbicide on 20 DAS but later stages minimum weed control efficiency of 56.2, 60.0 and 50.3% at 60, 90 DAS and at harvest respectively recorded in pyrazosulfuron-ethyl at 25 g/ha as pre-emergence herbicide on 3 DAS.

Table 1. Influence of different methods of weed control practices on weeds at 90 DAS, growth, yield and economic of aerobic rice under sodic soil condition

Treatment	Total weeds density (no./m^2)	Total weeds biomass (g/m^2)	Weed control efficiency (%)	Grain yield (t/ha)	B:C ratio
T_1 - Pretilachlor (6.6 GR) at 600 g/ha as PE on 3 DAS	42.6 (3.78)	41.8	69.2	3.22	4.05
T_2 – Metasulfuron-methyl 10 % + chlorimuron-ethyl 10% WP at 20 g/ha as POE on 20 DAS	46.3 (3.93)	48.6	64.1	3.18	3.93
T_3 – Pyrazosulfuron-ethyl (5 WP) at 25 g/ha as PE on 3 DAS	44.0 (3.83)	54.1	60.1	3.10	3.85
$T_4 = T_1 + T_2$,	36.6 (3.65)	40.5	70.1	3.51	4.31
T_5- Metsulfuron-methyl 10% + chlorimuron-ethyl 10% WP at 20 g/ha as PE on 8 DAS and POE on 20 DAS	37.3 (3.67)	44.8	67.0	3.24	4.01
T_6 -T_3 + T_5	39.3 (3.55)	55.0	59.4	3.30	4.05
T_7- T_1 + bispyribac-sodium 10% SC at 20 g/ha as POE on 20 DAS	23.0 (3.99)	28.2	79.1	3.54	4.31
T_8 - T_3 + bispyribac-sodium 10% SC at 20 g/ha as POE on 20 DAS	29.6 (3.73)	36.7	72.9	3.37	4.13
T_9 – Bispyribac-sodium 10% SC at 20 g/ha as POE on 20 DAS	40.0 (3.69)	50.0	63.1	3.22	3.98
T_{10} - HW twice at 20 and 40 DAS	38.3 (3.79)	51.7	62.8	3.23	3.92
T_{11} - Unweeded check	109.3 (3.30)	135.5	0.0	2.00	2.61
LSD (P=0.05)	11.1 (0.18)	14.9	-	0.88	-

Among the herbicidal treatments, pretilachlor at 600 g/ha as pre emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post-emergence herbicide on 20 DAS recorded maximum grain yield which was at par with pretilachlor at 600 g/ha as pre-emergence on 3 DAS +

metsulfuron-methyl 10 % + chlorimuron-ethyl at 20 g/ha as post-emergence on 20 DAS, but significantly higher as compared to other herbicide treatments. Lowest grain yield was recorded in unweeded check. The maximum straw yield was recorded in pretilachlor at 600 g/ha as pre emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post emergence herbicide on 20 DAS. The similar trend was also observed in all growth and yield attributes (Table 1). The B: C ratio was found maximum with pretilachlor at 600 g/ha as pre emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post emergence herbicide on 20 DAS followed pyrazosulfuron-ethyl at 25 g/ha as pre-emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post emergence herbicide on 20 DAS which was significantly lower than all other treatments.

CONCLUSION

It was concluded that pretilachlor at 600 g/ha as pre emergence herbicide on 3 DAS + bispyribac-sodium at 20 g/ha as post emergence herbicide on 20 DAS was most effective for controlling weeds, improving grain yield and profitability of aerobic rice under sodic soil condition.

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Effect of new post-emergence herbicides in wet-seeded rice

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METHODOLOGY

An experiment was conducted in Kole lands of Thrissur, Kerala, India, during October 2011 to February 2012 to study the effect of various post emergent herbicides on weed flora and density in wet-seeded rice. The herbicidal treatments included application of three graminicides (metamifop, fenoxaprop-p-ethyl and cyhalofop-butyl), graminicides with follow up spray of herbicides (almix, carfentrazone and ethoxysulfuron) to kill non-grassy weeds and herbicides with broad spectrum activity (bispyribac sodium, penoxsulam and azimsulfuron). Hand weeded and unweeded controls were also included.

RESULTS

The results showed that grasses were the dominant weed flora followed by broad leaved weeds and sedges. *Echinochloa* was the main grass weed whose density was 21 /m^2 in unweeded control whereas the lowest density (3-5 /m^2) was registered in graminicide applied plots. The highest broad leaved weed population was in metamifop sprayed plots. The lowest grass population was noticed in bispyribac-sodium which was free of sedges also. At harvest stage of rice, in hand weeded plots the broad leaved weed *Lindernia crustacea* alone was present. The best herbicide treatment with low weed dry matter production was fenoxaprop-p-ethyl or cyhalofop-butyl with follow up spray of Almix. Bispyribac-sodium registered the highest weed control efficiency next to hand weeding which was comparable to application of cyhalofop-butyl / fenoxaprop-p-ethyl / metamifop with follow-up spray of metsufluron-methyl + chlorimuron-ethyl.

CONCLUSION

Thus for wet-seeded rice, spraying of fenoxaprop-ethyl or cyhalofop-butyl or metamifop along with metsulfuron-methyl + chlorimuron-ethyl (as post-emergence) or bispyribac-sodium alone as post- emergence appeared to be effective in controlling weeds, which were next to hand weeding in producing higher yield.

Evaluation of spada60 DF for post-emergent weed control in lowland irrigated direct seeded rice (*Oryzasativa* L.) in Guyana

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In Guyana, rice cultivation is predominantly done by broadcasting pre-germ seed in shallow floodconditions mainly due to labour shortage and associated high cost. Weeds are the number one constraints to rice production in Guyana.Singh *et al.* (2005) reported that weeds can reduce the grain yield of wet seeded paddy by 70.6%. Spada 60 DF is a 60% dry flowable formulation containing 600 g Propanil kg^{-1}finished product which can provide control for a broad spectrum of weeds, thus this investigation was undertaken to find out the efficacy of the new herbicide.

METHODOLOGY

The field experiment was carried out during first crop of 2011 at the Rice Research Station, Burma, Guyana in a randomized complete block design with four replications with variety G98-22-4 at 135 kg/ha seed rate. The treatments were Spada at 3.72 kg/ha (T_1), Spada at 7.43 kg/ha (T_2), Spada at 3.72 fb Spada at 3.72 kg/ha (T_3), Spada at 3.72 kg/ha + 2, 4-D at 0.65 L/ha (T_4), Spada at 3.72 + metsulfuron-methyl at 0.0099 kg/ha (T_5), Propanil at 1.3 L ha^{-1} (T_6), Propanil at 1.3 + 2, 4-D at 0.65 L ha (T_7), 2, 4-D at 0.65 L/ha (T_8), Metsulfuron methyl at 0.0099 kg/ha (T_9) and control (T_{10}). Treatment $T_2$and part of T_3 were applied at 4-5 leaf stage, while all other treatments were applied at 2-3 leaf stage of weeds.

RESULTS AND DISCUSSION

The dominant weed specie during the experiment was *Echinochloaglaberescens*. At maturity,application of Spada at 3.72 kg/ha twice at 2-3 and 4-5 leaf stage recorded significantly lowest (3.5) number of weed tillers m^{-2}andWDM (8 kg/ha)and significantly

highest WCE (98.53%).Weeds that escape initial control measure and those emerge as second flush was taken care of when another dose of the herbicide was applied at the 4-5 leaf stage. Significantly more panicles (524)/m^2, larger panicle (26.6 cm) length and maximum number of (70.4) fill grains/panicle were recorded when Spada at 3.73 kg/ha was applied at 2-3 and 4-5 leaf stage of weed. Maximum grain yield (3775 kg ha^{-1}) was recorded when Spada was applied at 3.72 kg/ha at 2-3 and 4-5 leaf stage.Higher rice yield in response to efficient weed control are reported elsewhere (Mahajan *et al.* 2009, Khaliq *et al.*). Significant correlation with grain yield against WDM, plant height and panicle/m^2 was -0.74, 0.82 and 0.81 respectively.

Table 1. Effect of herbicide applications on growth, yield parameters and grain yield in lowland irrigated direct seeded rice.

Treatment	Weed tillers at maturity (m^2)	Weed dry matter (kg/ha)	Weed ontrol efficacy (%)	Plant height (cm)	Panicles/ m^2	Panicle length (cm)	Grains/panicle		1000-grain weight (g)	Grain yield (kg/ha)
							Fill	Unfilled		
T_1	11.19(110.5)	17.14(382)	51.72	102.7	490	25.3	53.3	7.9	29.0	2722
T_2	9.55(131.8)	12.52(170)	68.86	99.7	465	25.0	57.8	9.3	28.0	2900
T_3	2.31(3.5)	3.01(8)	98.53	104.3	524	26.6	70.4	8.5	28.3	3775
T_4	7.47(46.0)	10.60(101)	81.50	102.4	481	26.4	66.7	11.3	27.7	2928
T_5	10.34(110.3)	15.92(278)	49.08	100.6	506	26.1	63.1	10.6	28.4	2825
T_6	7.00(38.5)	15.27(237)	56.59	99.5	479	25.8	60.1	12.4	27.9	2725
T_7	11.18(107.3)	21.19(443)	48.86	99.0	458	25.7	59.8	9.0	28.7	2650
T_8	6.12(33.8)	11.20(156)	71.43	102.3	456	25.7	63.3	10.0	28.4	2925
T_9	9.95(102.0)	14.89(232)	57.51	97.5	348	26.0	65.0	7.4	28.8	2238
T_{10}	14.16(174.3)	24.06(546)		98.2	387	25.7	52.8	10.4	27.0	1876
LSD (P=0.05)	6.00	9.06		6.6	129.7	1.4	13.7	4.4	1.4	843

CONCLUSION

Spada at 3.72 kg/ha applied twice at 2-3 and 4-5 leaf stage of weed gave significant reduction on weed population and WDM at maturity, thus resulting in high WCE. Spada 60 DF proved very good for the control of *E. glaberescens*, which is presently the number one rice weed in Guyana.

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Efficacy of rinskor™ active in wet-seeded rice in China

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Rice is one of the most important food crops in China, but weed infestation can resultinconspicuous yield loss. The weeds causing yield loss in rice include barnyardgrass (*Echinochloa* spp.), Chinese sprangletop (*Leptochloa chinensis*), sedges, and broadleaf weeds. Currently, herbicides are widely used to control weeds but control failures caused by resistance to quinclorac, ALS, and ACCase herbicides have become more frequent, especially in Yangtze River rice production areas and NE China where herbicides are intensively used (Ma *et al*. 2012, Lu *et al*. 2009). New herbicides with alternative modes of action are needed because of the resistance issues and would offer effective herbicide options that are needed by rice growers in China. Rinskor is a new arylpicolinate herbicide has a synthetic auxin mode of action being developed by Dow AgroSciences with global utility in rice and other crops. This new herbicide can provide an alternative MOA for the control of existing target site resistant weed species. Field performance of Rinskor was evaluated in wet-seeded rice in China in 2013and 2014.

METHODOLOGY

Field trials were carried out to evaluate the efficacy of Rinskor™ active on ECHCG (*Echinochloa crus-galli*), LEFCH (*Leptochloa chinensis*), CYPDI (*Cyperus difformis*), MOOVA (*Monochoria vaginalis*), LUDOC (*Ludwigia octovalvis*), AMMSS (*Ammannia* sp.), LIDPY (*Lindernia procumbens*), and ROTIN (*Rotala indica*) in key rice provinces. Herbicides were foliar applied at the 4 to 5 leaf stage of ECHCG. Rinskor was formulated as a NeoEC™ with a loading of 25 g/l Efficacy and crop injury were evaluated visually at 7, 15, 30, and 45 days after application (DAA).

RESULTS

Rinskor™ active at 25 g/ha provided satisfactory control of ECHCG; whereas Rinskor at 30 g/ha was required to achieve satisfactory control of LEFCH (Table 1 and 2). For ECHCG, Rinskor™ active at 20 g/ha or greater was more effective than bispyribac at 30 g/ha. At 20 g/ha, Rinskor gave nearly perfect control against CYPDI, MOOVA, LUDOC, AMMSS, LIDPY, and ROTIN. Effective broad-spectrum control of grass, broadleaf, and sedge weeds was demonstrated with Rinskor in these trials and the overall efficacy of Rinskorwas superior to the commercialstandardbispyribac Na applied at 30 g/ha.

Slight and transient crop injury was observed in isolated trials in plots treated with Rinskor at 40 g/ha. This injury was present at about 5DAA but was no longer detected at 30daa.

Table 1. Visual control (%) of grass and sedge weeds with herbicides 30 DAA after application in wet-seeded rice in China.

Treatment	Rate (g/ha)	ECHCG[1]		LEFCH		CYPDI	
		Obs[2]	Mean (%)[3]	Obs	Mean (%)	Obs	Mean (%)
Rinskor	20	42	88	16	89	28	100
Rinskor	25	16	92	4	81	12	100
Rinskor	30	66	95	20	95	36	100
Rinskor	35	16	98	4	93	12	100
Bispyribac Na	30	24	79	-	-	8	33

[1]ECHCG (*Echinochloa crus-galli*), LEFCH (*Leptochloa chinensis*), and CYPDI (*Cyperus difformis*)

[2]Number of observations

[3]Mean visual control ratin

Table 2. Visual control (%) of broadleaf weeds with herbicides 30 DAA after application in wet-seeded rice in China

Treatment	Rate (g/ha)	MOOVA[1]		LUDOC		AMMSS		LIDPY		ROTIN	
		Obs	Mean (%)	Obs	Mean (%)	Obs	Mean (%)	Obs	Mean (%)	Obs	Mean (%)
Rinskor	20	24	100	16	99	8	100	-	-	4	100
Rinskor	25	4	100		-	4	100	-	-	-	-
Rinskor	30	36	100	28	99	12	100	8	100	8	100
Rinskor	35	4	100	-	-	4	100	-	-	-	-
Bispyribac Na	30	12	91	8	96	4	63	4	99	4	100

[1]MOOVA (*Monochoria vaginalis*), LUDOC (*Ludwigia octovalvis*), AMMSS (*Ammannia* sp.), LIDPY (*Lindernia procumbens*), and ROTIN (*Rotala indica*); [2]Number of observations; [3]Mean visual control rating

CONCLUSION

When applied at the 4-5 leaf stage of ECHCG, Rinskor™ active (applied at 20 to 30 g/ha)provided effective control of ECHCG, CYPDI, MOOVA, LUDOC, AMMSS, LIDPY, and ROTIN with favorable crop selectivity.

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Evaluation of bispyribac sodium for weed control in aerobic rice

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Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population. It is no longer feasible to flood rice field to ensure better crop establishment and control weeds (Johnson and Mortimer 2005). Rice cultivation under aerobic system can save about 50-60% irrigation water and increase the water productivity by around 200% as compared to lowland flooded system (Bouman *et al*. 2002). Although this system has huge potential as a water-wise technology, its adoption has been impeded by serious weed problems, since both weed and crop seeds emerge at the same time resulting in less grain yield. Therefore, developing an effective weed management approach has been a challenge for widespread adoption of aerobic rice technology. Heavy infestation of weeds at later stages of rice growth is not controlled effectively by pre-emergence herbicides. This necessitates evaluation and identification of suitable early post-emergence herbicides which have wider applicability and weed control spectrum for successful cultivation of aerobic rice.

METHODOLOGY

A field experiment was conducted during *Rabi* 2013 in the farm lands of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry. A medium duration (135 days) rice cv. ADT(R) 46 was sown on 5 September, 2013 and the recommended package of practices was followed. The experiment was laid out in randomized block design (RBD), replicated thrice. The experiment involved 11 treatments consisting of varying doses and time of bispyribac sodium application, hand hoeing twice, and unweeded control (Table 1). The data on weed density, weed biomass, weed control efficiency and yield of rice were recorded and statistically analyzed by following standard procedures.

RESULTS

Application of bispyribac sodium 25 g/ha at 10 DAS recorded the lowest population (61.3/m^2) and biomass of weeds (63.1 g/m^2) and was similar to that in hand hoeing twice. Five days after bispyribac sodium application, weeds turned purple in colour. Then yellowing started from the tip and complete death of weeds occurred within 10 days after application. Among the different weeds, grasses started drying quicker than sedges and broadleaved weeds indicating that bispyribac sodium is more effective against grasses. Application of bispyribac sodium at 10 DAS resulted in the lower total weed density and biomass when compared to application at 15 or 20 DAS. With delay in time of bispyribac sodium application, the biomass of weeds increased. Irrespective of doses, application of bispyribac sodium at 10 DAS registered higher weed control efficiency than application at 15 or 20 DAS. This indicateds that the efficacy of bispyribac sodium decreased as the weeds grew older.

When weeds were left unchecked in aerobic rice, the loss in yield was found to be 93.1%. Application of bispyribac sodium at 25 g/ha recorded significantly higher grain and straw yields (3.89 and 7.67 t/ha, respectively) when compared to 20 or 30 g/ha. Irrespective of doses, application of bispyribac sodium at 10 DAS significantly increased the grain and straw yield (3.56 and 7.20 t/ha, respectively) than application at 15 or 20 DAS which in turn were on par with each other. Applying 25 g bispyribac sodium/ha at 10 DAS registered the highest grain and straw yields (4.67 and 8.55 t/ha) while the lowest grain yield was recorded with application of 20 g bispyribac sodium/haat 20 DAS (2.36 t/ha).

Table 1 Weed control and rice yield as influenced by dose and time of bispyribac sodium application

Treatment	Weed density at 60 DAS (no./m^2)		Weed biomass at 60 DAS (g/m^2)		Weed control efficiency*	Grain yield (t/ha)	Straw yield (t/ha)
Bispyribac sodium 20 g/ha at 10 DAS	13.9	(201.3)	10.7	(118.5)	79.7	3.02	6.39
Bispyribac sodium 25 g/ha at 10 DAS	7.6	(61.3)	8.0	(63.1)	89.2	4.67	8.55
Bispyribac sodium 30 g/ha at 10 DAS	12.9	(169.3)	8.6	(74.5)	87.2	2.98	6.61
Bispyribac sodium 20 g/ha at 15 DAS	21.5	(466.7)	14.0	(199.5)	65.8	2.58	6.21
Bispyribac sodium 25 g/ha at 15 DAS	19.8	(390.7)	11.4	(130.2)	77.7	3.56	7.25
Bispyribac sodium 30 g/ha at 15 DAS	20.4	(416.0)	12.8	(165.8)	71.6	2.63	6.13
Bispyribac sodium 20 g/ha at 20 DAS	23.7	(561.3)	14.8	(231.8)	60.2	2.36	6.21
Bispyribac sodium 25 g/ha at 20 DAS	23.0	(526.7)	12.3	(154.2)	73.6	3.44	7.22
Bispyribac sodium 30 g/ha at 20 DAS	23.0	(540.0)	14.0	(197.5)	66.1	2.44	5.86
Hand hoeing at 20 and 40 DAS	10.5	(113.3)	5.2	(26.9)	95.4	4.67	8.80
Unweeded control	35.9	(1290.7)	24.0	(583.0)	--	0.33	1.90
LSD (P= 0.05)	4.5		3.7		--	0.57	1.45

Figures in the parentheses indicate original values; * Data statistically not analyzed

CONCLUSION

Applying 25 g bispyribac sodium/ha at 10 DAS is a suitable weed management practice for effective control of weeds and obtaining higher yields equivalent to two hand hoeings in aerobic rice.

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Evaluation of herbicides for effective weed management in wet-seeded rice

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Rice is the major food crop grown in North Coastal districts of Andhra Pradesh (4.5 – 5.0 lakh ha). Late planting with over aged seedlings is the major constraint to achieve higher productivity under conventional transplanting, due to late receipt of rains and late filling of tanks. Non availability labour and hike in labour wages necessitates the farmers to search for alternate methods of rice establishmentand "Direct-seeding in puddled soil (wet-seeded rice)" appeared to be a viable option to reduce cost of cultivation and to overcome labour problem and over aged seedling transplantation. However, weeds cause greatest menace in wet-seeded rice (Rao *et al.* 2007), as light irrigations are scheduled and only saturated conditions will be maintained at initial stages of crop growth (upto 20-25 days).

METHODOLOGY

With this background, field experiment was carried out for two consecutive *Kharif* seasons (*Kharif*, 2009 and 2010) at regional agricultural research station, Anakapalle to identify effective herbicides and optimum time of application for management of weeds in wet-seeded rice. A medium duration rice variety Vijetha (MTU 1001) was sown during 1[st] week of August with drum seeder. The experiment was laid out in RBD with 10 treatments. (T1: Pretilachlor at 1.25 t/ha at 3-5 days after seeding (DAS), T2: Pretilachlor at 1.25 l/ha at 8-10 DAS, T3: Anilophos at 1.25 kg/ha at 3-5 DAS, T4: Anilophos at 1.25 l/ha at 8-10 DAS, T5: Oxadiargyl at 90 g/ha at 3-5 DAS, T6: Oxadiargyl at 90 g/ha at 8-10 DAS, T7: Pyrazosulfuran ethyl (Sathi) at 375 g/ha at 20 DAS, T8: Bispyribac sodium at 250 ml/ ha at 20 DAS, T9: Hand weeding twice at 20 and 40 DAS, T10: Weedy check (control) and replicated thrice. All other management practices were followed as per recommendation to North Coastal zone.

RESULTS

Sand mix application of Anilophos at 1.25 l/ha at 3-5 DAS controlled the weeds effectively and recorded significantly higher rice yield (4.15 t/ha) over all other herbicides. Lowest rice grain yield of 2.65 t/ha was recorded inweedy check with areduction in grain yield of 56.4%. due to uncontrolled weeds. Application of pretilachlor (with safner) or Anilophos at 3-5 DAS controlled the weeds more effectively than their application at 8-10 DAS, while oxadiargyl application at 8-10 DAS (4.08 t/ha) was more effective than its application at 3-5 DAS (3.41 t/ha). Between the two post emergence herbicides pyrazosulfuran ethyl at 375 g/ha at 20 DAS proved superior (3.65 t/ha) over bisypribac sodium at 250 ml/ha at 20 DAS (3.36 t/ha)

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Standardization of irrigation and integrated weed management practices in aerobic rice

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Rice *(Oryza sativa* L.) is the leading cereal of the world. India ranks first in area (42.4 million hectares) and second in rice production (104 million tonnes). Maximum water use efficiency and grain yield possible with the application of different irrigation regimes and weed management practices under deficit rainfall and irrigation and heavy weeds in aerobic rice (Narolia *et al*. 2014, Jadhav *et al*. 2014). Hence, thisinvestigationwas conducted in aerobic rice.

METHODOLOGY

A field experiment was conducted at Professor Jayashankar Telangana State Agricultural University, Hyderabad during *Kharif*, 2013 and 2014 to study four irrigation schedules (based on IW/CPE ratios) as main plots and six treatmentson sequential application ofpendimethalin and butachlor as PE followed by fenoxaprop-p-ethyl and metsulfuronmethyl + chlorimuron ethyl as post emergence, weed free check and un weeded control as sub-plots, in split plot design with three replications. The rice variety JGL-17004 was direct seeded andfertilizers were applied at 140, 60, 50 kg/ ha of NPK.

RESULTS

At 40 DAS, weed density and dry matter were significantly higher with IW/CPE ratios of 2.0 and 1.5 due to availability of resources for the growth of weeds, but weed control efficiency was lower. Higher yields were obtained with ratios of 2.0 and 1.5 than others. Lower weed density, weed dry weight, higher weed control efficiency and yield was obtained in sequential application of pendimethalin and butachlor as PE followed by metsulfuronmethyl + chlorimuron ethyl treatments, which were on par. Fenoxaprop-p-ethyl, applied as post emergence also gave better results than unweeded control. Fenoxaprop-p-ethyl controlled only grassy weeds. Metsulfuronmethyl + chlorimuron ethyl controlled broad leaved weeds and sedges.Heavyweed infestation in un weeded controlrecorded lower yields. Similar findings were alsoreported by Narolia *et al*. (2014) and Jadhav *et al*. (2014).

CONCLUSION

Combination of irrigations at IW/CPE ratios 2.0 and 1.5 and application of pendimethalin *fb* metsulfuronmethyl + chlorimuron ethyl, or butachlor *fb* metsulfuronmethyl + chlorimuron ethyl can be recommended for reducing weed infestation, better crop growth and higher yields in aerobic rice.

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Effect of herbicide and nutrient management on weed flora, grain yield and economics of transplanted rice in eastern dry zone of Karnataka

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Rice (*Oryzasativa* L.) is a staple food for more than 60% of the world population and is extensively grown in tropical and subtropical regions of the world. Rigorous efforts are being made under several research programmes by scientists around the world to evolves trategies for improving rice yield. Most of the improved crop management practices in rice cultivation failed due to poor and improper practices for containing weeds. In India, rice is cultivated annually in an area of 44.0 Mha with aproduction of 103.4 Mt average productivity of 2.3t /ha (FAO 2012). Uncontrolled weeds have caused yield reduction of 28-45% in transplanted rice (Manhas *et al.* 2012) and hence, the present investigation was undertaken.

METHODOLOGY

The field experiment was conducted during *Kharif* and summer from 2010-14 at the Agricultural and Horticultural Research Station, Kathalagere in Davanagere district. The soil type was sandy clay loam with average fertility level. The three weed control treatments tested were W_1 – Butachlor 0.75 kg/ha + 2,4-D Sodium salt 0.4 kg/ha (pre-emergence), within 3 days after planting (applied in sequence), both during *Kharif* and summer, W2 – Butachlor 0.75 kg/ha + 2,4-D Sodium salt 0.4 kg/ha (pre-emergence, within 3 DAP, applied in sequence) during *Kharif* followed by pretilachlor 0.75 kg/ha (pre-em, within 3 DAP) during summer, and W3 – Hand weeding twice (20 and 45 days after planting, DAP) during both the seasons. The weed management practices were integrated with two sources of fertility levels, F1 – 75% NPK supplied through fertilizer + 25% NPK supplied through FYM (with organic matterdesignated as'+ OM'), F2 – 100% NPK supplied through fertilizers only (without organic matterdesignated as '– OM'). The experiment was laid out in randomized complete block design. The rice cultivar *JGL-1798* was transplanted at a common spacing of 20 X 10 cm and 100% NPK level was 100 kg N, 50 kg P_2O_5 and 50 kg K_2O /ha. Pooled analysis was carried out for weed density/ weed dry weight, grain / straw yield and economics was worked out.

RESULTS

Major weed flora observed in the experimental plots were *Cyperus iria, Fimbristylis miliacea, Scirpus* sp., *Cyperus procerus* (from 60 DAP onwards) (among sedges) and *Echinochloa colona, Panicum tripheron* (grasses). Among broadleaved weeds, *Ludwigia parviflora, Dopatrium junceum, Marsilea quadrifolia, Monochoria vaginalis* were dominant. At 60 DAP, the density and dry weight of broad leaf weeds and sedges weredominant over grasses. Hand weeding recorded significantly lower weed density and dry weight. Among herbicide treatments application of pretilachlor during summer season had reduced weed density and weed dry weight compared to application of butachlor + 2,4-D sodiumsalt in both the seasons. The highest grainand straw yields and number of panicles were recorded inhand weeding 20 and 45 DAP (5.76 t/ha, 7.91 t/ha and 370 numbers) compared to other treatments. Among herbicidal treatments, application of pretilachlor during summer season had given higher grainand straw yields and higher number of panicles (5.40 t/ha, 7.55 t/ha and 358 numbers) as compared to the application of butachlor + 2,4-D sodium salt in both the seasons. Similar results were obtained by Deepthi Kiran and Subramanyam (2010). The highest B:C ratio was obtained in the plots applied with pretilachlor (2.9) compared to other weed management treatments and lower B:C ratio was obtained in hand weeding (2.25). This was because of high cost involved in weed management. Differences between the plots applied with and without organic matter was non-significant.

Table 1. Effect of herbicidesand nutrient management on weeds, number of panicles, grain, straw yield and economics in transplanted rice

Treatment	Weed density at 60 DAT (no./m²)	Weeds' dry weight at 60 DAT (g/m²)	No. of panicles/ m²	Paddy yield (kg/ha)	Straw yield (kg/ha)	B:C ratio
F1W1-Butachlor 0.75 kg + 2,4-D Na salt 0.4 kg – 3 DAP + With OM	(79.4)3.12	(62.5)1.76	340	5.25	7.21	2.7
F1 W2-Pretilachlor 0.75 kg – 3 DAP + With OM	(78)3.17	(61.4)1.72	360	5.48	7.62	3.0
F1W3-Hand weeding (20 & 45 DAP) + With FYM	(57.3)2.90	(40.0)1.47	380	5.82	7.99	2.3
F2W1-Butachlor 0.75 kg + 2,4-D Na salt 0.4 kg – 3 DAP + Without OM	(90.7)3.20	(73.7)1.83	328	5.12	7.02	2.6
F2W2-Pretilachlor 0.75 kg – 3 DAP + Without-OM	(80.7)3.08	(61.6)1.74	355	5.32	7.48	2.8
F2W3-Hand weeding (20 & 45 DAP) + Without- FYM	(66.9)2.98	(52.2)1.53	360	5.70	7.84	2.2
LSD (P - 0.05)	NS	NS	NS	NS	NS	NA
Weed management practices						
W1-Butachlor 0.75 kg + 2,4-D Na salt 0.4 kg – 3 DAP	(85.0)3.16	(68.1)1.79	334	5.19	7.11	2.65
W2-Pretilachlor 0.75 kg ai/ha – 3 DAP	(79.3)3.13	(61.5)1.73	358	5.40	7.55	2.9
W3-Hand weeding (20 & 45 DAP)	(62.1)2.94	(46.1)1.50	370	5.76	7.91	2.25
LSD (P - 0.05)	0.09	0.05	18	0.16	0.31	NA
Fertility sources						
F1-25% Nthrough FYM + 75% NPK of the recommended Fertilizer dose	(71.5)3.06	(54.6)1.65	360	5.520	7.61	2.6
F2-Recommended Fertilizer dose(100% NPK)	(79.4)3.09	(62.5)1.70	348	5.385	7.45	2.5
LSD (P - 0.05)	NS	NS	NS	NS	NS	NA

Data within the parentheses are original values. Data transformed tolog (X + 2) / square root transformation; DAT- Days after planting

CONCLUSION

Application of butachlor 0.75 kg/ha + 2, 4-D sodium salt 0.4 kg/ha (pre-emergence, within 3 DAP, applied in sequence) during *Kharif* followed by pretilachlor 0.75 kg/ha (pre-emergence, within 3 DAP) during summer was more effective for controlling weeds, improving grain and straw yields rather than applying butachlor 0.75 kg/ha + 2,4-D sodium salt 0.4 kg/ha in both the seasons. Herbicide application proved profitable as compared to hand weeding.

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Long term effect of herbicides on soil properties in rice –rice cropping system

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Rice–rice is the predominant cropping system of Assam. Heavy weed infestation is one of the major constraints for higher productivity, causing yield loss in transplanted rice to the extent of 15-45% (Chopra and Chopra 2003). Limited labour availability, escalation of labour wages as well as high drudgery with manual weeding warrants other suitable options for weed control. Of late, use of herbicides is gaining popularity due the multiple advantages associated with herbicides such as cost effectiveness and timely weed control. Soil health is one of the important aspects to be considered for sustaining crop productivity and herbicide application can cause changes in microbial population in the soil rhizosphere as a whole (Latha and Gopal 2010). As limited information is available about the long term effect of herbicides on important soil properties, an investigation was undertaken.

METHODOLOGY

A long term field experiment was initiated since 2002 at Research Farm of the Assam Agricultural University, Jorhat (Assam) to evaluate the effect of herbicides on weed growth, crop productivity and soil health. Five treatments (Table 1) comprising combinations of herbicides and nutrient management practiceswere laid out in a randomized block design with three replications. Herbicides as par treatments were applied to both autumn and winter rice.The soil of the experimental field was acidic with sandy clay loam in texture and belonging to group Aquic Dystrochrept. A recommended dose of 40:20:20 kg /ha of N, P_2O_5 and K_2O was applied as par treatments in both the seasons. Soil samples (0-15 cm) were collected as par standard procedure after harvest of winter rice during 2014. Samples were processed and analyzed for different nutrients following standard procedure. Soil microbial population was analyzed through serial dilution methods.

RESULTS

Long term use of herbicides along with nutrient management practices significantly influenced the different soil properties. Soil bulk density was significantly lower (1.23 g/cc) with rotational use of butachlor and pretilachlor followed by 2,4-D under integrated use of 75% NPK through fertilizer + 25% as organic manure and was at par with the treatments that received butachlor + 2,4-D under the same nutrient management practices. Farmers practice registered the highest bulk density (1.38 g/cc). Soil organic carbon was significantly higher with integrated use of 75% NPK through fertilizer and 25% through organic manure. Significantly higher available N and P was recorded with the application of butachlor + 2,4-D with 100% NPK as fertilizer. Available K was however, significantly higher with the rotational use of butachlor and pretilachlor followed by 2,4-D under 100% NPK applied through fertilizer. Significant variation in fungal and bacterial population in soil was recorded due to different treatments. The highest fungal and bacterial population was recorded with the rotational use of butachlor and pretilachlor followed by 2,4-D under integrated use of 75 % NPK through fertilizer and 25% through organic manure.

Table 1. Long term effect of herbicides use on certainsoil properties and microbial population

Treatment	pH	Bulk density (g/cc)	O C (%)	Available nutrient (kg/ha) N	P	K	Fungal population (x 10^3/g)	Bacterial population (x 106 /g)	Microbial biomass cvarbon (µg/g)
T1	4.55[a]	1.38[a]	0.58[c]	294[b]	27.6[a]	219[e]	26.43[b]	34.7[b]	39.9[a]
T2	4.55[a]	1.32[ab]	0.65[bc]	313[a]	31.5[a]	276[d]	47.72[a]	43.7[b]	42.3[a]
T3	4.57[a]	1.26[bc]	0.88[a]	294[b]	28.6[a]	333[c]	53.25[a]	43.8[b]	46.4[a]
T4	4.63[a]	1.36[a]	0.74[ab]	231[d]	26.7[ab]	362[a]	57.67[a]	52.3[ab]	49.5[a]
T5	4.56[a]	1.23[c]	0.85[a]	263[c]	25.5[b]	346[b]	58.14[a]	64.2[a]	52.5[a]

T1- Farmers' practice (one HW), T2- Butachlor + 2,4-D (100% NPK fertilizer), T3- Butachlor + 2,4-D (75% NPK through fertilizer, 25% organic source), T4- Butachlor + 2,4-D rotated with pretilachlor (100% NPK through fertilizer), T5- Butachlor + 2,4-D rotated with pretilachlor (75% NPK through fertilizer, 25% organic source)

CONCLUSION

It was concluded that pre emergence application of butachlor rotated with pretilachlor followed by 2,4-D along with 75% NPK through fertilizer and 25% through organic manure was superior in improving different soil properties under rice-rice cropping system in Assam.

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Studies on weed management indrip irrigated aerobic rice

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Rice (*Oryza sativa* L.) is the world's most important staple food crop and primary source of food for more than half of the world's population, occupying a prime place among the food crops after wheat. It is cultivated in different ecosystems in different ways. In India, it is grown in an area of 46.19 mha with a production of 106.2 mt and productivity of 2.46 kg/ha (Anonyomous 2014). The shrinking water resources and competition from other sectors, the share of water allocated to irrigation decrease by 10-15% in the next two decades. Aerobic rice with drip irrigation can address the multifacet problems of water scarcity, weed competition and environmental pollution. Herbigation is the improved method of application of herbicides through irrigation water and may be superior over conventional spraying mainly by reducing the herbicide loss through run-off and leaching. Hence, the herbigation may be used as the solution to manage the weed problems in the aerobic rice system.

METHODOLOGY

A field experiment was conducted to study the efficacy of herbigation for weed management in drip irrigated aerobic rice during *Summer* 2014 at Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru. Field experiment was designed using RCBD consisting of 10 weed management practice with three replications. The soil of the experimental plot was red sandy loam. The aerobic rice hybrid (*KRH-4*) was fertilized with 100:50:50 N, P_2O_5, K_2O kg/ha through urea, single super phosphate and murate of potash respectively. Data on weed growth, yield performance and economics were recorded.

RESULTS

Herbigation of pre-emergent application of pretilachlor + bensulfuran methyl and post emergent bispyribac sodium at 20 DAS (Table 1) resulted in significantly higher grain and straw yield (9.89 and 18.0 t/ha, respectively) which was on par with weed free check (10.6 and 20.0 t/ha, respectively) and hand hoeing at 15, 30 and 45 DAS (8.30 and 17.1 t/ha, respectively). These practices have also recorded least total weed biomass at 80 DAS (3.77, 0.00, 4.54 and 17.69 g, respectively), weed index (6.69, 0.00, 20.8 and 89.5%, respectively) and higher weed control efficiency (95.2, 100.0, 83.3 and 0.00%, respectively). These results are in conformity with the findings of Madukumar (2011). Highest net return (Rs. 90540 /ha) was recorded in herbigation of pre-emergent application of pretilachlor + bensulfuran methyl and post emergent bispyribac sodium at 20 DAS and weed free check (`. 126613 / ha).

Table 1. Grain yield, straw yield, Total weed biomass at harvest, WCF, WI, net return and B:C ratio of aerobic rice as influenced by weed management practices.

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Weed biomass (g) at 80 DAS	Weed control efficiency (%)	Weed index (%)	Net returns (x 10^3 `/ha)	B:C
T_1: Weed free check	10.6	20.0	0.50 (0.00)	100.0	0.00	126.6	3.09
T_2: Weedy check	1.101	1.86	17.69 (315.84)	0.00	89.58	-33.4	0.36
T3: Two hand weeding at 20 and 40 DAS	7.563	14.5	7.82 (60.83)	66.3	28.31	74.9	2.27
T_4: Hand hoeing at 15,30 and 45 DAS	8.308	17.1	4.54 (20.35)	83.3	20.81	88.8	2.49
T_5: One hand hoeing at 15 DAS and one HW at 20 DAS	5.727	13.3	8.65 (74.67)	57.0	45.83	46.6	1.81
T_6: One HW at 20 DAS and mulching with Glyricidia at 30 DAS	8.009	16.0	6.27 (39.07)	70.5	24.83	85.1	2.48
T_7: Pre-emergent application Pretilachlor + Bensulfuran methyl	5.386	11.7	10.02 (100.19)	55.4	48.91	41.9	1.76
T_8: Pre-emergent application of Pretilachlor + Bensulfuran methyl and Post emergent application of Bispyribac sodium at 20 DAS	7.662	15.2	7.08 (49.85)	66.0	27.33	80.3	2.44
T_9: T_7 through herbigation (Drip)	8.194	16.3	5.26 (27.38)	71.1	22.45	90.540	2.64
T_{10}: T_8 through herbigation (Drip)	9.892	18.0	3.77 (14.00)	95.2	6.99	117.7	3.10
LSD (P=0.05)	1.238	1.45	1.19	1.64	2.99	--	--

Note: * ($\sqrt{x + 0.25}$) transformed; ** Figures in the parenthesis indicates original values; DAS: Days after sowing; HW: Hand weeding; Dosage: Pretilachlor + Bensulfuran methyl @ 10 kg ha^{-1}, Bispyribac sodium @ 100 g ha^{-1}.

CONCLUSION

Herbigation of pre-emergent application of pretilachlor + bensulfuran methyl and post emergent bispyribac sodium at 20 DAS, hand hoeing at 15, 30 and 45 DAS and weed free check condition is best weed management practice for aerobic rice.

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Effect of irrigation schedulingand weed management practices on nutrient uptake in dry seeded irrigated rice

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Water shortage is becoming severe in many rice growing areas in the world, the introduction of dry seeded irrigated (semi-dry) rice systems can reduce water use in rice production by as much as 50% (Bouman 2001). However, in dry seeded rice, weeds and rice emerge simultaneously, and compete with each other for light, nutrients and moisture resulting in reduction of grain yield upto 80% (Sinha Babu *et al*. 1992). Weed competition in dry seeded rice is largely influenced by moisture and nutrient availability.So the present study was undertaken with the objectives to determine the best irrigation water management practice and to find out the effective weed management practice for higher nutrient uptake by the rice crop under dryseededirrigated conditions.

METHODOLOGY

An experiment was carried out during *Kharif* season at PJTSAU, Rajendranagar, Hyderabad with three irrigation schedules (starting of irrigation from 45 DAE, 60 DAE and 75 DAE) as main plots and five weed management practices (pre-em application of butachlor at 1.0 kg/ha *fb* 2,4-D Na salt at 1.0 kg/ha at 30 DAE, PE application of pretilachlor at 0.75 kg/ha *fb* 2,4-D Na salt at 1.0 kg/ha at 30 DAE, interculture at 20 DAE *fb* HW at 40 DAE, interculture at 20 DAE *fb* HW at 40 and 60 DAE and unweeded check) as sub plots in split plot design replicated thrice.

RESULTS

The uptake of nitrogen and potassium by weeds was not influenced with time of start of irrigation (Table 1). However, significantly higher Phosphorus uptake was recorded with time of start of irrigation at 75 DAE. Among weed management practices significantly the lowest nitrogen (5.3 kg/ha), phosphorus (1.8 kg/ha) and potassium (10.9 kg/ha) uptake was recorded in inter-culture at 20 DAE *fb* HW at 40 DAE and 60 DAE over rest of treatment. However, it was comparable with inter-culture at 20 DAE *fb* HW at 40 DAE.

Significantly higher nitrogen (81.6 kg/ha), Phosphorus (13.1 kg/ha) and potassium (74 kg/ha) uptake was recorded in the crop that received irrigation from 45 DAE over other treatments. Among weed management practices interculture at 20 DAE *fb* HW at 40 and 60 DAE was recorded significantly higher nitrogen (105.8 kg/ha), phosphorus (18.3 kg/ha) and potassium (97 kg/ha) uptake over rest of weed management practices.

Table 1. Effect of treatments on nutrient uptake by weeds and rice

Treatment	Nutrient uptake (Kg/ha) by weeds			Nutrient uptake (Kg/ha) by rice		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Time of irrigation						
45 Days after emergence (DAE)	12.7	3.5	12.5	81.6	13.1	74.0
60 Days after emergence (DAE)	10.4	3.2	12.5	68.5	12.3	69.6
75 Days after emergence (DAE)	9.2	2.8	12.2	64.5	10.9	60.4
SEm+	0.9	0.2	0.1	2.3	0.5	0.4
LSD (P=0.05)	NS	0.7	NS	9.0	1.8	1.5
Weed management						
Pre-em application of butachlor at 1 kg/ha *fb* 2, 4-D Na salt at 1.0 kg/ha at 30 DAE	12.4	3.3	11.8	60.1	10.9	70.5
PE application of pretilachlor at 0.75 kg/ha *fb* 2, 4-D Na salt at 1 kg/ha at 30 DAE	10.4	3.1	12.3	70.0	12.1	73.5
Interculture at 20 DAE *fb* HW at 40 DAE	7.1	1.8	11.2	100.1	16.3	86.4
Interculture at 20 DAE *fb* HW at 40 and 60 DAE	5.3	1.4	10.9	105.8	18.3	97.0
Unweeded check	18.5	6.3	15.9	21.5	3.0	12.6
LSD (P=0.05)	2.9	0.9	0.6	8.6	1.0	1.7
Interaction (IxW)						
LSD (P=0.05)	NS	NS	NS	NS	NS	NS

CONCLUSION

Scheduling of irrigation from 45 DAE and adopting inter-culture at 20 DAE *fb* HW at 40 and 60 DAE results in higher nutrient uptake by rice under dry seeded irrigated conditions.

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Efficacy of Pyrazosulfuron Ethyl in managing weeds of transplanted rice

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Agriculture has been a forefront agenda at national and international level for food security and management of natural resources. Cereals are the most important part of our diet throughout the world and thus, play a major role in our food security. Among cereals, rice has been staple food and energy source for more than 60 and 40%, respectively, of the world population. The present experiment was undertaken to study the efficacy and phytotoxicity of pyrazosulfuron ethyl application in pre-emergence control of major weeds in transplanted rice and to determine an optimum dosage of application for recommendation to rice farmers.

METHODOLOGY

An experiment was conducted during *Kharif* 2012 and 2013 at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences (UAS), Raichur, Karnataka. The experiment was laid out in a randomized block design with eight treatments, *viz.* T_1- pyrazosulfuron ethyl at 5 g a.i./ha, T_2-pyrazosulfuron ethyl at 10 g/ha, T_3-pyrazosulfuron ethyl 15 g/ha, T_4-pyrazosulfuron ethyl at 20 g/ha, T_5- Saathi (pyrazosulfuron ethyl) (Market sample) at 15 g/ha, T_6- pretilachlor at 500 ml/ha T_7- weed free check (weeding at 15 days after sowing) and T_8- weedy check (Untreated check) and replicated thrice. The test herbicide pyrazosulfuron ethyl at 4 different doses along with commercially sold herbicide "Saathi" and Pretilachlor were sprayed at early pre-emergence stage (3 DAT) with the spray volume of 500 l/ha using knapsack sprayer with flat fan nozzle. Weed species density (number per m^2) was measured using a quadrat of 0.25 m^2randomly placed at two spots Weed control efficiency (WCE) was worked out using the formula as suggested by Mani *et al.* 1973 and Gill and Vijayakumar 1969. Five rice plants were randomly selected in each plot of each replication and were tagged for the purpose of recording rice growth parameters, *viz.* plant height and number of productive tillers per hill at harvest andrice yield parameters, *viz.* panicle length, test weight and number of filled grains per panicle. Similarly, rice from each net plot of each replication was harvested and dried. The grains after threshing were weighed and recorded as grain yield. The net plot grain yield was converted to grain yield per hectare.

RESULTS

In the experimental plots, the dominant weeds were *Echinochloa colona, Panicum repens, Cynodon doctylon, Ludwigia parviflora, Leptochloa chinensis and Cyperus* sp. All the herbicides treatments effectively controlled all types of dominant weeds resulting in less weed biomass and higher weed control efficiency when compared to untreated check**.** The dominant broad-leaved, grass and sedge weeds density has decreased gradually with the increase of doses of pyrazosulfuron ethyl at all the three dates of observation. Better weed control was observed with pyrazosulfuron ethyl at 20 g/ha. Weed control efficiency (100%) was higher in hand weeding treatment (Table 2). Pyrazosulfuron ethyl at 20 g/ha given higher weed control efficiency (76.88, 87.39 and 91.33% at 15, 30 and 60 DAA, respectively) when applied at 3 DAT. It was closely followed by the application of Pyrazosulfuron ethyl at 15 g/ha (72.31, 79.44 and 86.02% at 15, 30 and 60 DAA, respectively) and Saathi at 15 g/ha (72.13, 79.06 and 86.29% at 15, 30 and 60 DAA, respectively).Significantly higher grain and straw yield were observed in weed free treatment which was onpar with the application of pyrazosulfuron ethyl at 20 g/ha (6.26 and 7.46 t/ha, respectively).

Table 1. Effect of weed control treatments on weed biomass, weed control efficiency and grain yield of transplanted paddy (Pooled data of *Kharif* 2012 and 2013)

Treatment	Total weed bionass (g/m^2)			Weed control efficiency (%)			Grain yield (t/ha)	Straw yield (t/ha)
	15 DAA	30 DAA	60 DAA	15 DAA	30 DAA	60 DAA		
Pyrazosulfuron ethyl at 5 g/ha	22.82	19.36	16.48	64.47	71.90	80.50	5.55	6.71
Pyrazosulfuron ethyl at 10 g/ha	21.02	16.83	14.32	67.29	76.55	83.38	5.68	6.83
Pyrazosulfuron ethyl at 15 g/ha	17.79	14.18	12.68	72.31	79.44	86.02	6.01	7.21
Pyrazosulfuron ethyl at 20 g/ha	14.42	9.46	7.48	76.88	87.39	91.33	6.26	7.46
Saathi (Market Sample) at 15 g/ha	17.56	14.56	10.93	72.13	79.06	86.29	5.89	7.10
Pretilachlor at 500 ml/ha	20.18	16.52	12.38	68.10	76.58	85.41	5.79	6.97
Weed free check	--	--	--	100.0	100.0	100.0	6.42	7.61
Weedy check	64.26	68.42	83.46	--	--	--	4.18	5.02
LSD (P=0.05)	3.14	5.10	3.45	4.75	8.33	5.04	0.53	0.50

DAA: Days after application

CONCLUSION

Pyrazosulfuron ethyl at 20 g/ha can be recommended for controlling all three categories of weeds in transplanted rice and get higher rice grain yield.

Effect of herbicides sequential application in managing weeds of direct-seeded rice

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Rice (*Oryza sativa* L.) is an important staple crop in India, where it is mainly grown by manual transplanting of seedlings into puddled soil (Chauhan 2012). In the same way, rice is the important crop of ThungaB hadra Project (TBP) command area and known as "*rice bowl*" of Karnataka. In TBP command area, rice is cultivated in an area of 3.62 lakh hectares. Recently, however, there is a trend towards dry-seeded rice (DSR) because of labour and water scarcity (Rao *et al.* 2015). In DSR, weeds are the main biological constraint. Pre-emergence herbicides are used to manage weeds in DSR systems, but the use of pre-emergence herbicides alone does not provide effective and sustainable weed control (Rao *et al.* 2007, Kumar and Ladha 2011). Therefore, there is a need forusing herbicides in sequence as both pre and post emergence applictions. Sequential application herbicides may results in better control of weeds.

METHODOLOGY

A field experiment was carried out during *Kharif* season of 2014 at Agricultural Research station, Gangavathi, Karnataka to evaluate herbicide sequence for direct- seeded rice. Ten treatments, consisting of different pre and post emergence herbicides and hand weeding, were arranged in a randomised block design with three replications. Rice variety GGV-05-01 (Gangavathisona) was direct-seeded in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, diamonium phosphate and muriate of potash at 150 kg N, 75 kg P_2O_5 and 75 kg K_2O /ha, respectively. Data on weed growth, rice yield and economics were recorded.

RESULTS

Grassy weeds were predominant followed by broad-leaved and sedges. *Echinochloa colona* among the grassy weeds and *Ludvigia parviflora* among the broad-leaved weeds were more dominant. Herbicidal treatments significantly influenced the weed biomass and weed control efficiency. Among the herbicidal treatments, the lowest weed biomass and weed control efficiency was observed withpendimethaline *fb* by one hand weeding at 30 days after seeding (DAS) which was closely followed by application of pyrazosulfuron ethyl *fb* bispyribac sodium . The minimum weed biomasswas also recorded in these treatments, which was significantly lower than all other treatments. These results are in conformity with the findings of Singh *et al.* (2006).

Rice grain and straw yield was significantly higher with weed free check. Among the herbicide treatments rice grain and straw yield was significantly higher with application of pendimethaline *fb* by one hand weeding at 30 DAS and application of pyrazosulfuron ethyl fb bispyribac sodium, due to fewer weeds in weedicide applied treatment.

Table 1. Weed growth, yield and economics of DSR as influenced by different weed control treatments

Treatment	Total Weed dry wt (g/m^2)	Weed Control Efficiency (%)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x 10^3 Rs/ha)	Gross returns (x 10^3 Rs/ha)	Net returns (x 10^3 Rs/ha)	B:C ratio
Pendimethalin at 1.0 kg/ha – Bispyribac sodium at 250 ml/ha	46.7 (6.90)	72.5	5.89	7.10	37.0	95.5	58.5	2.58
Pendimethalin at 1.0 kg/ha – 2,4-D sodium salt at 600 kg/ha	50.9 (7.20)	70.0	5.68	6.83	36.2	92.0	55.8	2.54
Pendimethalin at 1.0 kg/ha – Azimsulfuron at 17.5 g/ha	56.4 (7.58)	66.8	5.42	6.65	36.3	88.0	51.7	2.43
Pendimethalin at 1.0 kg /ha –Metsulfuron methyl + chlorimuron at 4 g/ha	50.6 (7.18)	70.2	5.79	6.97	36.9	93.8	56.9	2.54
Pyrazosulfuron ethyl at 20 g//ha – Metsulfuron methyl + chlorimuron at 4.0 g/ha	54.2 (7.43)	68.1	5.55	6.71	36.2	90.0	53.7	2.48
Oxodiagil at 100 g/ha – Penoxsulam at 25 g/ha	71.4 (8.51)	58.0	5.21	6.52	35.9	84.7	48.7	2.35
Pyrazosulfuron ethyl at 20 g/ha – Bispyribac sodium at 250 ml/ha	34.0 (5.91)	80.0	6.01	7.21	36.3	97.4	61.0	2.68
Pendimethalin at 1.0 kg/ha + HW at 30 DAP	7.60 (2.93)	95.5	6.26	7.46	37.0	101.4	64.4	2.74
Weed free check	0.00 (1.00)	100.0	6.42	7.61	37.0	103.9	66.9	2.81
Weedy check	169.9 (13.1)	--	4.18	5.02	35.0	67.7	32.7	1.94
LSD (P=0.05)	0.85	7.62	0.54	0.51	NA	NA	5.92	0.14

Note: cost of cultivation

Materials	*Urea*	*DAP*	*MOP*	*Pyrazosulfuron ethyl*	*Pendimethalin*	*Bispyribac sodium*	*2,4 –D Sodium salt*	*Azimsulfuron*	*Metsulfuron*	*Oxodiargil*	*Penoxsulum*	*Grain*	*Straw*
Prices (Rs/kg/litre)	*5.0*	*20.0*	*15.0*	*320*	*1000*	*1000*	*240*	*300*	*935*	*696*	*300*	*15.0*	*1.0*

With respect to economics, grass returns, net returns and B:C ratio was significantly higher with weed free check (Rs. 103971, Rs. 66971 and 2.81). Among the herbicide treatments, grass returns, net returns and B: C ratio was significantly higher with application of pendimethaline fb by one hand weeding at 30 DAS which was closely followed by application of pyrazosulfuron ethyl *fb* bispyribac sodium. The above results are in line with the findings of Yadav *et al.* (2011).

CONCLUSION

Pendimethaline fb by one hand weeding at 30 DAS was found superior. In case of labour scarcity for hand weeding at 30 DAS, application of pyrazosulfuron ethyl *fb* bispyribac sodiumresults in higher rice grain yield and higher B:C ratio.

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Bioefficacy and phytotoxicity of *Eucalyptus* leaf oil emulsion on wheat and associated weeds under field condition

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Wheat is an important crop worldwide and in India, its production increased from a mere 11.0 mt during 1960-61 to 93.9 mt during 2011-12. This jump in the productivity was due to use of modern dwarf varieties, heavy use of input (fertilizers, irrigation, pesticides). But this also led to increased pressure from weeds as modern varieties are less competitive and weeds take major chunk of applied inputs. Use of herbicide is the most convenient one thus very popular among farmers now days. Increased/faulty use on the other side had led to many draw backs like herbicide resistance, environmental pollution and human health hazards. Use of ecofriendly herbicides is one way to reduce these ill effects. *Eucalyptus* species release volatile compounds such as benzoic, cinnamic and phenolic acids, which inhibited growth of crops and weeds growing near it (Kohli *et al.* 1998). Seed germination, seedling growth, chlorophyll content and respiratory ability of some weed plants was drastically affected by allelochemical extracted from *Eucalyptus citriodora*. Both aqueous extract and volatile oil of *Eucalyptus* species inhibit the germination and growth of weed species and wheat, with oil being more effective. Moreover, little has been done to further explore phytotoxic potential against cropped and non- cropped weed species under field condition. Therefore, the present investigation was undertaken to assess the phytotoxicity of eucalypt oil against some weeds with a view to explore it as a bioherbicide for weed management in wheat crop

METHODOLOGY

The field experiment was conducted in D-2 block of Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, during *Rabi* season 2011-12. Soil of the experiment was silty clay loam, with high in organic C content.

Twelve treatments consisting of different oil concentrations (1.0, 2.5 and 5.0%), different stages of application {20, 30 days after sowing (DAS) as well as pre + post emergence application under above concentrations), best bet herbicide (pre emergence application of pendimethalin at 1.0 kg/ha followed by sulfosulfuron at 0.025 kg/ha as post emergence}, weed free and weedy check were studied in randomized block design with three replications for testing bioefficacy and phytototoxicity of volatile leaf oil of *E. citriodora*. Wheat variety '*UP-2572*' was used in the experiment with all other recommended package of practices.

Table 1. Dry matter of different weed species and wheat crop at different stages of crop growth as influenced by treatment

Treatment	Stage of Application	Weed dry matter (g/m^2)			
		P minor	*M indica*	*M. denticulata*	*C. album*
Eucalyptus Oil spray 1.0%	20 DAS	3.72 (13.8)	1.47 (2.13)	1.51 (2.24)	1.60 (2.53)
Eucalyptus Oil spray 1.0%	30 DAS	3.42 (11.7)	1.36 (1.80)	1.39 (1.90)	1.48 (2.14)
Eucalyptus Oil spray 1.0% + 1.0%	PE+30 DAS	3.22 (10.4)	1.28 (1.61)	1.31 (1.69)	1.39 (1.91)
Eucalyptus Oil spray 2.5%	20 DAS	3.48 (12.1)	1.38 (1.87)	1.42 (1.97)	1.50 (2.22)
Eucalyptus Oil spray 2.5%	30 DAS	3.33 (11.1)	1.32 (1.71)	1.32 (1.71)	1.44 (2.04)
Eucalyptus Oil spray 2.5% + 2.5%	PE+30 DAS	3.07 (9.5)	1.23 (1.47)	1.31 (1.69)	1.33 (1.74)
Eucalyptus Oil spray 5.0%	20 DAS	3.25 (10.5)	1.29 (1.63)	1.36 (1.81)	1.40 (1.93)
Eucalyptus Oil spray 5.0%	30 DAS	3.21 (10.4)	1.28 (1.61)	1.25 (1.54)	1.39 (1.91)
Eucalyptus Oil spray 5.0% + 5.0%	PE+30 DAS	3.05 (9.4)	1.21 (1.45)	1.24 (1.53)	1.32 (1.72)
Pendimethalin + Sulfosulfuron	PE+30 DAS	3.07 (9.3)	1.22 (1.45)	1.23 (1.52)	1.33 (1.73)
Weed free*		0.22 (0.0)	0.22 (0.0)	0.22 (0.0)	0.22 (0.0)
Weedy	-	6.51 (42.3)	2.56 (6.54)	2.63 (6.88)	2.79 (7.77)
LSD (P=0.05)		0.36	0.13	0.14	0.16

Figures in parentheses are original values. Data were subjected to angular transformation

RESULTS

Among the weed species which infested the crop, only four were dominant, *viz. Phalaris minor* in grassy, *Melilotus indica*, *Medicago denticulata* and *Chenopodium album* in non-grassy. Other weed species included *Anagalis arvensis*, *Coronopus didymus*, *Rumex acetosella*, *Vicia sativa and Cyperus rotundus.* At 60 days stage *P. minor* was the most dominant weed species followed by *C. album*, *M. denticulata* and *M. indica*. At 60 DAS, dry matter accumulation by all weed species was significantly affected by various weed control treatments. Highest dry matter accumulation of all weeds was recorded from weedy check plot 5.0%. Eucalyptus oil spray at pre-emergence + 30 days stage of application had lowest dry matter accumulation which was at par with best bet herbicidal control (pre emergence pendimethalin at 1.0 kg followed by 0.025 g/ha sulfosulfuron post emergence). However non- significant differences were observed among different pre and post emergence eucalyptus oil treatments irrespective of doses. Non-significant differences too were observed between 1.0% oil spray at 30 days and its application as pre and post emergence at 1.0% concentration. There was no visual toxicity of Eucalyptus leaf oil up to 1.0% concentration level on wheat crop, visual toxicity however was observed beyond 1.0 % concentration level. Severe phyto toxicity was the reason behind reduced weed dry matter in eucalyptus oil treated plots.

CONCLUSION

Based on the study, it may be concluded that volatile oil of *Eucalyptus citriodora* show ability to control wheat weeds. Hence, Eucalyptus oil emulsions could be used as a potential bioherbicide (1.0% concentration as post emergence application) for future weed management programmes as it is a natural plant product, easily biodegradable and eco-friendly.

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Efficacy of post-emergence herbicides on weeds and productivity of wheat

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Wheat (*Triticum aestivum* L.) is predominant *Rabi* season crop of northern, central and upper peninsular region of the country. Among the various factors responsible for low productivity of wheat, weed infestation during early stages of growth is one of the major factors. Due to initial slow growth, it provides a congenial environment for weed growth. In wheat generally, first 30-40 days are highly critical from the point of crop weed competition. Mechanical weeding is costly, time consuming and sometimes not possible due to non-availability of labour. Under such circumstances, use of effective herbicides with suitable dose remains the pertinent choice for controlling the weed. With these considerations in view, the present experiment was undertaken.

METHODOLOGY

An experiment was conducted during *Rabi* season of 2011 at Agronomy Farm, College of Agriculture, Pune. The experiment was laid out in randomized block design with three replications. The ten treatments comprised of different weed control methods. The crop was fertilized with 120 kg N/ha, 60 kg P_2O_5/ha and 40 kg K_2O /ha. As per the treatments, post-emergence herbicides were sprayed at 30 DAS through knapsack sprayer with flat fan nozzle using 500 litres of water per ha. The variety '*Trimbak*' (NIAW-301) was sown at 22.5 cm apart by using seed rate of 125 kg/ha.

RESULTS

The unweeded control registered significantly higher weed population and dry matter of weeds due to resulting from the luxuriant growth of the weeds in absence of any weed control treatments. Among the weed control treatments, application of sulfosulfuron 16.5 g/ha + 2,4-D 563 g/ha registered significantly lower weed population (7.6 /m^2) and dry matter of weeds (3.1 g/m^2) than rest of the treatments. The significantly lower weed population and dry matter of weed in sulfosulfuron 16.5 g/ha + 2,4-D 563 g/ha might be due to excellent efficacy against all grassy and non-grassy type of weeds. Bharat and Kacharoo (2010) observed that application of sulfosulfuron + 2,4-D (25 + 500 g/ha) or alone sulfosulfuron (25 g/ha) reduced the weed population. The spraying of sulfosulfuron 16.5 g/ha + 2,4-D 563 g/ha) observed significantly more weed control efficiency of 81.27% than rest of the treatments. Whereas, application of 2,4-D alone showed statistically lower weed control efficiency (54.92%) than other treatments. The statistically higher weed index was observed under unweeded control than rest of the treatments. Among weed control treatments, application of sulfosulfuron 16.5 g/ha + 2, 4-D 563 g/ha resulted into statistically lowest weed index (7.84%), however, it was at par with metsulfuron methyl 4.5 g/ha + 2,4-D 563 g/ha and sulfosulfuron 22 g/ha.

Table 1. Weed growth, yield and economics of wheat as influenced by different treatments

Treatment	Weed population /m^2	Weed dry matter (g/m^2)	WCE (%)	Weed index (%)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x10^3 /ha)	B : C ratio
Unweeded control	6.4* (40.6)	18.4	-	34.90	3.13	4.52	36.98	1.68
Weed free check	0.7 (0.0)	0.0	90 (100)	0.00	4.83	6.52	50.29	1.89
One hand weeding at 20 DAS and one hoeing at 40 DAS	3.2 (10.0)	4.7	60.25 (75.35)	16.39	4.03	5.58	43.02	1.85
Isoproturon 1000 g/ha	3.8 (14.6)	6.4	53.14 (64.03)	18.63	3.92	5.03	40.18	1.91
Isoproturon 750 g/ha + 2, 4-D 563 g/ha	3.9 (15.0)	6.8	52.56 (63.04)	18.37	3.94	5.14	40.32	1.92
Sulfosulfuron 22 g/ha	3.3 (10.6)	4.7	59.27 (73.89)	12.26	4.23	5.77	40.97	2.03
Sulfosulfuron 16.5 g/ha + 2, 4-D 563 g/ha	2.8 (7.6)	3.1	64.36 (81.27)	7.84	4.45	5.98	41.10	2.13
Metsulfuron methyl 6 g/ha	3.4 (11.0)	5.1	58.63 (72.88)	14.33	4.13	5.72	40.63	2.01
Metsulfuron methyl 4.5 g/ha + 2, 4-D 563 g/ha	3.2 (9.6)	3.5	60.90 (76.34)	11.90	4.25	5.82	40765	2.05
2, 4-D 750 g/ha	4.3 (18.3)	6.4	47.82 (54.92)	20.02	3.86	5.22	39.85	1.91
LSD (P=0.05)	0.1	0.4	1.36	5.57	0.28	0.46	-	-

* Transformed values ("x+0.5) ** original values

Data from Table 1 revealed that weed free check produced significantly higher grain and straw yield than all other treatments. Amongst the weed control treatments, application of sulfosulfuron 16.5 g/ha + 2,4-D 563 g/ha recorded maximum grain and straw yield of 4.45 and 5.98 t/ha, respectively as compared to other treatments. It has been observed that sulfosulfuron is a broad spectrum herbicide, which controlled both grassy and broadleaved weeds, while, 2,4-D also controlled dicot weeds effectively. The increase in yield might be because of less weed competition, significant reduction in weed population and weed biomass, which may be enhanced N, P and K uptake by crop. Punia *et al.* (2006) reported that application of sulfosulfuron 25 g + 2,4-D 500 g/ha gave statistically higher yields as compared to other herbicides. Bharat and Kachroo (2010) revealed that application of sulfosulfuron + 2,4-D produced significantly higher grain and straw yield than application of metsulfuron methyl and 2,4-D alone. The weed free check recorded maximum cost of cultivation. However, maximum benefit cost ratio of 2.13 was obtained with the application sulfosulfuron 16.5 g + 2,4-D 563 g/ha, which might be due to lower cost of cultivation and higher grain and straw yields.

CONCLUSION

Thus, it could be concluded that post emergence application of sulfosulfuron 16.5 g/ha + 2,4-D 563 g/ha was most effective for controlling weeds and for obtaining higher yield and returns of wheat.

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Effect of integrated weed management on weed parameters and yields of wheat

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Wheat (*Triticum aestivum* L.) being a major food crop of India is cultivated on 29.64 mha, production of 92.46 mt and average productivity of 3.12 t/ha (Anonymous 2013). Integrated weed management is a science based decision making process that coordinates the use of environmental information, weed biology and ecology, and all available technologies to control weeds by the most economical means, while posing the least possible risk to people and the environment. However, conclusive information is not available on relative efficacy of herbicides alone or in combination with other weed control methods; hence the present investigation was undertaken.

METHODOLOGY

A field experiment was carried out during *Rabi* season of 2012-13 at College of Agriculture, Pune to test the influence of integrated weed management practices against weeds. Nine treatments consisting of herbicides like pendimethalin, metsulfuron methyl, metribuzin and 2,4-D alone and in combination with management practices were arranged in a randomized block design with three replications. Wheat variety '*Godavari (NIDW-295)*' was used with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at 120 kg N, 60 kg P_2O_5 and 40 kg K_2O /ha, respectively. Data on weed dry matter, weed index and weed control efficiency were recorded.

RESULTS

Grassy weeds were predominant followed by broad-leaved. *Cynodon dactylon* among the grassy weeds and *Parthenium hysterophorus* among the broad leaved weeds were dominant. Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest dicot weed density was observed under pendimethalin at 1.0 kg/ha as pre-emergence + hoeing at 30 DAS (1.0 /m^2), followed by metsulfuron methyl at 4 g/ha POE at 18 DAS (5.0 /m^2) (Table1). The minimum weed dry weight was also recorded in these treatments, which was significantly lower than all other treatments. These results are in conformity with the findings of Pisal and Sagarka (2013). The weed index was significantly the highest in weedy check (42.14%) than rest of the treatments .Among the weed management treatments, application of pendimethalin (pre-emergence) at 1.0 kg/ha + hoeing at 30 DAS recorded minimum weed index (5.69%). This clearly indicated that weeds were effectively controlled under pendimethalin at 1.0 kg/ha +hoeing at 30 DAS. The highest grain yield (5.00 t/ha) was recorded with weed free check (3 HW at 20, 40 and 60 DAS) and the lowest (2.89 t/ha) was under weedy check. Among the weed management treatments, pendimethalin (pre-emergence) at 1.0 kg/ha + hoeing at 30 DAS recorded maximum grain yield (4.72 t/ha) which was at par with metsulfuron methyl at 3 g/ha POE at 18 DAS + hoeing at 30 DAS, metribuzin at 131 g/ha POE at 18 DAS+ hoeing at 30 DAS and 2,4-D at 563 g/ha POE at 18 DAS + hoeing at 30 DAS, but significantly higher as compared to metsulfuron methyl at 4.0 g/ha POE at 18 DAS, metribuzin at 175 g/ha PoE at 18 DAS and 2,4-D at 750 g/ha PoE at 18 DAS. Same trend was observed in case of straw yield also.

Table 1. Weed growth, weed index and yields of wheat as influenced by different weed control treatments

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	Weed index (%)	Weed control efficiency (%)	Yield (t/ha)	
					Grain	Straw
Weedy check	59	32.83	42.14	0.00	2.89	4.11
Weed free check (3 HW at 20,40 and 60 DAS	1	2.06	0.00	97.72	5.00	7.54
Pendimethalin (Pre-emergence) at 1.0 kg/ha + hoeing at 30 DAS	7	5.10	5.69	88.63	4.72	6.92
Metsulfuron methyl at 4 g/ha POE at 18 DAS	3	19.83	20.00	37.60	4.00	6.08
Metsulfuron methyl at 3 g/ha POE at 18 DAS + hoeing at 30 DAS	24	11.66	10.31	59.13	4.48	6.64
Metribuzin at 175 g/ha POE at 18 DAS	41	22.16	20.08	29.57	4.00	5.90
Metribuzin at 131 kg/ha POE at 18 DAS+ hoeing at 30 DAS	27	14.83	11.12	53.40	4.44	6.37
2,4-D at 750 g/ha POE at 18 DAS	45	24.20	26.81	23.88	3.66	5.35
2,4-D at 563 g/ha POE at 18 DAS+ hoeing at 30 DAS	31	16.66	11.95	47.16	4.41	6.31
LSD (P=0.05)	5.33	2.96	12.39	14.18	0.7	1.23

CONCLUSION

It was concluded that pre-emergence application of pendimethalin at 1.0 kg/ha + hoeing at 30 DAS was most effective for controlling weeds and improving grain and straw yields of wheat.

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Efficacy of pyroxsulam with polyglycol against mixed weed flora in wheat

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Wheat is an important crop of Punjab and weeds are a major problem in wheat. Many herbicides are being tried for the control of grass as well as broad leaf weeds but continuous use of same herbicide reduce its bio-efficacy and leads to evolution of resistant weed population (Malik and Singh 1995). So this calls for the evaluation of some new herbicide molecule against the weeds in wheat. The bio-efficacy of pyroxsulam with polyglycol against mixed weed flora was evaluated in wheat.

METHODOLOGY

The experiment was laid at Punjab Agricultural University, Ludhiana during *Rabi* 2013-14 with six treatments in a Randomized Block Design. The treatments were pyroxsulam 4.5% OD12, 15 and 18 g/ha applied with polygycol 26-2N at 1.0 l/ha, sulfosulfuron 25 g/ha and metsulfuron 4 g/ha. Wheat variety '*HD-2967*' was sown on 14.11.2013 by using seed rate of 100 kg/ha. Recommended dose of fertilizers were applied at the time of sowing and thereafter. The herbicides were applied 30-35 DAS with knap sack sprayer fitted with flat fan nozzle. The data on weed count and dry matter accumulation were recorded at 60 days after sowing (DAS) using 50 cm × 50 cm quadrat. The grain yield at harvest was recorded. The weed data was analyzed statistically after square root transformation.

RESULTS

The experimental field has mixed weed flora viz. grass weed *Phalaris minor* and broadleaf weeds, *viz. Chenopodium album, Medicago denticulata, Rumex dentatus, Coronopus didymus, Anagallis arvensis etc.* Narrow and broadleaf weeds recorded were significantly less in higher dose of pyroxsulam15 g/ha than lower dose of 12 g/ha. This showed the decreasing trend with the increase in the dose of pyroxsulamwith polyglycol. Population of *P. minor* was significantly less in pyroxsulam18 g/ha than 15 g/ha. Population of *P. minor* was similar where pyroxsulam was applied at 12 g/ha and sulfosulfuron. Metsulfuron significantly reduced the broadleaf weed population than lower dose of pyroxsulam with polyglycol, *i.e.* 12 g/ha, 15 g/ha and 18 g/ha (Table 1).

Table 1. Efficacy of pyroxsulam with polyglycol on weed count and grain yield of wheat during *Rabi* 2013-14

Treatment	Dose (g a.i./ha)	*P minor* (No./m^2) at 60 DAS	Broad leaf weds (No./m^2) at 60 DAS				Grain yield (t/ha)
			Chenopodium album	*Rumex dentatus*	*Coronopus didymus*	*Medicago denticulata*	
Pyroxsulam + Polyglycol	12	4.2 (17)	1.7 (2)	3.0 (8)	2.6 (6)	3.5 (11)	5.13
Pyroxsulam + Polyglycol	15	3.2 (9)	1.2 (0.5)	2.2 (4)	1.3 (1)	2.3 (4)	5.31
Pyroxsulam + Polyglycol	18	2.6 (6)	1.1 (0.2)	1.6 (2)	1.3 (0.7)	1.8 (3)	5.63
Sulfosulfuron + surfactant	25	4.0 (15)	2.4 (5)	4.0 (15)	3.2 (9)	3.1 (9)	4.97
Metsulfuron + surfactant	4	5.8 (33)	1.0 (0)	1.2 (0.7)	3.0 (8)	3.0 (8)	4.78
Unsprayed Control	-	5.8 (33)	4.3 (17)	5.4 (28)	5.1 (25)	5.0 (25)	3.41
LSD at 5%	-	0.4	0.4	0.4	0.4	0.9	0.11

*Figures within brackets are original means and data is subjected to square root transformation

All the herbicidal treatments recorded significantly higher wheat grain yield than the unsprayed control. Pyroxsulam with polyglycol at 18 g/ha recorded the highest wheat grain yield (5.63 t/ha). Grain yield differed significantly with each dose of pyroxsulam. Significantly less grain yield was obtained in sulfosulfuron as compared to pyroxsulam with polyglycol at 12 g/ha, 15 g/ha and 18 g/ha due to more weed population. Metsulfuron, being only broad leaf killer having significantly higher *P. minor* population which ultimately recorded significantly less grain yield than all doses of pyroxsulam (Table 1).

CONCLUSION

Post-emergence application of pyroxsulam with polyglycol at 18 g/ha recorded effective control of grasses and broadleaf weeds and recorded the highest wheat grain yield.

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Effect of integrated weed management in wheat in lower Gangetic plains of West Bengal

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Wheat is one of the most important winter cereals contributing approximately 30-35% of total food grain production in our country. Heavy infestation of weeds alone causing 33% reductions in yield is a serious constraint in sustaining productivity of wheat. The field experiment on effect of integrated weed management in wheat was carried out at RRSS, Farm of Bidhan Chandra Krishi Viswavidyalaya, Chakdaha, Nadia, West Bengal during *Rabi* seasons of 2013-14 and 2014-15. The experiment was laid out in Randomized Block Design with three replications and seven different weed management practices consisting of hoeing with wheel hoe at 15 DAS, application of Sulfosulfuron + Metsulfuron Methyl at 50 g/ha at 30 DAS alone, hoeing with wheel hoe at 15 DAS + Sulfosulfuron + Metsulfuron Methyl at 50 g/ha at 30 DAS, hand weeding at 15 DAS + Sulfosulfuron + Metsulfuron Methyl at 50 g/ha at 30 DAS, One hand weeding at 15 DAS, hand weeding twice at 15 and 30 DAS and weedy check. The results of two years of experiment revealed that all weed management practices improved the growth parameters such as, plant height, no. of tiller, dry matter production, yield components like spike density m^{-2}, spike length, number of filled grain per spike and 1000 grain weight of the crop. The study also revealed that grain yield of the crop was reduced up to 34% by different categories of weeds. Predominant weed flora appeared during the experiment were *Cyperus rotundus, Cynodon dactylon, Anagallis arvensis, Chenopodium album, Physalis minima, Rumex retroflex* and *Vicia sativa* and other minor weed flora were also observed. Regarding controlling of weeds hoeing with wheel hoe at 15 DAS + (Sulfosulfuron + Metsulfuron Methyl) at 50 g/ha at 30 DAS proved to be the best treatment for lowering done the weed population as well as dry weight of all categorized weeds. It was comparable with the treatment of two hands weeding at 15 and 30 DAS. The same trends were found in the production of grain and straw yields. Considering the non-chemical treatments, single hoeing with wheel hoe at 15 DAS was comparable with single hand weeding at 15 DAS.

Studies on residual effect of 2, 4-D applied in wheat on succeeding rice crop under rice-wheat cropping system

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Bioassy techniques are valuable and relevant to determine the phytotoxic residues of herbicides in soil. For bioassay studies cucumber seeds/ sensitive seeds are used (Kumar *et al.* 1988). Very little information is available on residual effect of 2,4-D Na salt at different doses (at 0.5, 0.8 and 1.0 kg/ha post-emergence) applied in wheat on succeeding rice crop.

METHODOLOGY

Field trials were conducted during *Kharif* 2012 and 2013 in a randomized block design with four replications and four treatments (Table 1) at Agronomy Research Farm, N.D.U.A.T., Kumarganj, Faizabad (U.P.). Rice was transplanted as a tested crop in the field at its proper timely transplanting and irrigated when required. The data regarding weed density/m^2, weed dry weight m^{-2} and grain yield q/ha were analyzed statistically and result were discussed. Boassy techniques are available and relevant to determine the phytotoxic residues of herbicides in soil (2). For bioassay studies, cucumber seeds/ sensitive seeds are used (1, 2)

RESULTS

Application of 2, 4-D Na salt at 0.5, 0.8 and 1.0 kg/ha at post emergence applied in wheat to control the weeds did not show its residual effects on weeds density, weed dry weight and rice yield significantly (Table 1).

Table 1. Studies on residual effect of 2,4-D Na salt applied in wheat on succeeding rice crop under rice-wheat cropping system.

Treatment	Weed density (m^{-2})		Weed dry weight (g/m^2)		Grain yield (q/ha)	
	2012	2013	2012	2013	2012	2013
Control	266	265	48.00	47.00	36.00	35.50
2, 4-D Na salt at 0.5 kg/ha post-emergence	262	263	45.50	45.00	37.50	36.50
2, 4-D Na salt at 0.8 kg/ha post-emergence	260	260	44.25	44.50	38.00	37.25
2, 4-D Na salt at 1.0 kg/ha post-emergence	258	256	42.50	42.00	37.00	36.25
LSD (P=0.05)	NS	NS	NS	NS	NS	NS

CONCLUSION

It is concluded from the experiment that 2,4-D Na salt at different doses (at 0.5 kg/ha, 0.8 kg/ha and 1.0 kg/ha post-emergence) applied in wheat did not show its residual effects on weed density, weed dry weight and rice yield significantly.

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Effect of different herbicides on weed, quality and nutrient uptake of wheat

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Wheat (*Triticum aestivum* L.) is most important cereal crop of the world and it plays vital role in stabilization of national food supply to ensuring decades. Multifarious weed menace is the most important factor responsible to lower down yield, nutrient availability and quality of wheat. Continuous use of same herbicide for many years results in the development of resistance against some weeds which happened in case of isoproturon. Post emergence application of metsulfuron methyl alone or its combination with 2,4-D have effective in controlling weeds and broad spectrum as sulfosulfuron herbicide effectively controls both grassy and broad leaf weeds. In view of efficacy of herbicides with different practices for wheat crop the experiment was conducted.

METHODOLOGY

A field experiment was conducted at Agronomy Farm, College of Agriculture, Pune during *Rabi* 2010-11 in medium black soil. There were ten treatment combinations with randomized block design. Hand weeding and hoeing was done as per the treatment. The required quantity of all herbicides was worked as per the treatment and dissolved in required quantity of water at 500 l/ha. The prepared solution was sprayed separately at 30 DAS as per the treatments as post emergence. Wheat variety '*Trimbak*' was sown at 22.5 cm with fertilizer dose of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. Weed studies was taken at 15 days interval up to harvest of the crop and biometric observations were taken at 30 days interval. The quality and nutrient status was analyzed after harvesting of the crop.

RESULTS

Post emergence application of sulfosulfuron at 16.50 g/ha + 2,4-D at 563 g/ha recorded lower both the monocot and dicot weed population as compared to rest of the herbicide treatments which was significantly more over un weeded control. Significantly lower weed population observed with application of sulfosulfuron at 16.50 g/ha + 2,4-D at 563 g/ha which might be due to excellent efficacy against all grassy and non-grassy type of the weeds. The weed free check and sulfosulfuron at 16.50 g/ha + 2,4-D at 563 g/ha recorded significantly higher weed control efficiency over rest of the treatments which is directly proportional to the yield of wheat. The lowest weed index was noticed with application of sulfosulfuron at 16.50 g + 2,4-D at 563 g/ha herbicides as compared to the other treatments.

Table 1. Mean weed dynamics, yield, quality and nutrient uptake of wheat as influenced by different treatments

Treatment	Weed population /m^2	WCE (%)	Weed index (%)	Grain yield (q/ha)	Protein % in grain	Total uptake (kg/ha)		
						N	P	K
Unweeded control	6.41*(40.6)**	-	34.90	31.33	10.73	98.41	19.31	64.62
Weed free check	0.71(0.00)	90 (100)	0.00	48.27	11.56	181.71	56.18	115.36
One hand weeding at 20 DAS and one hoeing at 40 DAS	3.24 (10.00)	60.25 (75.35)	16.39	40.34	11.31	143.55	35.68	91.37
Isoproturon 1000 g/ha	3.89(14.6)	53.14 (64.03)	18.63	39.24	11.07	128.52	28.93	80.67
Isoproturon 750 g/ha + 2,4-D 563 g/ha	3.9 4(15.0)	52.56 (63.04)	18.37	39.39	11.18	135.03	29.93	75.19
Sulfosulfuron 22 g/ha	3.33(10.60)	59.27 (73.89)	12.26	42.27	11.34	146.13	38.26	93.77
Sulfosulfuron 16.5 g/ha + 2, 4-D 563 g/ha	2.85(7.60)	64.36 (81.27)	7.84	44.48	11.46	165.19	45.38	102.25
Metsulfuron methyl 6 g/ha	3.39(11.0)	58.63 (72.88)	14.33	41.34	11.26	149.11	31.47	91.55
Metsulfuron methyl 4.5 g/ha + 2, 4-D 563 g/ha	3.18(9.6)	60.90 (76.34)	11.90	42.51	11.44	154.70	42.94	96.98
2, 4-D 750 g/ha	4.3 4(18.3)	47.82 (54.92)	20.02	38.60	11.03	126.53	31.27	77.77
LSD (P=0.05)	0.12	1.44	5.57	2.82	0.19	5.27	4.43	4.39

Among the different weed control treatments, application of sulfosulfuron at 16.50 g + 2,4-D at 563 g/ha recorded statistically highest grain yield as compared to the other treatments but it was found at par with application of sulfosulfuron at 22 g/ha POE at 30 DAS and Metsulfuron methyl at 4.5 g + 2, 4-D at 563 g/ha PoE at 30 DAS. This might be due to low weed intensity and more space with moisture was effective for growth and development of the crop. Weed free check recorded significantly higher protein than other treatments where as it was at par with spraying of sulfosulfuron at 16.50 g + 2,4-D at 563 g/ha and T9. The weed free registered significantly higher nitrogen, phosphorus and potassium uptake by crop than all other treatments. Application of sulfosulfuron at 16.50 g a.i. + 2, 4-D at 563 g/ha gave maximum total uptake of N, P and K.

CONCLUSION

The combined application of sulfosulfuron at 16.50 g + 2,4-D at 563 g/ha as a post emergence herbicide in wheat crop could be used for effective control of different wheat flora and for obtaining higher yield, quality and total nutrient uptake by wheat crop.

Effect of herbicidal weed management in irrigated wheat in Jammu

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Wheat is the most important cereal among the food grain crops in the world. It is cultivated in wide range of climatic environments and geographic regions. Among several constraints of wheat production, weeds are one of the major constraint causing yield losses to the extent of 50% (Azad 2003). The crop is infested with heavy population of common broad-leaf weeds, annual grassy weeds like *Phalaris minor, Avena fatua, Poa annua etc*. It has been proved that continuous use of single herbicide has developed the resistance Herbicides such as sulfosulfuron, fenoxaprop have shown high efficacy against grasses in wheat. Use of such herbicides against non- grassy weeds has resulted in proliferation of broad leaved weeds like *Chenopodium album*. But to control mixed weed flora, use of single herbicide/ compatible mixtures can be employed to widen the spectrum of weed control. Keeping the above facts in view, an investigation was carried out to screen out the compatible/ herbicide for broad spectrum weed control in wheat.

METHODOLOGY

A field experiment was conducted at Agricultural Research Farm, SKUAST-J, during *Rabi* seasons of 2012 in randomized block design replicated thrice. The treatments consisted of weedy check, weed free, isoproturon at 1 kg/ha, isoproturon + 2,4-D at 1.0 kg/ha + 1.47 kg/ha at 30 DAS, metribuzin at 285 g/ha, metribuzin at 300 g/ha, pendimethalin at 2500 ml/ha, sulfosulfuron + metsulfuron at 30 g/ha + 2 g/ha, mesosulfuron-methyl + iodosulfuron at 12 g/ha + 2.4 g/ha, clodinafop-propargyl at 60 g/ha, sulfosulfuron at 33.75 g/ha, pinoxaden at 1000 ml/ha, metsulfuron at 25 g/ha and fenoxaprop at 1000 ml/ha. Wheat variety '*RSP-561'* was sown with recommended package of practices. Fertilizers were applied uniformly through urea, diammonium phosphate and muriate of potash at 100 kg N /ha, 50 kg P_2O_5 /ha and 25 kg K_2O /ha, respectively. Observations on total weeds dry weight, yield and Weed index were recorded.

RESULTS

The experimental field was heavily infested by *Anagallis arvensis, Chenopodium album, Fumaria parviflora, Crisium arvense* and *Poa annua* during both the years of experimentation. Weed management treatments significantly influenced the dry matter of weeds. Amongst herbicidal treatments, pre-emergence application of pendimethalin at 0.75 kg/ha significantly reduced the total dry matter of weeds which was found to be statistically at par with post-emergence application of sulfosulfuron + metsulfuron at 30 g/ha + 2 g/ha, isoproturon + 2,4-D at 1.0 kg/ha + 1.47 kg/ha, metribuzin at 285 g/ha, metribuzin at 300 g/ha led to significantly higher crop yield (Table 1). Herbicidal treatments resulted in considerably lower weed index compared with weedy check treatment. Weed index was found minimum with pre-emergence application of pendimethalin at 2500 ml/ha which showed its superiority over other weed control treatments.

Table 1. Effect of weed control treatments on weed dry weight, grain yield and weed index of wheat

Treatment	Total weed dry weight (g/m^2)	Grain Yield (t/ha)	Weed Index (%)
Isoproturon at1 kg/ha	13.44 (179)	2.67	59.11
Isoproturon + 2,4-D at 1.00 kg/ha + 1.47 kg/ha	9.82 (95.6)	3.91	9.46
Sulfosulfuron + metsulfuron at 30g/ha + 2g/ha	9.65 (92.3)	3.96	10.02
Metribuzin at 285 g/ha	9.96 (98.4)	3.87	10.59
Metribuzin at 300g/ha	9.86 (96.3)	3.89	7.26
Pendimethalin at 2500 ml/ha	9.63 (91.8)	3.99	8.08
Mesosulfuron-methyl + iodosulfuron at 12 g/ha + 2.4 g/ha	10.80 (115)	3.57	19.89
Clodinafop-propargyl at 60 g/ha	12.54 (156)	3.02	41.72
Sulfosulfuron at 33.75 g/ha	13.39 (178)	2.72	57.35
Pinoxaden at1000 ml/ha	12.56 (157)	3.00	42.67
Metsulfuron at 25 g/ha	11.61 (133)	3.28	30.48
Fenoxaprop at1000 ml/ha	13.43 (179)	2.69	60.29
Weedy Check	14.11 (198)	2.38	81.35
Weed Free	1 (0.00)	4.28	-
LSD (P=0.05)	0.62	0.24	

CONCLUSION

It was concluded that pre-emergence application of pendimethalin at 2500 ml/ha which was closely followed by sulfosulfuron + metsulfuron at 30 g/ha + 2 g/ha, isoproturon + 2, 4-D at 1.00 kg/ha + 1.47 kg/ha, metribuzin at 285 g/ha , metribuzin at 300 g/ha was found effective for broad spectrum weed control in wheat

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Effect of herbicides on growth and yield of irrigated wheat

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Wheat is second important food crop being consumed next to rice and contribute to the extent of 25 per cent of total food grain production of the country. During *Rabi* season wheat is generally sown after giving pre-sowing irrigation to obtain uniform crop stand, but at the same time irrigation favours germination of *Rabi* weed seeds. Under such situation, it is very essential to control grassy as well as broad leaved weeds to avoid losses caused by weed population, and therefore, timely control of weeds is of great importance. Weed seed germinate along with wheat seed and establishes earlier than wheat and the field suffer from heavy weed infestation. Most of the weed competition is during the first 35 to 45 days after sowing. The weed competition for longer period results into reduction of surviving tillers and the tillers bear short ears, less number of grains in comparison to crop tillers produced in weed free situation (Rathod and Vadodaria 2004). In view of above the present study was undertaken to study the effect of herbicide on weed population in irrigated condition, to study the efficacy of different post-emergence herbicides on growth and yield of wheat and to study the economics.

METHODOLOGY

A field experiment was carried out during *Rabi* season of 2012-13 at Agronomy Farm, College of Agriculture, Nagpur, Maharashtra. The soil was clayey in texture and slightly alkaline in reaction (pH 7.8), low in available N (206.9 kg/ha), medium in available P_2O_5 (19.53 kg/ha) and fairly reach in available K_2O (393.0 kg/ha). The experiment was laid out in randomized block design with nine treatment replicated thrice. The treatment comprised of weedy check-control (T_1), weed free check (Two hand weeding at 15 and at 30 DAS-T_2), 2, 4-D (1.0 kg/ha) at 30 DAS (T_3), Sulfosulfuron at 25 g/ha at 30 DAS (T_4), Metsulfuron methyl at 4 g/ha at 30 DAS (T_5), 2, 4-D at 1.0 kg/ha + Metsulfuron methyl at 4 g/ha at 30 DAS (T_6), 2, 4-D at 1.0 kg/ha + Sulfosulfuron at 25 g/ha at 30 DAS (T_7), Sulfosulfuron at 25 g/ha + Metsulfuron methyl at 4 g/ha at 30 DAS (T_8) and one hand weeding at 30 DAS. (T_9). Wheat variety AKAW-4627 was sown with recommended package of practices and recommended dose of fertilizers (100:50:50 kg NPK /ha) was given at the time of sowing as a basal dose. Remaining half dose of N was applied as top dressing at the time of first irrigation 21 DAS. Grain yield was recorded after harvest of the crop from respective treatments and the various economic parameters such as GMR, NMR and B:C ratio was estimated according to prevailing market value of produce and inputs during the years.

RESULTS

Effect on weeds

Total weed population was reduced significantly due to different weed control treatments, weed free check (two hand weeding at 15 and 30 DAS) recorded lowest density of total weed at all growth stages. However, one hand weeding at 30 DAS (T_9) reduced the total weeds next to the weed free check. Regarding herbicidal weed control, application of 2,4-D at 1.0 kg/ha + Metsulfuron methyl at 4 g/ha at 30 DAS (T_6) controlled significantly total weeds than all the other treatments.

Table 1. Effect of various weed management treatments on weed control, yield and economics of irrigated wheat

Treatment	Weed control efficiency at harvest (%)	Weed Index (%)	Mean number of effective tillers at harvest/plant	Weed dry matter at harvest (g/m^2)	Grain yield (q/ha)	Straw yield (q/ha)	GMR Rs./ha	NMR Rs./ha	B:C Ratio
T_1- Weedy check (control)	-	42.60	5.50	12.66	16.35	18.99	26424	10364	1.64
T_2- Weed free check (two hand weeding 15, 30 DAS	85.82	-	13.05	16.00	40.73	44.02	65497	47637	3.66
T_3-2, 4-D (1 kg/ha) at 30 DAS	56.83	23.17	10.20	13.06	26.53	29.23	42718	26158	2.57
T_4- Sulfosulfuron at 25 g/ha 30 DAS	60.24	20.19	10.85	13.16	29.31	32.79	47244	29984	2.73
T_5- Metsulfuron-methyl at 4 g/ha 30 DAS	65.06	19.09	11.00	13.16	31.73	34.85	51080	34645	3.10
T_6-2, 4-D (1kg//ha) + metsulfuron-methyl at 4 g/ha 30 DAS	71.60	11.36	11.80	14.30	36.01	39.01	57916	41418	3.51
T_7-2, 4-D (1 kg/ha) + Sulfosulfuron at 25 g/ha 30 DAS	66.23	20.52	11.25	13.20	33.32	36.25	53605	36695	3.17
T_8- Sulfosulfuron (25 g/ha) + metsulfuron-methyl (4 g/ha) at 30 DAS	68.17	16.55	11.30	13.40	35.03	37.89	56334	39486	3.34
T_9- One hand weeding at 30 DAS	-	-	12.05	15.20	38.57	42.13	62068	45108	3.60
LSD (P=0.05)	-	-	1.04	0.47	2.35	2.44	865	763	-

Note - Figures in parenthesis are original values and above figures are transformed values, "(x+0.5)

Highest weed control efficiency was recorded under treatment weed free check (weeding at 15 and 30 DAS, T_2) at all the observation except at 20 DAS, followed by one hand weeding (T_9) treatment. The better control of weeds was by the application of 2, 4-D at 1kg a.i. ha^{-1} + Metsulfuron methyl at 4 g/ha at 30 DAS (T_6). These results are in agreement to the results that obtained by Anonymous (1995).

Amongst all the weed control treatments, one hand weeding at 30 DAS (T_9) showed minimum weed index 7.2% followed by application of 2,4-D at 1.0 kg/ha + Metsulfuron methyl at 4.0 g/ha at 30 DAS (T_6), which proved better than other combinations and alone herbicidal application. Weedy check control treatment (T_1) recorded highest weed index 42.6% causing reduction in wheat grain yield due to presence of weed throughout growth period. Lower weed index in chemical treatments might be due to better weed control as compared to weedy check control (T_1). Similar results were also reported by Anonymous (1992) and Anonymous (1995).

Weed free check (T_2) recorded highest number of effective tillers plant^{-1} and dry matter plant^{-1} which was significantly superior over application of the herbicide, followed by one hand weeding (T_9). The application of 2,4-D at 1kg/ha + Metsulfuron methyl at 4 g/ha at 30 DAS (T_6) recorded significantly higher number of effective tillers plant^{-1} and dry matter plant^{-1} than all chemical herbicide treatments. Lowest number of effective tillers plant^{-1} and dry matter plant^{-1} were observed in weedy check (T_1). The higher number of effective tillers plant^{-1} and dry matter plant^{-1} might be due to lesser number of monocot and dicot weeds, thus a reduced crop-weed competition which might have helped in bearing the more number of tillers plant^{-1} and dry matter plant^{-1}

Effect on crop yield and economics

Grain yield and straw yield of wheat was significantly higher with treatment weed free check (two hand weeding at 15 and 30 DAS) than weedy check. However, in respect of herbicidal combination, application of 2, 4-D at 1kg/ha + Metsulfuron methyl at 4 g/ha at 30 DAS (T_6) recorded significantly higher grain and straw yield over rest of the chemical treatment except (T_8). Weedy check (T_1) recorded lowest grain and straw yield. This might be due to more dry matter plant^{-1} in wheat and lesser dry matter accumulation in weeds, in all treatments facilitating better crop growth and production of more grain and straw yield (Singh and Ali, 2004).

Weed management with weed free check i.e. two hand weeding at 15 and 30 DAS (T_2) registered highest GMR (Rs.65497 ha^{-1}) and NMR (Rs. 47637 ha^{-1}) and was found significantly superior over other treatments. In herbicidal application, 2, 4-D at 1kg/ha + Metsulfuron methyl at 4 g a.i/ ha at 30 DAS (T_6) recorded higher GMR (Rs.57976 ha^{-1}) and NMR (Rs. 41418 ha^{-1}) than other herbicidal treatment. Similar results were obtained by Singh *et al*, 2004.

Maximum benefit: cost ratio (B:C) was obtained with the treatment of two hand weeding at 15 and 30 DAS (T_2) followed by one hand weeding (T_9). Amongst herbicidal application, 2, 4-D at 1kg a.i/ ha + Metsulfuron methyl at 4 g/ha at 30 DAS (T_6) registered more B:C ratio than other herbicidal treatment. Weedy check recorded lowest benefit: cost ratio.

CONCLUSION

In situation where timely weeding is not feasible due to paucity and high cost of labour as well as unfavorable weather and unworkable field condition, post emergence application of 2, 4-D at 1 kg/ha + Metsulfuron methyl at 4 g/ha at 30 DAS found suitable for better weed control in irrigated wheat.

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Efficacy of flufenacet against littleseed canary grass (*Phalaris minor*) in wheat

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Wheat is an important crop of India including Madhya Pradesh. Weeds are major constraints in the wheat production. Irrigated wheat, in general, is deadly infested with grassy weeds particularly *Phalaris minor* because of similar ecological requirements. If weeds are not controlled timely and effectively they cause identical reduction in wheat yields (Bhan and Kumar 1997). In the recent past, isoproturan was most potential herbicide for control of grassy weeds. But due to its continuous use in wheat, it led to development of resistance in *P. minor*. Recently, flufenacet has been developed which reportedly gives satisfactory control of *P.minor* in wheat. Since, the meagre information on the efficacy of flufenacet against *P. minor* in wheat is available for Madhya Pradesh; therefore, a comprehensive study was under taken.

METHODOLOGY

A field experiment was carried out during *Rabi* season of 2012-13 at Jawaharlal Nehru Kirshi Vishwa Vidyalaya, Jabalpur (M.P.) to judge the efficacy of flufenacet against weeds in wheat. Six treatments consisting of four doses of flufenacet (200 g/ha, 250 g/ha, 300 g/ha), clodinafop-proaprgyl (60 g/ha), hand weeding twice (20 and 40 DAS) and weedy check, were carried out in randomised block design with four replications. Wheat variety '*GW 273*' was sown on 12th November, 2012 in the experimental field with recommended package of practices. Data on weed growth yield and yield attributes were recorded using suitable techniques.

RESULTS

Phalaris minor was more rampant in wheat crop, as it constituted the major share (28.86%) of relative weed density as compared to *Medicago hispida*, *Cichorium intybus*, *Cyperus rotundus* and *Dinebra retroflexa* which had 21.32%, 19.9, 18.2 and 11.6% relative density, respectively at harvest.

It is evident from the data cited in Table 1 that activity of flufenacet 200 g/ha against *P. minor* was less, but it was improved with the increase in application rates being the higher when flufenacet was applied at 250 g/ha or higher rate (300 g/ha) and proved superior over Clodinafop-propargyl 60 g/ha. But all the herbicidal treatments did not surpass hand weeding twice which curbed the density and dry weight of *P. minor* to the tune 100% at 60 days after application of herbicides in wheat.

Table 1. Density and dry weight of *Phalaris minor*, WCE (%), yields attributes and yield of wheat as influenced by different weed control measures

Treatment	*Phalaris minor* (60 DAS)		Weed control efficiency (%) (60 DAS)	Effective tillers/m^2	Earhead length (cm)	Grains/ earhead	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
	Density (No./m^2)	Dry weight (g/m^2)							
Flufenacet 200 g/ha	1.90 (3.50)	1.46 (2.04)	95.19	246.60	09.78	52.80	41.85	58.85	70.50
Flufenacet 250 g/ha	1.82 (3.00)	1.24 (1.16)	97.27	270.85	09.90	56.55	42.75	60.78	71.20
Flufenacet 300 g/ha	1.27 (1.25)	1.00 (0.50)	98.82	272.65	09.86	57.60	43.50	61.65	72.60
Clodinafop propargyl 60 g/ha	0.71 (0.00)	1.57 (2.00)	95.29	230.25	09.70	51.70	41.70	57.95	69.25
Hand weeding twice (20 & 40DAS)	0.71 (0.00)	0.71 (0.00)	100.0	285.75	10.08	60.65	46.30	65.50	77.15
Weedy check	7.00 (48.75)	6.55 (42.45)	0.0	200.55	07.85	36.10	40.10	28.85	44.50
LSD (P=0.05)	0.84	0.48	-	15.90	1.23	7.65	1.62	2.14	2.32

*Values in parentheses are original. Data transformed to square root transformation; DAS- Days after spraying of herbicide

Weedy check plots had poor values of yield attributing traits of wheat (effective tillers/m^2, earhead length, grains/ earhead and seed test weight *etc.*). But the values of these parameters were improved marginally in plots receiving flufenacet at 200 g/ha being the higher when it was applied at 250 g/ha or at higher rate (300 g/ha) and proved significantly superior over check herbicide Clodinafop-propargyl (60 g/ha). However none of the herbicidal treatment excelled the hand weeding twice which attained the highest grain and straw yields (6.55 and 7.71 t/ha).

CONCLUSION

Post emergence application application of flufenacet between 250-300 g/ha was found to be good for effective control of *Phalaris minor* in wheat.

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Effect of herbicides and row spacing on weed control and productivity of bread wheat

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Wheat is one of the most important cereal crops of the world. In India, it is the second important staple crop, rice being the first. The irrigated wheat is infested with several broad as well as narrow leaf weeds which creates competitive stress resulting in yield loses varying from 7-50% depending on their densities (Sharma *et al.* 2001). Among the existing weed management recommendations in wheat, 2,4-D as post emergence is the commonly used by majority of the farmers which is effective only on broad leaf weeds. Therefore, there is an urgent need to have alternative herbicides which may provide wide range of weed control as well as to avoid herbicide resistance by continuous use of same herbicides. In addition to use of latest herbicides, closer row spacing than recommended may also play an important role in weed control as it has shading effect on weeds which is capable of suppressing the photosynthesis of weeds as well as better use of available resources. Keeping in view, the present experiment was planned to study the efficacy of herbicides in conjunction with varying row spacing on weed control and yield of wheat.

METHODOLOGY

A field experiment on weed control in wheat through different herbicides and reduced row spacing was conducted at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Raj.) during *Rabi* 2012-13. The experiment consisted of six weed control treatments (post emergence application of pinoxaden, isoproturon, metribuzin, sulfosulfuron, idosulfuron 40 g/ha, 750 g/ha, 400 g/ha, 25 g/ha, 25 g/ha, respectively at 32 DAS and weedy check) and three row spacing (17.5, 20 and 22.5 cm) thereby making eighteen treatment combinations laid out in factorial randomized block design replicated thrice using wheat variety Raj 4037. Soil of experimental site was clay loam in texture, alkaline in reaction (pH 8.1). The soil was medium in available nitrogen (249.26 kg/ha) and phosphorus (19.41 kg/ha) but high in available potassium (371.82 kg/ha).

RESULTS

Data presented in Table indicate that all the herbicides under test significantly reduced weed dry matter at harvest over weedy check and minimum being recorded under post emergence application of metribuzin 400 g/ha followed by isoproturon 750 g/ha. However, metribuzin was found phytotoxic to crop among different treatments as evident from the lowest plant height, effective tillers as well as ear length under this treatment probably due the fact that at this dose it might have adversely affect all categories of weeds including crop itself. Grain yield of wheat is significantly increased under the influence of all herbicides compared to weedy check with an inverse relation to weed dry matter yield. Per cent increase in grain yield due to isoproturon, sulfosulfuron, pinoxaden, idosulfuron and metribuzin is 71.77, 59.18, 50.15, 48.05 and 33.93, respectively over weedy check. The trend of net returns also follows the trend as that of grain yield under different treatments. The superiority of treatments in terms of grain yields under all the weed control treatments compared to weedy check may be due the fact that different herbicides control weed growth at varying extent and provide congenial environment for crop leading better plant height, effective tillers and length of ears which ultimately resulted into higher grain yield thereby net returns. While the trend of grain yield is somewhat different in case of metribuzin when compared with weed dry matter yield.

Table 1. Effect of herbicides and row spacing on various parameters in wheat

Treatment	Weed dry matter (g/m^2) at harvest	Plant height (cm) at harvest	Effective tillers (0.5 row/m)	Ear length (cm)	Grain yield (t/ha)	Net returns (Rs/ha)
Herbicides						
Pinoxaden 40 g/ha	171.56	88.7	65.29	10.19	5.00	72316
Isoproturon 750 g/ha	150.11	91.6	69.53	10.36	5.72	83753
Metribuzin 400 g/ha	137.44	84.5	59.40	9.35	4.46	63200
Sulfosulfuron 25 g/ha	163.78	90.8	66.60	10.34	5.30	77129
Idosulfuron 25 g/ha	183.33	88.3	64.29	9.71	4.93	71405
Weedy check	577.22	87.0	54.67	9.26	3.33	44020
LSD (P=0.05)	3.89	1.1	0.92	0.14	0.07	1134
Row Spacing (cm)						
17.5	198.72	89.2	63.50	9.80	4.94	71314
20.0	234.61	88.2	64.41	9.91	4.83	69485
22.5	258.39	88.0	61.99	9.85	4.60	65112
LSD (P=0.05)	7.79	NS	NS	NS	0.04	567

Varying row spacing indicate that reducing row spacing from 22.5 cm to 17.5 and 20.0 cm significantly decreased weed dry matter with the tune of 23.09 and 9.20 per cent at harvest compared to conventional row spacing *i.e.* 22.5 cm. Grain yield and net returns follows reverse trend as that of weed dry matter under varying row spacing probably due to the fact that narrow row spacing provides maximum cover over soil surface which suppressed growth and development of weeds and thus provided better environment in terms of availability of various growth resources require for growth and development of crop. Results collaborate with the findings of Andrade *et al.* 2002.

CONCLUSION

On medium fertility soil of Udaipur isoproturon 750 g/ha 32 DAS resulted into effective weed control, maximum grain yield and net returns. For better weed control and good yield as well as monetary returns it is also advised to sow the crop at narrow row spacing *i.e.* 17.5 cm.

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Tolerance of wheat to herbicides applied at different growth stages

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Proper time of herbicide application plays a key role in achieving effective weed control without causing injury to crop. Crop tolerance to herbicides varies with growth stage and environmental conditions which affect the plant's ability to metabolize herbicides. *Phalaris minor* is a dominant grassy weed in wheat in Northern India. Majority of herbicide labels specify that herbicide applications to wheat should be made from tillering to early flag leaf emergence. In some years, low temperature early in the season may cause *P. minor* seeds to germinate in high densities along with wheat and substantial wheat yield loss can result from such competition if proper weed control strategies are not implemented timely (Wegulo *et al.* 2011). Many wheat growers find themselves in a situation whereby wheat crop is not at the labelled stage, yet *P. minor* plants are at an ideal stage for herbicide application. Under these conditions, farmers are in a dilemma that whether they should apply herbicides, or wait and apply the herbicides at recommended time of 30 days after seeding. Therefore, the consequence of spraying when wheat crop is not at the ideal stage is unknown. Keeping this in view, present study was conducted.

METHODOLOGY

A field experiment was carried out at Punjab Agricultural University, Ludhiana, India during winter season of 2013-14. Wheat variety '*HD-2967*' was seeded on 15th November, 2013, using 100 kg seed/ha, in 22 cm spaced rows, on clay loam soil. The experiment was laid out in Randomised Complete Block Design (Factorial) with three replications. The treatments included sulfosulfuron 24.4 g/ha, fenoxaprop + metribuzin 275 (100+175) g/ha, mesosulfuron + iodosulfuron 14.4 (12+2.4) g/ha each at 14 days after sowing (Zadoks 12), 21 days after sowing [(before irrigation) (Zadoks 13)] and 30 days after sowing (Zadoks 21). The herbicides were applied by using knapsack sprayer fitted with flat fan nozzle which delivered 375 litres of water/ha. First irrigation was applied at 23 days after sowing. Visual observations, for assessing phytotoxicity due to herbicides, were taken on 0-10 scale (0-no phytotoxicity; 10-complete killing) at weekly interval. The crop was harvested in the last week of April, 2014.

RESULTS

Application of fenoxaprop + metribuzin at Zadoks 12 and Zadoks 13 caused phytotoxicity to wheat; leaves of sprayed plants showed wilting symptoms followed by bleached appearance. The injury symptoms appeared after two weeks and one week in case of spray at Zadoks 12 and Zadoks 13, respectively. The injury was more severe when the crop was sprayed at Zadoks 13 compared to Zadoks 12 (Fig. 1 and 2). Even though the symptoms recovered after some time in most of the plants, there was mortality of few plants, which led to a reduction in plant stand and wheat grain yield (33.8 and 35.3% due to spray at Zadoks 12 and Zadoks 13 respectively). Mesosulfuron + iodosulfuron at Zadoks 12 and Zadoks 13 also resulted in slight suppression of crop (Fig. 1 and 2) which recovered later on. The crop showed a good tolerance to sulfosulfuron with no injury or yield reductions detected even when applied at the first and more sensitive application timing (Zadoks 12). All the herbicides were safe to the crop at Zadoks 21.

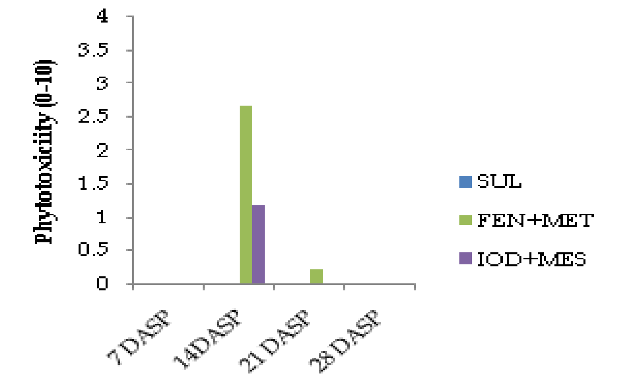

Fig. 1 Spray at Zadocks 12

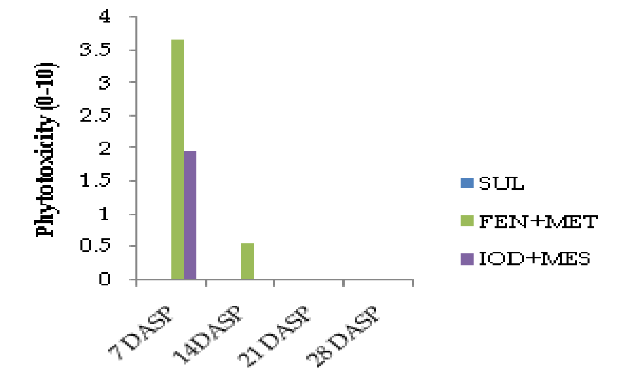

Fig. 1 Spray at Zadocks 13

SUL-Sulfosulfuron, FEN+MET-Fenoxaprop+Metribuzin, IOD+MES-Iodosulfuron+Mesosulfuron

DASP- Days after spray

CONCLUSION

Sulfosulfuron at 24.4 g/ha can be used for controlling *P. minor* at early stages of growth (Zadoks 12-13) in wheat.

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Performance of wheat as affected by different post-emergence herbicides

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Wheat is one of the most important cereal crops of the world and the second important staple food crop of India after rice. Inadequate weed control in wheat is one of the important reasons of poor productivity of this crop. Acute problem of booth grassy and broad leaf weeds is becoming very common in this crop, which often results in huge yield loss and makes the weed control more complex (Singh *et al.* 2002). Weeds in this crop are controlled by many methods including different herbicides but most of the methods are not perfect due to one or other reasons. Since the continuous use of herbicides with similar mode of actions may results in resistance development as well as build up residue in soil, hence it was felt necessary to evaluate various herbicides, their combinations and ready mix herbicides against the mixed weed complex in this crop.

METHODOLOGY

A field experiment on weed control through of use of the post emergence herbicides in wheat was conducted at Research Farm of Agronomy N. D. University of Agriculture and Technology, Kumarganj, Faizabad (U. P) during *Rabi* 2012-13. Experiment consisted on 12 weed control treatments namely Isoproturon 1000 g /ha, Isoproturon + 2,4-D 1000 + 500 g/ha, Clodinafop + Metsulfuron methyl 60 + 4 g/ha, Vesta 400 (Clodinafop + Metsulfuron methyl) 400 g/ha, Clodinafop + 2,4-D 60 + 500 g/ha, Sulfosulfuron 25 g/ha, Sulfosulfuron + Metsulfuron methyl 25 + 4 g/ha, Total (Sulfosulfuron + Metsulfuron methyl) 40 g/ha, Metribuzin 175 g/ha, Atlantis (Mesosulfuron + Iodosulfuron) 400 g/ha, Weed Free and weedy check. Experiment was conducted in RBD replicated thrice using wheat variety NW- 1014. All the herbicides were applied as post emergence at 35 DAS. The soil of the experiment was silt loam in texture, slightly alkaline in reaction, low in organic matter and available N and P and medium in potassium.

RESULTS

Data in Table indicate that weed control efficiency fluctuate to a great extent under different weed control treatments varying from minimum of 80.90% under isoproturon to 100% in under weed free treatment. Next to weed free the highest weed control efficiency of 93.6% was observed under post emergence application of 400 g Vesta a ready mix of Clodinafop + Metsulfuron methyl. The major growth and yield attributes, *viz.* dry matter accumulation in plants, number of spikes/m^2 as well as length of spike were significantly influenced by all the weed controlled treatments compared to weedy check but the pronounced effect on these parameters was noticed under the post emergence application of 400 g Vesta /ha which is significantly at par with Atlantis 400 g/ha. Grain yield of wheat is also significantly affected by all the weed control treatments compared to weed check at varying extent and follows inverse relation with weed control efficiency under different treatments. Percent reduction in grain yield under various treatments varied from 30.92 % in weedy check to 17.6% in isoproturon compared to weed free treatment. On the other hand % increase in grain yield due to weed free, Vesta and Atlantis was 44.75, 41.50 and 35.46, respectively compared to weedy check. Significant effect of all weed control treatments under test was due to the fact that different herbicides might have controlled growth of weeds in different fashion with varying magnitude and resulted into batter environment with respect to availability of different resources including nutrients. Data also shows that all the weed control treatments decrease the uptake of N by weeds resulted into availability of more N for the crop as evident with its uptake by the crop under different treatments. The uptake of N by weeds was estimated as 8.90 % of the total removal (crop + weeds) in weedy check and only 1.51 and 1.63% in Vesta and Atlantis, respectively. Thus, saving of 7.39 and 7.29% N could be obtained by application of Vesta and Atlantis, respectively compared to weedy check.

Table 1. Effect of post emergence herbicides on various parameters in wheat

Treatment	W.C.E. (%)	N uptake by weeds (kg/ha)	N uptake by crops (kg/ha)	DMA by wheat (g/m^2)	No. of spikes/m^2	Length of spike (cm)	Grain yield (q/ha)
Isoproturon 1000 g/ha	80.90	3.92	93.08	670.56	325.00	8.30	35.23
Isoproturon + 2,4-D 1000+500 g/ha	84.77	3.60	97.08	730.80	352.45	8.70	36.69
Clodinafop + Metsulfuron methyl 60+4 g/ha	89.34	2.45	103.55	780.15	375.80	9.20	39.34
VESTA (Clodinafop15% + Metsulfuron methyl 1%) RM 400 g/ha	93.60	1.75	113.89	860.50	390.00	9.70	41.80
Clodinafop + 2,4-D 60+500 g/ha	86.80	3.30	97.81	745.65	355.50	8.90	37.58
Sulfosulfuron 25 g/ha	82.23	3.90	96.66	690.45	330.15	8.40	36.25
Sulfosulfuron + Metsulfuron methyl 25 + 4 g/ha	88.07	3.10	100.49	765.60	365.60	9.12	38.90
Total (Sulfosulfuron 75% + Metsulfuron methyl 5%	91.11	2.10	106.87	795.25	382.15	9.35	39.47
Metribuzin 175 g/ha	83.50	3.70	97.18	710.20	340.35	8.55	36.57
Atlantis (Mesosulfuron 3% + Iodosulfuron 0.6%) RM 400 g/ha	92.36	1.88	113.39	800.25	385.00	9.45	40.00
Weed free	100.00	0.00	118.67	885.15	405.10	9.80	42.76
Weedy check	0.00	6.68	68.36	590.30	290.15	8.15	29.54
SEm±	-	0.08	2.40	23.96	11.72	0.21	1.42
CD at 5%	-	0.25	7.18	70.29	34.38	0.61	4.17

CONCLUSION

Post emergence application of Vesta a ready mix of Clodinapof and Metsulfuron methyl 400 g/ha 35 DAS effectively controlled weeds and gave maximum grain yield and saving of N compared to all other treatments while post emergence application of Atlantis 400 g/ha recorded as the next best option in this regard.

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Green forage yield and quality in oat as influenced with integrated weed management

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In India, oat (*Avena sativa* L.) is the major cereal forage crop for *Rabi* season which is quick growing, palatable and nutritious for the livestock. Compared to other cereal straws which have similar chemical compositions, oat straw has more digestible organic matter (Cuddeford 1995). Being a winter, irrigated and long durational crop, the oat is heavily infested with various species of annual and perennial weeds. This infestation results in decline in fodder productivity. In the changing climate situation weeds have a greater genetic diversity than crops. Consequently, if a resource (light, water, nutrients or carbon dioxide) changes within the environment, it is more likely that weeds will show a greater growth and reproductive response. Changes in temperature, wind speed, soil moisture and atmospheric humidity can influence the effectiveness of herbicide applications. However, on the other side due to scarcity of labourers, it becomes very difficult to manage the weeds in time under irrigated condition resulting in to more crop weed competition for nutrient, light, moisture and space thus, causing substantial reduction in green forage yield and quality of oat (Anonymous 2010). Hence the present investigation was carried out to find the effective integrated weed management method in oat crop.

METHODOLOGY

A field experiment was conducted at the farm of Forage Crops Research Project, M.P.K.V., Rahuri during *Rabi* 2011-12 to study the effect of integrated weed management on growth, yield and quality of oat. The soil was loam and low in available nitrogen, available phosphorus and very high in potassium with pH 8.4. The trial of nine treatments was laid out in randomized block design (RBD) with three replications. Oat variety 'RO-19' (*Phule harita*) with spacing of 30 cm in rows and fertilizer dose of 100: 50: 40 (N: P: K) kg/ha apart. Treatments consisted of T_1, weedy check (control); T_2, weed free check; T_3, HW (hand weeding) at 3 WAS (weeks after sowing); T_4, HH (hand hoeing) at 3 WAS; T_5, pre-emergence (P-E) pendimethalin at 0.75 kg/ha + 1 HW at 5 WAS; T_6, post emergence (PoE) 2,4-D at 0.75 kg/ha at 3 WAS + 1 HW at 5 WAS; T_7, PoE MSM (metsulfuron methyl) at 0.004 kg/ha at 3 WAS + 1 HW at 5 WAS; T_8, PoE 2,4-D at 0.75 kg/ha at 3 WAS + 1 HH at 5 WAS and T_9, PoE MSM at 0.004 kg/ha at 3 WAS + 1 HH at 5 WAS.

RESULTS

The major weed species observed included dicot weeds such as *Chenopodium album* and *Parthenium hysterophorus*; and monocot weeds such as *Cyperus rotundus* and *Cynodon dactylon*.

The lowest population (plants /m^2) and dry weight of weeds were recorded in weed free check and was at par with post emergence metsulfuron methyl at 0.004 kg/ha at 3 WAS+1 HW at 5 WAS, pre-emergence pendimethalin at 0.75 kg/ha + 1 HW at 5 WAS and post emergence 2,4-D at 0.75 kg/ha at 3 WAS+ 1 HW at 5 WAS resulting into higher WCE than other treatments. These results are corroborated with the results of Kumar *et al.* (2001).

Weed free check recorded significantly higher growth and yield attributes compared to other weed control treatments. Amongst integrated weed management treatment highest green forage (43.30 t/ha) and dry matter (9.26 t/ha) yield of post emergence metsulfuron methyl at 0.004 kg/ha at 3 WAS + 1 HW at 5 WAS and pre-emergence pendimethalin at 0.75 kg/ha + 1 HW at 5 WAS, giving the lowest WI. These results are in conformity with the results reported by Pandey and Singh (1994) and Satao and Padole (1994).

Table 1. Weed dynamics, forage yield, quality and economics as affected by different integrated weed management treatments in oat

Treatment	GFY (t/ha)	DMY (t/ha)	Dry wt. of weeds (kg/ha)	WCE (%)	WI (%)	Crude protein content (%)	Crude protein yield (t/ha)	Net returns (Rs./ha)	B:C ratio
Weedy check (Control)	24.51	4.53	543	0.00	45.45	7.13	0.32	7313.1	1.59
Weed free check	44.93	9.72	0.00	100.00	0.00	7.19	0.70	10706.6	1.42
HW at 3 WAS	37.17	7.37	057	89.32	17.24	7.07	0.52	13128.4	1.79
HH at 3 WAS	32.27	6.12	236	56.20	28.18	7.00	0.42	10587.7	1.70
Pendimethalin at 0.75 kg/ha + 1 HW at 5 WAS	41.66	8.70	025	95.44	7.26	7.25	0.63	14970.2	1.82
2,4-D at 0.75 kg/ha at 3 WAS + 1 HW at 5 WAS	34.72	6.67	028	94.76	22.67	7.15	0.47	10084.5	1.57
MSM at 0.004 kg/ha at 3 WAS + 1 HW at 5 WAS	43.30	9.22	013	97.60	3.60	7.22	0.66	17331.8	2.00
2,4-D at 0.75 kg/ha at 3 WAS + 1 HH at 5 WAS	33.49	6.38	046	91.53	25.45	7.15	0.45	9794.6	1.58
MSM at 0.004 kg/ha at 3 WAS + 1 HH at 5 WAS	39.21	8.14	043	92.16	12.69	7.25	0.59	14581.7	1.87
LSD (P=0.05)	2.75	0.80	029	4.50	6.00	NS	0.064	2159.49	0.13

Similar trend was observed in Crude protein and crude fibre yield and proved to be the most remunerative weed control treatment, recording the highest net monetary returns (17331.8 Rs./ha) and B:C (2.00). These results are in close conformity to the findings reported by Naik *et al.* (2001).

CONCLUSION

It can be concluded that post emergence metsulfuron methyl at 0.004 kg/ha at 3 WAS + 1 HW at 5 WAS, can be a better option for weed control in oat alongside pre-emergence pendimethalin at 0.75 kg/ha + 1 HW at 5 WAS as it ensures higher green forage and dry matter yield which is even at par with weed free check; and it provides higher net returns and B:C ratio.

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Effect of herbicides with and without surfactant against weeds in wheat

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Wheat (*Triticum aestivum* L.) is one of the most important cereal crop because it is the staple food of the people of India. There has been tremendous increase in area, production and productivity of this crop during the green revolution phase of Indian agriculture in India. It occupies second position both in terms of area and production in the world. It is cultivated over an area of 29.86 mha with an annual production of 94.88 mt and productivity of 3.18 mt/ha, whereas in Madhya Pradesh, it is cultivated in 4.89 thousand hectares of land with an annual production of 12.69 million tonnes and productivity of 2.36 mt/ha (CLRS, 2014). Among various factors responsible for low yield, weed infestation and nutrient management are of supreme importance. In order to sustain global agriculture food production, the importance of protecting arable crops against negative yield effect from weeds is well recognized. The manual weeding is not feasible in all situations and had many problems with varying crops and soil types. Chemical weed control is an important alternative for controlling of weeds in wheat because they are quite effective and efficient.

METHODOLOGY

A field experiment was conducted under AICRP on weed control at Research Farm of RVSKVV, College of Agriculture, Gwalior (M.P.) in *Rabi* seasons of 2008-09 and 2009-10. The soil of experimental field was sandy clay loam in texture, neutral in reaction (pH 7.6), low in organic carbon (0.44%) and low in available nitrogen and medium in phosphorus and potash. The field experiment was laid out in a randomized block design (RBD) with three replications having twelve weed management treatments. The recommended agronomical practices of wheat were adopted during the experiment.

RESULTS

The results revealed that the dry weight of weeds significantly influenced due to weed control treatments at 60 DAS. All weed management treatments gave lower weed dry weight compared with weedy check. The significantly minimum dry weight of weeds was noted in weed free (3.50 g/m^2) which was at par with Pinoxaden 40 g *fb* Carfentazone 25 g/ha with Ammonium sulphate 1.0% (4.43 g/m^2), while maximum dry weight of weeds was recorded in weedy check (202.86 g/m^2). It might be due to more density and unsuppressed weed growth under untreated check plot. Similar results were also obtained by Katara *et al.* (2012) in case of combined application of pinoxaden with metsulfuron methyl or carfentrazone-ethyl (Bahart and Kachroo 2007) in case of pinoxaprop + metribuzin. Nariyal *et al.* (2007) also reported that the herbicide with surfactant effectively controlled the all type weeds in wheat crop.

The higher weed control efficiency was recorded in weed free (77.48%) followed by pinoxaden 40 g fb carfentazone 25 g/ha with ammonium sulphate 1% (75.09%), carfentazone 25 g fb pinoxaden 40 g /ha (66.57%) and pinoxaden 35 g *fb* carfentazone 20 g/ha with ammonium sulphate 1% (63.14%). The higher weed control efficiency under these treatments was reflected through to lower dry weight of weeds. These results are in tune with the finding of Katara *et al.* (2012).

All the weed control treatments significantly increased the grain yield over weedy check. The highest grain yield recorded in weed free plot (4.62 t/ha) while, minimum in weedy plot (2.38 t/ha). Among the herbicides, pinoxaden 40 g fb carfentazone 25 g/ha with ammonium sulphate 1% obtained the higher grain yield (4.42 t/ha) which was at par with carfentazone 25 g *fb* pinoxaden 40 g/ha and they were significantly superior to carfentazone 25 g, pinoxaden 40 g herbicidal treatments. The superiority of these treatments over weedy check in increasing grain yield due to minimized crop-weed competition has also been reported by Sharma and Singh (2011).

Table 1. Effect of different weed management treatments on grain yield, dry weight of weeds, WCE, net return and B: C ratio of wheat. (Pooled data of 2008-09 & 2009-10)

Treatments (Post emergence application)	Seed yield (t/ha)	Dry wt. of weeds at 60 DAS (g/m^2)	WCE (%)	Net Return (Rs./ha)	BCR
Carfentazone 15 g fb Pinoxaden 30 g/ha	3.38	11.13	47.10	31816	3.04
Carfentazone 20 g fb Pinoxaden 35 g/ha	3.63	8.13	61.77	34974	3.25
Carfentazone 25 g fb Pinoxaden 40 g/ha	3.95	5.96	66.57	38468	3.40
Pinoxaden 30 g fb Carfentazone 15 g/ha (Ammonium sulphate 1%)	3.78	6.73	52.90	37991	3.41
Pinoxaden 35 g fb Carfentazone 20 g/ha (Ammonium sulphate 1%)	3.90	5.93	63.14	38986	3.56
Pinoxaden 40 g fb Carfentazone 25 g/ha (Ammonium sulphate 1%)	4.42	4.43	75.09	43775	3.70
Carfentazone 25 g/ha	3.37	22.60	26.62	32940	3.10
Pinoxaden 40 g/ha	3.55	12.56	55.63	31867	2.90
Sulfosulfuron 25 g/ha	4.14	13.26	51.89	41902	3.60
IPU +2,4-D (1000 + 500 g/ha)	3.98	11.83	47.26	39786	3.55
Weed free (2, hand weeding)	4.62	3.50	77.48	40012	3.15
Weedy check	2.38	202.86	-	21560	2.40
LSD (P=0.05)	855	2.26		-	-

The pinoxaden 40 g *fb* carfentazone 25 g/ha with ammonium sulphate 1% gave highest net return (Rs 43775 /ha) and benefit cost ratio (3.70) followed by the sulfosulfuron 25 g/ha, net profit of Rs 41902 and benefit cost ratio (3.60). The minimum net return (Rs 21560 /ha) and benefit cost ratio (2.40) were recorded in weedy check.These findings are in close agreement with previous finding of Ashrali *et al.* (2009).

CONCLUSION

It was concluded that the pinoxaden 40 g/ha *fb* carfentazone 25 g/ha as POE with and without ammonium sulphate 1% gave excellent management of grassy and broad leaf weeds and gave higher net return and B:C ratio also.

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Bioefficacy of herbicides on performance of maize and residual effect on succeeding wheat

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The queen of cereals "maize" is an important crop with a very high production potential among cereals. Being a widely spaced crop it gets infested with a variety of weeds and subjected to heavy weed infestation, which often reduces yield varying from 18-85% depending on the type of weed flora, their density and function of crop weed competition (Sunitha and Kalyani 2012). Manual weeding is difficult due to inadequate availability of labour and lack of workable field conditions at critical stages of crop weed competition. In such situation use of herbicides become essential. In southern Rajasthan majority of farmers in the area are unaware about the use of some alternate herbicides except Atrazine for control in this crop. With this background it was felt necessary to explore performance of some other herbicides for effective control of weeds in this crop along with their residual effect on succeeding wheat.

METHODOLOGY

A field experiment on weed control in maize and residual effect thereof on succeeding wheat was conducted consecutively for two years during *Kharif* and *Rabi* seasons of 2012-13 and 2013-14 at Instructional Farm of Agronomy, R.C.A., Udaipur. Experiment consisted of seven treatments viz., 2.5 kg Alachlor/ha, each of sponsor and market product, Atrazine 1.0 kg/ha, 2, 4-D dimethyl amine salt 0.5 kg/ha, weedy check and weed free and double dose sponsor product of Alachlor (5.0 kg/ha). Atrazine and Alachlor were applied as pre emergence while 2, 4-D was applied as early post emergence at 16 days after sowing. Herbicides were sprayed through knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare. Soil of the experimental fields was clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus and high in potassium. Experiment was conducted in RBD replicated thrice using maize and wheat varieties as PEHM-2 and Raj. 4037 respectively. Weed control efficiency at 60 days after sowing was calculated on the basis of weed dry matter yield of dicot, monocot and total weeds recorded from 1 m^2. Two years data were analysed for various parameters and presented as mean.

RESULTS

Major weeds during the observations recorded were *Commelina benghalensis*, *Parthenium hysterophorus*, *Echinochloa crusgalli* and *Cyperus rotundus* and their respective mean contribution in the total density of weeds at 60 DAS was 25.56, 17.92, 46.48 and 10.04. Thus, in the total population of weeds dicot and monocot contribute 43.48 and 56.52 per cent, respectively.

Data in Table 1 indicate that weed control efficiency at 60 DAS under different weed control treatments vary to a great extent. As far as weed control efficiency of dicot weed is concerned it is maximum (40.54%) under 2,4-D 0.5 kg/ha and minimum (23.5%) under Atrazine 1.0 kg/ha. Weed control efficiency of monocot weed is maximum under application of Alachlor irrespective of its dose and product but minimum was recorded fewer than 2,4-D sodium salt followed by Atrazine. Weed control efficiency of total weeds under various treatments vary from minimum of 72.0% in Atrazine to 77.68% in Alachlor 5 kg/ha. Data on mean grain yield under influence of different treatments indicate that all treatments significantly affected maize grain yield compared to weedy check, however, grain yield under all the herbicidal treatments were significantly at par to each other and significantly lower than weed free treatment. The per cent increase in maize grain yield under weed free and Alachlor 2.5 kg/ha sponsor sample was 47.3% and 21.3%, respectively compared weedy check.

Data on wheat grain yield under the influence of different weed control treatments tested in maize could not significantly affect grain yield which indicate that neither of the herbicides at any of the dose could not leave any residual effect that adversely affect grain yield of succeeding wheat crop. Significant increase in maize grain yield under various treatments curtail nutrient uptake by weeds and provided weed free environment to the crop.

Table 1. Effect of weed control treatments in maize and its residual effect on succeeding wheat yield

Treatment	Mean weed control efficiency (%)			Mean grain yield (q/ha)	
	Dicot	Monocot	Total	Maize	Wheat
Alachlor 50% EC 2.5 kg/ha– Sponsor sample	33.53	87.49	76.44	34.05	41.54
Alachlor 50% EC 2.5 kg/ha– Market sample	30.92	87.32	75.33	33.71	43.66
Atrazine 50% WP 1.0 kg/ha	23.53	85.09	72.60	32.42	44.44
2, 4 - D Dimethyl amine salt 58% SL 0.5 kg/ha	40.54	83.80	74.60	32.86	44.05
Alachlor 50% EC 5.0 kg/ha - Sponsor sample	38.81	88.30	77.68	33.23	45.41
Weed free	0	0	0	41.35	44.37
Weedy check	-	-	-	28.06	42.74
LSD (P=0.05)				3.87	NS

CONCLUSION

From two years of results it can be concluded that weed free treatment significantly increased maize grain yield over all the weed control treatments but among herbicide treatments maximum grain yield of maize was obtained under pre emergence application of 2.5 kg Alachlor /ha irrespective of its source without adversely affecting the performance of wheat yield.

Effect of planting techniques and herbicides on weed management and productivity of wheat

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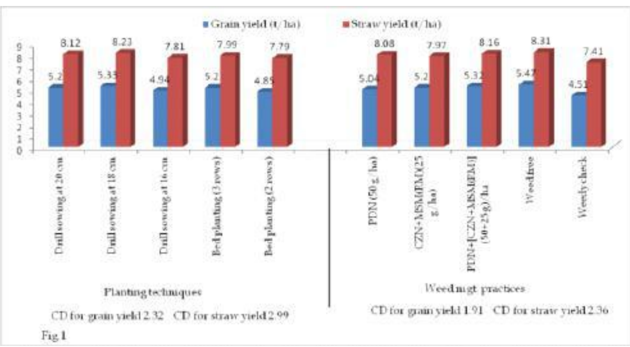
Ever increasing worldwide demographic pressure has made it necessary to augment the productivity of food crops on continues basis in order to feed the world's population and ensure future world food security. Wheat plays an important role in the food and nutritional security i.e. up to 40% of total food grain production of the country. In India, it is grown in 31.34 mha with production of 95.91 mt and productivity of 3.06 t/ha (Anonymous 2014). Factors like infestation of weeds and their control and suitable planting techniques affect the wheat productivity. As there is hardly any scope for expansion of area under wheat, the major emphasis need to be on increasing the productivity of wheat by adopting weed management practices and improved planting techniques.

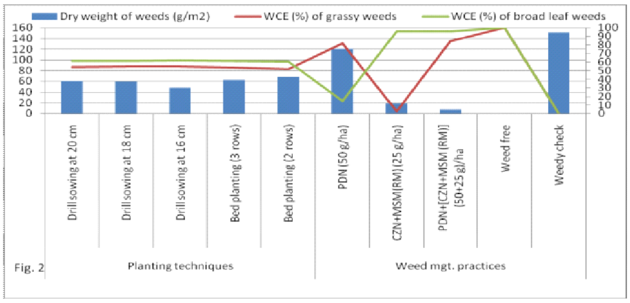
METHODOLOGY

During *Rabi* season of 2012-13, a field experiment was carried out at CCS Haryana Agricultural University, Hisar, Haryana to study the effect of planting techniques and herbicides on weed management and productivity in wheat. Experiment had five planting methods as main-plot treatments, *viz*. drill sowing at 20, 18 and 16 cm (conventional tillage), bed planting with 2 and 3 rows and five weed management practices as subplot treatments, *viz.* pinoxaden 50 g/ha, [carfentrazone+metsulfuron (RM)] 25 g/ha, pinoxaden + [carfentrazone+metsulfuron (RM)] (50+25) g/ha, weed free and weedy check. The experiment was laid out in split-plot design and replicated thrice. Wheat variety WH 711 was sown on 10th December, 2012 as per package of practices recommended by CCS Haryana Agricultural University, Hisar. Herbicides, as per treatments, were sprayed at 35 DAS by knapsack sprayer fitted with flat-fan nozzle using 500 l/ha water.

RESULTS AND DISCUSSION

Various planting methods significantly affected the wheat grain and straw yields (Fig. 1). Drill sowing at 18 cm row spacing in wheat recorded maximum grain yield (5.33 t/ha), which was statistically at par with the sowing at 20 cm row spacing and bed planting with 3 rows of wheat (5.20 and 5.20 t/ha, respectively). These treatments produced significantly higher grain yield over bed planting with 2 rows (4.85 t/ha) of wheat and drill sowing at 16 cm row spacing (4.94 t/ha) which were statistically at par to each other. The increase in grain yield was 7.2%, 9.8%, 1.7% and 7.1% with drill sowing at 20 cm, 18 cm and 16 cm and bed planting with 3 rows over bed planting with 2 rows planting techniques, respectively (Fig. 1). Drill sowing at 18 cm row spacing in wheat recorded maximum straw yield (8.23 t/ha), which was at par with drill sowing at 20 cm row spacing and bed planting with 3 rows of wheat (8.12 and 7.99 t/ha, respectively). The lowest straw yield (7.79 t/ha) was recorded under bed planting with 2 rows of wheat.





Various weed management treatments, however, recorded significantly higher grain yield than weedy check. The highest grain yield was observed under weed free (5.47 t/ha) treatment which was at par with the application of pinoxaden + [carfentrazone+metsulfuron (RM)] [(50+25) g/ha] (5.32 t/ha). The per cent increase in grain yield was 11.8, 15.2, 18.0 and 21.3 with the application of pinoxaden (50 g/ha), [carfentrazone+metsulfuron (RM)] 25 g/ha, pinoxaden + [carfentrazone+metsulfuron (RM)] (50+25) g/ha and weed free treatments over weedy check, respectively (Fig. 1). Similar trend was also observed for straw yield of wheat.

Dry matter accumulation of weeds was lower under drill sowing at 16 cm than other planting techniques. It significantly reduced dry matter accumulation by weeds to tune of 18.0 and 18.9% over drill sowing at 18 and 20 cm row spacing, while the decrease was 28.8 and 21.6% over bed planting with 2 and 3 rows of wheat, respectively (Fig. 2).

Among various weed management treatments, tank mixture of pinoxaden + ready mix of carfentrazone and metsulfuron (50 + 25) g/ha at 35 DAS produced least weed dry matter and was most effective against both grassy and broadleaf weeds with 84.3 and 95.9% weed control efficiency. Whereas, weed control efficiency was 82% with pinoxaden (50 g/ha) alone against grassy weeds and 95.8% with ready mix of carfentrazone and metsulfuron (25 g/ha) alone against broad leaved weeds only (Fig. 2). The results are in line with the results obtained by Sheoran *et al.* (2013).

CONCLUSION

Wheat sown at 18 cm row spacing gave maximum wheat yield and was at par with 20 cm row spacing and 3 rows bed planting system, whereas, combined application of pinoxaden + [carfentrazone+metsulfuron (RM)] (50+25) g/ha at 35 DAS effectively control both grassy as well as broad leaf weeds in wheat.

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Long-term effect of continuous use of herbicides on shift in weed flora in rice-wheat sequence

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Rice-wheat is the predominant cropping system in India occupying around 10.5 million ha area. The farmers realize much of their food security from this cropping system. Weeds are serious constraints in rice-wheat cropping system. Of the total losses caused by pests, weeds have a major share (30%). They reduce the crop yield and deteriorate the quality of produce and hence reduce the market value of the turn out (Arif *et al.* 2006).

METHODOLOGY

A long-term experiment was conducted on rice-wheat cropping system during *Rabi* 2000 to 2013-14 at Palampur. The soil of the test site was silty clay loam in texture, acidic in reaction, low in available N, P and K with CEC of 11.5 mol ($P^{\pm}$). Nine treatments viz. farmers' practice (T_1), continue use of herbicides (butachlor + 2,4-D) with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continue (isoproturon + 2,4-D; T_2 and T_4) and rotational (clodinafop/isoproturon; T_3 and T_5) use of herbicides in wheat and rotational use of herbicides (butachlor/pretilachlor (cyhalofop-butyl) in later years) + 2,4-D) with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continue (isoproturon + 2,4-D; T_6 and T_8) and rotational (clodinafop/ isoproturon; T_7 and T_9) use of herbicides in wheat were tested in rice – wheat cropping system from rabi 2000 to 2013-14.

RESULTS

During *Rabi* 2000, *Phalaris minor*, *Avena ludoviciana*, *Vicia sativa*, *Anagallis arvensis* and *Coronopus didymus* were dominant weeds. Population density of all these weeds decreased in later years. *Coronopus didymus* was not observed after 2009-10. After 3-4 years, *Poa*, *Lolium* and *Ranunculus* were appeared. *Poa* and *Lolium* had alarming proportion in the later years while *Ranunculus* disappeared after 2-3 years. From 2005-06, *Polygonum* and *Alopecurus* were the new invaders. In the later years, *Trifolium*, *Stellaria*, *Lathyrus*, *Plantago* and *Daucus carota* had little infestation in the experimental field. In rice, *Echinochloa crusgalli*, *Panicum dichotomiflorum* and *Cyperus iria* were the main weeds initially. The population of these weeds decreased over the years. Lately *Digitaria* (2002 and 2003), *Eschaemum* (2004 and 2005), *Aeschynomene* (2004-10), *Commelina* (2005), *Paspalum* (2005), *Ammannia* (2007-14), *Eriocolon* (2009-14), and *Monochoria* (2010-2014) were appeared in the experimental field. The population of *Monochoria* and *Ammannia* was in the decreasing trend while that of *Ericolon* showed increasing trend.

Yield of wheat was higher during the middle years followed by later and former years. All weed control treatments were superior to farmers practice in increasing wheat grain yield. Based on fourteen years pooled data, T_9 and T_7 remaining at par with T_5 resulted in significantly higher wheat grain yield over other treatments. T_9 had highest wheat sustainable yield index (0.743). Rice grain yield showed increasing trend over the years. T_4 remaining at par with T_3 had highest sustainable rice yield index (0.782). These were followed by T_8, T_9 and T_5. T_9 where rotational use of herbicides was practiced in both the crops along with 25% N substitution through *Lantana* in rice had highest sustainable yield index (0.763) with highest total grain productivity of rice and wheat. On an average, T_9 increased total grain productivity by 17% over the farmers practice.

Table 1. Effect of treatments on grain yield of rice and wheat and sustainability

Treatment			Grain yield (kg/ha)			Sustainable yield index (SYI)		
	Rice	Wheat	Rice	Wheat	Rice + wheat	Rice	Wheat	Rice + wheat
T_1	Farmers practice	Farmers practice	2684	2991	5675	0.584	0.731	0.695
T_2	Butachlor fb 2,4 DEE	Isoproturon + 2,4-D	2768	2818	5586	0.593	0.637	0.653
T_3	Butachlor fb 2,4 DEE	Clodinafop /isoproturon* +2,4-D	3048	3270	6318	0.638	0.775	0.748
T_4	Butachlor fb 2,4-DEE + 25% N through *Lantana*	Isoproturon +2,4-D	3217	3363	6579	0.663	0.782	0.765
T_5	Butachlor fb 2,4-DEE + 25% N through *Lantana*	Clodinafop /isoproturon +2,4-D	3426	3113	6538	0.714	0.735	0.777
T_6	Pretilachlor /Butachlor*	Isoproturon +2,4-D	2999	3073	6073	0.623	0.686	0.691
T_7	Pretilachlor /Butachlor	Clodinafop /isoproturon +2,4-D	3361	2842	6203	0.703	0.644	0.734
T_8	Pretilachlor /Butachlor + 25% N Lantana	Isoproturon +2,4-D	3171	3275	6447	0.647	0.729	0.720
T_9	Pretilachlor /Butachlor + 25% N Lantana	Clodinafop /isoproturon +2,4-D	3486	3157	6642	0.743	0.684	0.763
	LSD (P=0.05)		151	117	231	0.584	0.731	0.695

Butachlor 1.5 kg/ha, Pretilachlor 0.75 kg/ha, * Herbicides were used in rotation, from *kharif* 2007 cyhalofop-butyl 90 g/ha replaced pretilachlor; isoproturon 1.0 kg/ha, Clodinafop 75 g/ha, 2,4-D 0.75 kg/ha

CONCLUSION

The findings of the present investigation conclusively inferred that weeds are dynamic in nature and their populations are largely influenced by cropping systems and management strategies adopted. There is no chance of the development of herbicidal resistance in weeds even with continuous use of herbicidal weed control if the management techniques are suitably designed based on a system perspective.

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Bioefficacy and phytotoxicity of 2,4-D ethyl ester for weed control in wheat

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Wheat is one of the most important winter cereals contributing approximately 30-35% of total food grain production in our country. Heavy infestation of weeds alone causing 33% reductions in yield is a serious constraint in sustaining productivity of wheat. The extent of yield reduction largely depends on growth behaviour of individual weed species in relation to agro-ecological condition (Singh *et al.* 1997). Chemical weed management appears to be the best low cost alternative but still it needs more eco-safe. New herbicides are introducing in a regular manner but their eco-safe low cost efficiency needs to be investigated. In view of above, the present experiment was undertaken to study the efficacy on weed growth and yield in wheat.

METHODOLOGY

A field experiment was carried out during *Rabi* 2013-14 at Regional Research Sub-Station of New Alluvial Zone (NAZ), Chakdaha, West Bengal to evaluate the bio-efficacy and phytotoxicity of 2,4-D ethyl ester for weed control in wheat. The experiment was laid out in randomized block design (RBD) with 9 treatments (Table 1) replicated thrice in a sandy loam soil. The variety HD- 2733 was sown during last week of November in 4 m x 3 m plots with a spacing 20 cm (R-R) x 5 cm (P-P). Tested post emergence herbicides (2,4-D ethyl ester) with different doses were sprayed at 30 DAS, whereas Isoproturon applied as pre emergence at 3 DAS.

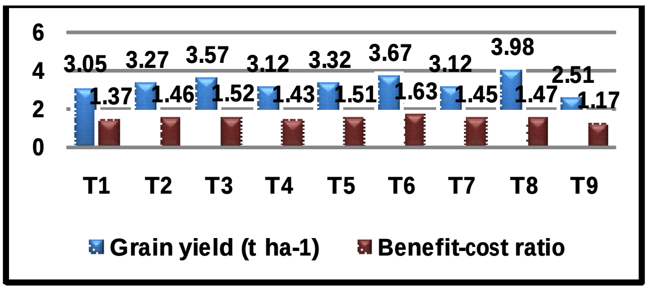
RESULTS

The predominant weed species were *Cynodon dactylon, Lolium temulentum* & *Digitaria sanguinalis* among grasses; *Cyperus rotundus* among sedge & *Physalis minima, Solanum nigram, Amaranthus viridis, Chenopodium album, Anagallis arvensis, Melilotus alba, Vicia hirsute* among broad leave weeds. Herbicidal treatments significantly influenced the weed population and dry matter production of weeds (Table 1). Hand weeding twice showed the best performance in respect of weed control (83.88 % WCE at 60 DAS) & grain yield (3.98 t/ha). Among the herbicidal treatments, 2,4-D EE at 1.80 kg/ha at 60 DAS recorded second highest WCE (66.72%) and grain yield (3.67 t/ha) with a maximum benefit-cost ratio of 1.63 (Fig. 1) followed by 2,4-D EE at 1.80 kg/ha (with 65.68 % WCE, 3.57 t/ha grain yield and 1.52 benefit-cost ratio), whereas control plot (weedy check) showed the worst performance (grain yield 3.01 t/ha and 1.17 benefit-cost ratio). No phytotoxicity symptoms were observed on wheat crop after 5, 15 and 30 DAA.

Table 1. Weed dry weight (g/m^2), weed population m^{-2} and weed control efficiency at 60 DAS

Treatment	Formulation dose (L/ha)	Weed dry weight (g/m^2) at 60 DAS			Weed population/m^2 at 60 DAS			WCE % at 60 DAS
		Broad leaved	Grasses	Sedges	Broad leaved	Grasses	Sedges	
T_1: 2,4-D EE 38 % EC at 0.675 kg/ha	1.776	5.56	4.12	3.17	22	17.00	6.00	56.33
T_2: 2,4-D EE 38 % EC at0.90 kg/ha	2.368	5.14	4.00	2.40	19	16.33	5.33	60.70
T_3: 2,4-D EE 38 % EC at 1.80 kg/ha	4.736	4.29	3.54	2.25	15.67	12.00	4.00	65.68
T_4: 2,4-D EE 80 % EC at 0.675 kg/ha	0.845	5.29	4.04	2.80	19.67	16.33	6.67	58.72
T_5: 2,4-D EE 80 % EC at 0.90 kg/ha	1.126	4.87	3.93	2.60	16.67	13.00	4.67	61.25
T_6: 2,4-D EE 80 % EC at 1.80 kg/ha	2.252	4.00	3.34	2.43	13.00	10.00	4.00	66.72
T_7: Isoproturon 75% WP at 0.60 kg/ha	0.800 (kg)	5.07	4.04	2.63	18.33	17.33	6.00	60.02
T_8: Hand weeding twice at 20 and 40 DAS	-	2.52	1.43	0.67	8.00	6.67	2.00	83.88
T_9: Weedy check	-	12.3	10.50	6.43	45.67	35.67	8.67	0
LSD (P=0.05)	-	0.483	0.450	0.504	3.289	3.687	1.985	2.064

Fig. 1. Effect of treatments on Grain yield (t ha^{-1}) and Benefit-Cost ratio of wheat



CONCLUSION

The results revealed that 2,4-D EE at 1.80 kg/ha was significantly at par with hand weeded treatment in case of grain yield, also resulted no phytotoxicity to wheat and non-toxic to microbes as well as give more benefit. The testing & standard herbicides did not show any detrimental effect on soil physic-chemical properties and micro-flora status excepting some reduction up to three weeks after application. As hand weeding is costly, time consuming & laborious it can be replaced by 2, 4-D EE at 1.80 kg/ha in case of wheat.

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Effect of day time application of mesosulfuron-methyl on weeds and yield of wheat

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Wheat (*Triticum aestivum* L.) is one of the most important crops among cereals. Many factors are responsible for low yields of wheat, but weed infestation may be cause yield losses upto 25-35 percent which is more than the combined loss by insects, pests and disease (Dangwal *et al.* 2010). Since mechanical method of weed control is not common in wheat fields and hence chemical method is widely used to control weeds (Montazeri *et al.* 2005). Mesosulfuron-methyl a broad spectrum herbicide which mostly applied as post-emergence to get rid of weed notority in wheat but information on effect of day time application on the efficacy of mesosulfuron-methyl is not available in the literature. Therefore a comprehensive study has done to see the effect of day time application of mesosulfuron-methyl on weeds and yield of wheat.

METHODOLOGY

A field experiment was conducted during, *Rabi* season of 2014-15 at Product Testing Unit, Department of Agronomy, JNKVV, Jabalpur (M.P.), to study the effect of day time application of mesosulfuron-methyl on weed flora and yield of wheat. Fifteen treatments comprising of three doses of mesosulfuron-methyl (10 g/ha, 11.5 g/ha and 12 g/ha) including one hand weeding (30 DAS) and weedy check as a main plots treatments and these were superimposed with three day times of herbicide application (8 am, 12 noon and 6 pm) as a sub plot treatments and these were laid out in split plot design with four replications. Wheat variety '*GW-273*' was sown on December 13, 2014 in the experimental field with recommended package of practices. Full doses of major plant nutrients (120 kg N, 60 kg P_2O_5, 40 kg K_2O/ha) was applied as basal through urea, single super phosphate and muriate of potash. Data on weed growth were recorded under different treatments at 60 DAS and grain and straw yields were recorded at harvest.

RESULTS

The important weed species observed in the experimental field cropped with wheat crop was comprised of mainly *Medicago denticulata, Anagallis arvensis, Alternanthera sessilis, cynodon dactylon and Chenopodium album*. Howevere, *Medicago denticulata* (42.48%) and *Anagallis arvensis* (38.67%) were predominant and other weeds were present in less numbers.

It is obvious from the data given in the Table 1 that with increase in application rates from 10 to 12 g/ha there was corresponding increase in the activity of mesosulfuron-methyl being higher when it was applied at 11.5 g/ha or higher rate (12 g/ha) but all the herbicidal treatments did not excel the hand weeding, which reduce the weed growth to the maximum extent (96.39%) and proved significantly superior to all the herbicidal treatments. Among the day time application, the lowest weed density (7.05 /m^2), weed dry matter (2.66 g/m^2) and weed control efficiency (60.67%) were observed when mesosulfuron was done at noon hours and proved superior over morning application being at par to evening application.

The seed and straw yields were poor when weeds are not controlled throughout the crop season. Among the herbicidal treatments, mesosulfuron-methyl 11.5 g/ha recorded higher grain yield (4.67 t/ha) and proved statistically superior over lower and higher rate application. However, the hand weeding excelled to mesosulfuron-methyl at all the rates of application (10, 11.5 and 12 g/ha), by recording maximum values of seed (4.97 t/ha) and straw (6.95 t/ha) yields and proved significantly superior over herbicidal plot treatments. Among the day time application, noon time application of mesosulfuron recorded maximum grain (4.44 t/ha) and straw (6.38 t/ha) yields but did not differ significant from its morning and evening application.

Table 1. Weed growth and yield of wheat as influenced by different weed control treatments and day time application

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	Weed control efficiency (%)	Seed yield (t/ha)	Straw yield (t/ha)
Main plot (Herbicide doses)					
Mesosulfuron-methyl 10 g/ha	9.14	3.24	50.89	4.37	6.36
Mesosulfuron-methyl 11.5 g/ha	6.00	2.54	71.18	4.67	6.52
Mesosulfuron-methyl 12 g/ha	4.87	2.19	78.64	4.33	6.12
Hand weeding (30 DAS)	2.13	1.11	96.39	4.97	6.95
Unweeded check	14.47	4.57	0.00	3.67	5.92
SEm	0.18	0.04	0.94	0.09	0.17
LSD (P=0.05)	0.56	0.1	2.91	0.28	0.51
Sub-plot (day time of spray)					
Morning (8am)	7.54	2.77	29.60	4.41	6.31
Noon (12pm)	7.05	2.66	60.67	4.44	6.38
Evening (6pm)	7.37	2.76	59.00	4.37	6.30
LSD (P=0.05)	0.40	NS	1.70	NS	NS

CONCLUSION

It is concluded that post emergence application mesosulfuron-methyl 11.5 g/ha during noon to evening hours found more productive.

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Effect of available soil moisture content on application of post-emergence herbicides on growth and yield of irrigated wheat

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Wheat is one of the most important cereal crops occupying the prime position among food crops in the world. The productivity of wheat depends on several factors viz; varieties, time of sowing, irrigation, fertilizer, weed management. Moisture at the time of herbicide application is important because it affects absorption and translocation of herbicides at the site of action. An appropriate adjustment of time of herbicide application in relation to suitable soil moisture seems desirable for proper activity of herbicides. As the soil moisture decreases, the weeds are not controlled due to lower herbicidal absorption and poor physiological activity (Porwal and Dadheech 2008). Keeping this in view, the present experiment was carried out to assess the effect of application of post emergence herbicides at different levels of available soil moisture content (ASM) on growth and yield of irrigated wheat.

METHODOLOGY

The field experiment was conducted at Livestock Farm, JNKVV, Jabalpur, M.P. during the *Rabi* seasons of 2008-09 and 2009-10. The soil of the experimental area was clayey in texture, medium in organic carbon, available nitrogen and phosphorus and high in available potassium. Twenty treatments consisting of five moisture levels 100, 95, 90, 85 and 80 % available soil moisture (ASM) and four weed control practices, *viz*. weedy check, isoproturon at 750 g/ha, clodinafop at 60 g/ha and clodinafop at 60 g/ha *fb* 2,4-D at 500 g/ha were laid out in split plot design and replicated four times. Wheat variety '*GW-273*' was sown in the experimental field with seed rate of 100 kg/ha. The soil moisture maintained during the herbicidal application by 6050 X3K1 minitrace kit soil moisture meter after the first irrigation. The crop growth rate (CGR) and net assimilation rate (NAR) was computed between 30-60 DAS interval.

RESULTS

The weed flora in the experimental field was mainly comprised of grassy weeds particularly *Dinebra retroflexa* (30.6%), *Cyperus rotundus* (16.8%) and *Phalaris minor* (8.42 %) and broadleaved weeds *Cichorium intybus* (8.63%) *Medicago hispida* (8.24%), *Alternanthera philoxeroides* (8.01%), *Melilotus indica* (6.14%), *Anagallis arvensis* (4.97%), *Chenopodium album* (4.36%) and *Trifolium fragiferum* (3.76%).

100% available soil moisture at the time of herbicidal application had significantly the lowest dry weight of weeds and highest weed control efficiency and proved significantly superior over 85 and 80% ASM. However, the significant differences in dry weight of weeds and weed control efficiency did not exist among 100, 95 and 90% ASM as well as 85 and 80% ASM. The dry weight of weeds was minimum at 100 % ASM followed by 95 and 90% ASM due to less time period for germination and emergence of weed seedlings. However, every five per cent decrease in moisture level provided more time for weed seeds germination and emergence that mainly contributed towards higher weed dry weight. Imanat (2002) also reported the higher uptake and translocation of herbicides on higher soil moisture content.

Crop growth rate and net assimilation rate decreased with correspondingly decrease in available soil moisture content from 100-80% during both the years of experimentation. 100% ASM had significantly higher CGR and NAR over 85 and 80% ASM and found statistically at par to 95 and 90% ASM during both the years. The apparent influence of weed control treatments was noted on CGR and NAR and both was significantly higher under clodinafop *fb* 2,4-D over isoproturon, clodinafop and weedy check. Application of isoproturon and clodinafop was found equally effective in respect of net assimilation rate during both the years.

The presence of 100% ASM registered significantly higher grain yield of wheat and proved significantly superior over 85 and 80% ASM but found at par with 95 and 90% ASM. In weed control practices, clodinafop *fb* 2,4-D produced significantly higher grain yield (4.97 t/ha) over isoproturon, clodinafop and weedy check. Clodinafop *fb* 2,4-D applied as post emergence showed knockdown effect on grassy and broad leaved weeds, resulted in increased grain yield of wheat.

Table1. Effect of available soil moisture at the time of post emergence herbicides on weeds, crop growth and yield of wheat

Moisture level	Dry weight of weeds (g/m^2)	Weed control efficiency	Crop Growth Rate (g/m2/day)	Net assimilation rate (g/m^2 leaf area/day)
100% ASM	6.54 (44.90)	49.11	16.34	2.56
95% ASM	6.74 (47.13)	45.32	15.86	2.52
90% ASM	6.97 (49.93)	42.40	15.35	2.46
85% ASM	7.27 (53.73)	37.51	14.70	2.38
80% ASM	7.47 (56.95)	33.96	14.30	2.35
LSD (P=0.05)	0.50	8.48	1.04	0.16
Weed control				
Weedy Check	8.57 (73.64)	0.00	12.16	2.22
Isoproturon (750 g/ha)	7.10 (50.27)	32.22	15.87	2.49
Clodinafop (60 g/ha)	7.18 (51.58)	29.43	15.39	2.44
Clodinafop (60 g/ha) *fb* 2,4-D (500 g/ha)	5.13 (26.63)	63.33	17.80	2.68
LSD (P=0.05)	0.38	4.54	0.75	0.12

*Original values are in parentheses

Among interactions, grain yield was significantly higher under all the plots receiving clodinafop *fb* 2, 4-D at different moisture levels being the maximum at 100% ASM (66.91 q/ha) than isoproturon, clodinafop and weedy check. Application of isoproturon and clodinafop was also found equally well at all the ASM levels and proved significantly superior over weedy check.

CONCLUSION

On the basis of results, it can be concluded that application of post emergence herbicides at 90-100 % available soil moisture registered higher growth rate and yield over their application at lower available soil moisture content.

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Evaluation of metsulfuron-methyl + carfentrazone-ethyl against broad-leaf weeds in wheat

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Weed infestation is one of the major constraints in achieving potential yield of wheat. The losses caused by weeds vary depending on the weed species, their abundance, crop management practices and environmental factors. Because of higher cost of labour for manual weeding and its lower efficacy, farmers are relying heavily on herbicides for effective weed control in wheat. As wheat fields are infested with diverse weed flora and combinations of herbicides either as ready mixture or sequential applications are required. However, dependence on herbicides of single mode of action is not advisable as it has contributed to shift towards difficult to control weeds and the rapid evolution of multiple herbicide resistance. It is almost more than a decade, both these solo products (Metsulfuron methyl & Carfentrazone ethyl) is registered in India and extensively used by the framers for control of broad leaf weeds in Wheat. Over a period of time the shift in efficacy level of these solo products and shift in dominance of certain weeds were observed. Due to continuous rely and use of both these product, a shift in tolerance level of certain weeds like *Lathyrus, Convolvulus, Cirsium, Medicago, Solanum nigrum, Fumari, Vicia, Rumex spinosus and Malva* was observed as a result above weeds are difficult to control with solo application of either Metsulfuron methyl or Carfentrazone ethyl. Efficacy of carfentrazone or metsulfuron on weeds like *Lathyrus aphaca, Fumaria parviflora* and *Coronopus didymus* is unsatisfactory when applied alone, but a combination of both would be ideal for increased spectrum of weed control without any adverse effect on crop or environment (Singh *et al.* 2008). The present experiment was conducted to evaluate a ready mixture of metsulfuron methyl 10 % and Carfentrazone 40 % (Ally Express 50% DF) against several weeds in wheat.

METHODOLOGY

A field trial was conducted during *Rabi* seasons of 2012-13 & 2013-14 at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture & Technology, Pantnagar to evaluate the bio-efficacy of (Metsulfuron methyl 10% + Carfentrazone ethyl 40%) 50 DF + 0.2% NIS. Ten treatments comprised with three doses of (Metsulfuron methyl 10% + Carfentrazone ethyl 40%) 50 DF + 0.2% NIS at 22.5, 25 and 30 g/ha and three doses of (Metsulfuron methyl 10% + Carfentrazone ethyl 40%) 50 DF at 22.5, 25 and 30 g/ha as test product and metsulfuron methyl 20% WDG + 0.2% NIS at 4 g/ha, carfentrazone ethyl 40% 40 DF at 20 g/ha and 2,4-D amine salt 58% SL at 750 g/ha, as commercial standards as well as untreated control. Herbicidal treatments were applied as post emergence at 35days

After sowing (2-4 leaf stage of weeds) of the wheat crop. Observation on weed density at 30 and 45 day after application and dry weight of weeds were taken at 30 and 45 days after application. Data on density of individual & total weeds were subjected to square root transformation before statistical analysis. Data on yield contributing characters and grain yield at harvest were recorded for both the years.

RESULTS

The Experimental field was naturally dominated with *Solanum nigrum*, *Rumex spinosus*, *Convolvulus arvensis*, *Vicia sativa*, *Anagallis arvensis* and *Melilotus indica* as broadleaf weeds in the wheat crop. However, negligible density of *Melilotus alba*, *Polygonum plebeium*, *Rumax acetosella*, *Fumaria parviflora*, *Chenopodium album*, *Medicago denticulata* and *Coronopus didymus* were also found in trial plot during both the years of experimentations. Ready mix application of metsulfuron methyl 10% + carfentrazone ethyl 40% 50 DF + 0.2% NIS at 30 g/ha caused highest reduction in the density of *C. arvensis* and *R. spinosus* at all the stages of observations and this treatment was found statistically at par with its lower dose applied at 25 g/ha with 0.2% NIS and 30 g/ha without surfactant. Complete control of *S. nigrum* and *V. sativa* was recorded with the application of this herbicide at 25 and 30 g/ha with surfactant and 30 g/ha without surfactant at 30 and 45 DAA. Among the weed control treatments, application of metsulfuron methyl 10% + carfentrazone ethyl 40% 50 DF at 30 g/ha with 0.2% NIS recorded highest weed control efficiency (98.03 and 98.14), which was followed by with its lower dose applied at 25 g/ha with surfactant and metsulfuron methyl 10% + carfentrazone ethyl 40% 50 DF at 30 g/ha without surfactant. The maximum no. of spikes and grain yield of (5142 & 4950 kg/ha) was recorded in plots treated with metsulfuron methyl 10% + carfentrazone ethyl 40% 50 DF + 0.2% NIS at 30 g/ha being at par with its lower dose *i.e.* 25 g/ha with surfactant and 30 g/ha without surfactant.

Table 1. Effect of metsulfuron methyl 10% + carfentrazone ethyl 40% 50 DF on total weed density, dry weight, weed control efficiency and grain yield of wheat

Treatment	Dose (g/ha)	Total weed dry weight at 30 DAA /m²				Total weed dry weight at 45 DAA /m²				Grain yield (Kg/ha)	
		2012-13	WCE %	2013-14	WCE %	2012-13	WCE%	2013-14	WCE %	2012-13	2013-14
MSM+CZN+ 0.2%NIS	22.5	3.19(9.2)	89.94	3.53 (11.5)	87.20	4.15)16.3)	86.85	4.44 (18.7)	84.67	4698	4611
MSM+CZN+ 0.2%NIS	25	1.95 (2.8)	96.93	2.01 (3.1)	96.55	2.60 (5.8)	95.32	2.19 (3.8)	96.88	5080	4883
MSM+CZN+ 0.2%NIS	30	1.64 (1.8)	98.03	1.52 (1.3)	98.55	1.82 (2.3)	98.14	1.22(0.5)	99.59	5142	4950
MSM+CZN	22.5	3.92 (14.4)	84.26	4.20 (16.7)	81.42	5.01 (24.2)	80.48	5.46 (29.3)	75.98	4670	4447
MSM+CZN	25	3.11 (9.0)	90.16	3.34 (10.2)	88.65	3.72 (12.9)	89.59	4.30 (17.9)	85.32	4890	4685
MSM+CZN	30	2.24 (4.1)	95.51	2.11 (3.5)	96.10	2.91 (8.1)	93.46	2.04(3.2)	97.37	4980	4800
MSM + 0.2%NIS	4	5.75 (32.3)	64.67	5.78 (32.7)	63.62	7.66 (57.8)	53.38	7.75 (59.8)	50.98	4120	3943
CZN	20	4.40 (18.4)	79.89	4.43 (18.7)	79.19	6.09 (36.2)	70.80	6.23 (38.0)	68.85	4290	4194
2,4-D amine salt 58% SL	750	5.78 (32.6)	64.37	5.73 (32.1)	64.29	7.79 (59.8)	51.77	7.82 (60.5)	50.41	4150	3978
Untreated Control	-	9.61 (91.5)	-	9.53 (89.9)	-	11.1 (124.0)	-	11.0 (122.0)	-	2960	2730
CD at 5%		0.64	-	0.51		0.79	-	1.01	84.67	160	153

CONCLUSION

It was concluded that that ready mix application of metsulfuron methyl 10% + carfentrazone ethyl 40% 50 DF + 0.2% NIS at 25 g/ha could be the standard dose for post emergence application in wheat to achieve effective control of broad leaf weeds .

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Yield performance of wheat with different herbicides alone and its mixture

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Wheat [*Triticum aestivum* (L.) emend. Fiori & Paol] is one of the chosen staple foods throughout the world. Wheat is essential for food security and poverty alleviation of our nation. Wheat occupies about 17% of the world's cropped land and contributes 35% of the staple foods so its increased production is essential for food security (Shamsi *et al.* 2006). According to Kumar *et al.* (2013) wheat is also considered as king of cereals and it provides foods to 36% of the global population, contributing 20% of the food calories. Wheat is grown in about 29.25 mha area in the country with the production of 93.90 mt in India whereas in Madhya Pradesh, it is grown in 4.89 mha area with the production of 10.58 million mt (Agricultural Statistics 2013). The estimated food requirement in 2025 is around 300 million tonnes, which can be elevated from present 230.67 mt through judicious application of nutrients (Gill and Singh 2009). Growing paddy-wheat cropping system year after year in the same field under high levels of fertilizer and irrigation has led to development of high infestation of crop with grassy weeds, *viz.* wild canary grass (*Phalaris minor*). Weeds are omnipresent pests that compete with crops for water, nutrients, space, and light; host pests and diseases; and release allelochemicals into the rhizosphere (Khaliq *et al.* 2013, 2014). Gupta *et al.* (2011) was of the opinion that weeds constitute one of the biggest problems in agriculture that not only reduce the yield and quality of wheat crop but also utilize essential nutrients.

METHODOLOGY

A field experiment was conducted during the winter season of 1999, 2000 and 2001 at Jabalpur. The soil of the field was silty clay loam with 7.6 pH, organic carbon content 0.56% and the available N, P and K were in the order of 241.4 kg/ha, 7.6 kg/ha and 384.5 kg/ha, respectively. Pendimethalin, Isoproturon (as pre and post-emergence), 2,4-D alone and in combination with isoproturon + applied in randomized block design. Wheat (cv. Lok-1) crop was sown on 28, 22nd and 26th November using a seed rate of 120 kg/ha during 1999, 2000 and 2001 respectively. Fertilizer and irrigation were applied in accordance with standard local practice.

RESULTS

Predominant weed species that infested the field were *Phalaris minor*, *Avena ludoviciana*, *Chenopodium album* and *Melilotus alba*. Besides *Anagallis arvensis*, *Rumex dentatus*, *Cyperus rotundus*, *Convolvulus arvensis* and *Medicago denticulata* also occurred but their population was scanty. Herbicides, Isoproturon as pre emergence + 2,4-D post emergence when applied were the most potent killer of weeds. It eliminated *Palaris minor* and *Chenopodium album* and gave excellent control of *Avena ludoviciana* and other weed species (Table 1.). Isoproturon + 2,4-D when applied as tank mixture it gave an excellent control of *Palaris minor* and good control over other dicot weeds but failed to bring about noticeable change in *Convolvulus arvensis*.

Table 1. Effect of weed control treatments on weed and yield attributing characters and seed yield (Pooled data of 3 years)

Treatment	Dose (kg/ha)	Weed Population ($0.5m^2$)	Weed Dry weight (g/ $0.5m^2$)	Weed Control efficiency (%)	Productive Tillers ($0.5m^2$)	Ear Length (cm)	Grains/ Ear	Grain Yield t/ha
Weedy Check	-	9.22 (85.8)	7.20 (48.3)	-	75.6	9.81	22.1	2.16
Hand weeding	Weed free	0.0 (15.1)	0.75 (5.03)	86.8	161.0	10.96	32.8	4.25
Pendimethalin (pre-emergence)	1.0	5.3 (27.8)	5.60 (37.6)	22.2	117.3	9.95	27.6	2.63
Isoproturon (pre-emergence)	1.0	4.8 (23.1)	3.83 (25.7)	47.9	129.7	10.24	28.3	3.30
Isoproturon (post-emergence)	1.0	4.8 (23.1)	4.12 (27.5)	42.7	124.5	10.13	28.6	3.13
2,4-D (post-emergence)	0.6	4.6 (21.6)	3.56 (23.9)	50.5	136.8	10.65	29.7	3.54
Tank mixture Isoproturon and 2,4-D (post-emergence)	0.5+0.5	4.3 (17.3)	3.21 (21.5)	55.4	138.5	10.71	29.8	3.76
Isoproturon (pre-emergence) and 2,4-D (post-emergence)	0.5+0.5	2.9 (21.6)	2.03 (13.6)	73.3	152.3	10.82	31.9	4.07
LSD(P=0.05)	-	0.90	-	-	6.7	0.62	3.11	2.66

* Values in parentheses are original ones

It is clear from the data that weed control through chemicals caused significant increase in productive tillers, compared to weedy check (table 1). Hand weeding affected maximum increase and proved statistically superior to herbicidal treatment. Isoproturon (pre-emergence) + 2,4-D (post-emergence) resulted in significant increase in productive tillers than other herbicidal treatments. The next best treatment was isoproturon + 2,4-D when applied as tank mixture (post-emergence), it produced higher number of productive tillers than isoproturon (pre and post emergence), 2,4-D (post emergence) and pendimethalin (pre-emergence). Singh and Malik (1994), Singh *et al.* (1997) and Chopra *et al.* (2001) reported similar findings in respect of tank mixture performance on seed yield.

In three years pooled data weed control treatment resulted in significant increase in ear length, grains/ear etc. Maximum increase occurred under hand weeding which proved significantly superior to herbicide treatments but was found at par to isoproturon + 2,4-D (pre and post emergence). The increase in productive tillers and yield attributes were also reported by Kumar *et al.* (1996) and Singh *et al.* (1997.)

Tank mixture of isoproturon + 2,4-D produced significantly higher grain yield than 2,4-D, isoproturon and pendimethalin. Higher increase under hand weeding, isoproturon and 2,4-D (pre and post emergence) may be assigned to marked increase in productive tillers and noticeable increase in grains/ear owing to effective control of weeds during critical period of crop weed competition. The yield reduction due to uncontrolled weed growth was 49.2%.

CONCLUSION

Isoproturon (pre-emergence) and 2,4-D (post-emergence) at 0.5 kg/ha proved to be significantly superior over other chemicals in respect of WCE and grain yield.

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Weed management in wheat

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Wheat (*Triticum aestivum* L.) is the world's largest famous energy rich cereal crop. It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. It is a C3 plant grown from temperate, irrigated to dry and high-rain-fall areas and from warm, humid to dry, cold environments. Undoubtedly, this wide adaptation has been possible due to the complex nature of the plant's genome, which provides great plasticity to the crop. Wheat has been bred for a wide array of specific end-use quality traits and various adaptive characteristics, resulting in the development of distinct cultivar tailored to specialized end uses and specific production environments. A field experiment was conducted to study the efficiency of different herbicides in wheat. The experiment was laid out in Randomized Block Design with three replications and nine treatments. The data revealed that spraying of sulfosulfuron at 25 g/ha registered significantly lower weed population dry matter of weed than other treatments. The same treatment also registered statistically higher weed control efficiency (80.5%) than rest of the weed control treatments. Among weed control treatments spraying sulfosulfuron at 25 g/ha, recorded statistically higher grain and straw yield of 37.10 q/ha and 4.82 t/ha , respectively. The maximum net returns of Rs. 27005 was recorded with T_5 *i.e.* application of sulfosulfuron at 25 g/ha which was significantly more than rest of the treatment except T_7 *i.e.* application of metribuzin at 175 g/ha and T_2 *i.e.* weed free check, which was found at par with each other. The higher value B: C of 1.91 was obtained with application of sulfosulfuron at 25 g/ha.

Biological efficacy of several active substances against broadleaf weeds in wheat: case of *Veronica* species in *durum* wheat fields

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In Algeria, cereal crops are seriously attacked by weeds, thus limiting production and yield. The continuous use of some herbicides has often resulted in the elimination of some species, in contrast to other species, *Veronica* spp., were strongly adapted to these chemical molecules. Becoming a real pest problem to solve, this has been the objective of this work.

Recognizing this, the present study examined the determination of optimal doses and dates of two herbicides namely Tribenuron-Methyl (Granstar) and Triasulfuron + Dicamba (Zoom) effective for the control of speedwell in fields soft wheat variety Bousselam, trial conducted at the Experimental Station of Sétif ITGC. The results showed a clear dominance *Veronica* spp. (*Veronica herbifolia*, *Veronica persica*) compared to other weeds encountered in the plot namely: *Fumaria officinalis*, *Fumaria densiflora*, *Gallium aparine*, *Papaver rhoeas*, *Diplotapsis muralis*, *Saponaria vaccaria*, *Polygonum aviculaire*. Using the Zoom at a dose of 150 g/ha at 2-4 leaf of *Veronica* spp. showed significant efficacy in their control compared to other doses of the same herbicide (120 and 180 g/ha) and also regarding to the most herbicide (Granstar) used in the region at the doses of 12.5 g/ha and 18 g/ha. This resulted in a gain of 1.29 t/ ha grain yield compared to non-weeded plots and 0.55 t/ha compared to the average of the control.

Major weed flora of wheat (*Triticum aestivum* L.) and its management through post-emergence herbicides in wet-temperate region of Himachal Pradesh

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Wheat is major *Rabi* crop in Himachal Pradesh. But, weeds are the main problem in wheat which cause about 66% reduction in crop yield or even more depending upon the weed densities, type of weed flora and duration of infestation (Angiras *et al.* 2008). In wet-temperate region of Himachal Pradesh, *Phalaris minor*, *Avena ludoviciana*, *Lolium temunlentum* and *Poa annua* are the major grassy weeds; while *Vicia sativa*, *Anagallis arvensis*, *Ranunculus arvensis* and *Coronopus didymus* are the main broad-leaved weeds which grow in association with wheat crop. '*Clodinofop Proprgyl*' is a new post-emergence selective herbicide for control of resistant *Phalaris minor* and *Avena fatua* in wheat (Angiras *et al.* 2008). Thus, an investigation was undertaken to assess its suitability in combination with sequential application of 2,4-D (Na salt) against above complex weed flora of wheat so as to develop some alternative weed management options.

METHODOLOGY

To assess the comparative bio-efficacy of post-emergence herbicides on above complex weed flora of wheat; an '*On-Farm Trial* (OFT)' comprising six treatment combinations [T_1 = Clodinofop at 60 g/ha; T_2 = Clodinofop at 60 g/ha followed by (fb) 2,4-D (Na) at 1.0 kg/ha; T_3 = Isoproturon 75 WP at 1.7 kg/ha; T_4 = Isoproturon 75 WP at 1.0 kg/ha + 2,4-D (Na) at 0.5 kg/ha; T_5 = Hand weeding (3 HW); and T_6 = Unweeded check], was conducted at 10 locations during *Rabi* 2008-09 in wet-temperate region of Mandi district in Himachal Pradesh. Treatments T_1–T_4 were conducted in plot size of 500 m^2 each while T_5–T_6 were conducted in plot size of 100 m^2 each on farmers' fields in above '*On-farm trial (OFT)*' covering a total of 2.2 ha area at 10 locations in Himachal Pradesh. Recommended fertilizer dose for irrigated wheat was 120 kg N + 60 kg P2O5 + 30 kg K2O/ha. The soil of the experimental plots of above OFT was silty-clay loam acid Alfisol.

RESULTS

The results revealed that post-emergence application of isoproturon 75 WP at 1.0 kg/ha + 2,4-D (Na) at 0.5 kg/ha controlled the grassy and broadleaf weeds most effectively with least grassy and broadleaf weed population, highest weed control index and least weed index at 120 DAS among the post-emergence herbicide treatments (Table 1). This treatment was followed by clodinofop at 60 g/ha fb by 2,4-D (Na) at 1.0 kg/ha; isoproturon 75 WP at 1.7 kg/ha; and clodinofop at 60 g/ha w.r.t. weed control index (WCI) with respective values of 74.6, 61.0, 59.4 in current study.

Table 1. **Weed dry matter, weed control index, weed index and grain yield of wheat as influenced by different weed management treatments.**

Treatment	Weed dry matter (g/m^2)	Weed control index (WCI)	Weed index (WI)	Grain yield (t/ha)
T_1 = Clodinofop @ 60 g/ha	68.5	59.4	12.6	3.06
T_2 = Clodinofop @ 60 g/ha fb 2,4-D (Na) @ 1.0 kg/ha	42.8	74.6	5.0	3.32
T_3 = Isoproturon 75 WP @ 1.7 kg/ha	65.8	61.0	10.6	3.13
T_4 = Isoproturon 75 WP @ 1.0 kg/ha + 2,4-D (Na) @ 0.5 kg/ha	36.6	78.3	0.85	3.47
T_5 = Weed free (3 HW)	12.3	92.7	0.0	3.50
T_6 = Unweeded check	168.6	0.0	47.7	1.83

The WCI values followed the trend of T_5>T_4>T_2>T_3>T_1 while the weed index (WI) values followed it as T_4<T_2<T_3< T_1< T_6. Application of isoproturon 75 WP at 1.0 kg/ha + 2,4-D (Na) at 0.5 kg/ha also realized higher grain yield and net returns followed by clodinofop at 60 g/ha fb by 2,4-D (Na) at 1.0 kg/ha having grain yield among herbicide treatments. The wheat grain yield followed the trend of T_5>T_4>T_2>T_3>T_1>T_5. The present investigation also inferred that isoproturon and clodinofop alone are either ineffective or less effective against one or the other category of weeds but in combination with 2,4-D they are quite effective against mixed weed flora in wheat.

CONCLUSION

Overall, post-emergence application of isoproturon 75 WP at 1.0 kg/ha + 2,4-D (Na) at 0.5 kg/ha is still the best weed management technology for grassy and broadleaf weed management and realizing higher productivity and profitability in wheat in Hiimachal Pradesh. However, repeated use of same herbicidal treatment may lead to development of resistant. Hence, clodinofop at 60 g/ha fb 2,4-D (Na) at 1.0 kg/ha seems to be another viable herbicide combination besides isoproturon + 2,4-D (Na) to tackle the problem of complex weed flora in wheat in wet-temperate region of Himachal Pradesh.

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Effect of integrated weed management on weed density and yield of groundnut

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Groundnut (*Arachis hypogaea* L.) is known as the **'*king*'** of oilseeds. It is one of the most important food and cash crop of our country. Presence of weeds in groundnut reduced harvesting efficiency and increased yield losses up to 40% (Clewis *et al*. 2007). It is important to remove weeds in groundnut at 15, 30, 45, 60 days after sowing and upto maturity to maximize yield and net returns (Nambi and Sundari 2008). However, hand weeding method is time consuming, expensive and hence application of herbicides in combination being proved most profitable ground nut production.

METHODOLOGY

A field experiment was conducted during *Kharif* season at College of Agriculture, Raichur, during 2013 to study the integrated weed management in *Kharif* groundnut under irrigated conditions. The soil of the experimental site was red having sandy loam in texture. R-2001-2 is a long duration (115 to 130 days) bunch type variety also called as Vijetha, a high yielding (2.50-3.00 t/ha) and it was resistant to important diseases like groundnut leaf spot and was sown with recommended package of practice. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at 25 kg N, 75 kg P_2O_5 and 25 kg K_2O/ ha, respectively. There were 10 treatment combinations comprising of one pre-emergence herbicide and two post - emergence herbicides compared with weed free check and weedy check laid out in randomized block design with three replications.

RESULTS

Among weed control treatments weed free check recorded significantly minimum total weed count and maximum higher pod yield and shelling per cent. However, pendimethalin *fb* imazethapyr fb one intercultivation at 35 DAS, pendimethalin *fb* 2 intercultivation at 25 and 35 DAS and pendimethalin *fb* quizalofop-ethyl at 20-25 DAS *fb* one intercultivation at 35 DAS were the best possible combination of herbicides to minimize weed density over crop growth period resulting in increased pod yield and shelling per cent. Further lowest pod yield was recorded in weedy check due to uncontrolled growth of weeds compared to weed free check as indicated by weed index of 60%. Herbicidal treatments resulted in considerably lower cost of cultivation compared with hand weeding. The B:C ratio was found maximum with weed free check followed bypendimethalin *fb* 2 intercultivation at 25 and 35 DAS.

Table 1. Weed growth, yield and economics of groundnut as influenced by weed control treatments

Treatments	Total weed count (no./ m^2)	WCE (%)	WI (%)	Pod yield (kg/ha)	Shelling (%)	B:C ratio
Pendimethalin (38.7% EC) 1000 g./ha *fb* 2 intercultivation at 25 and 35 DAS	2.11 (127.67)	36.93	15.23	2099	67.67	3.14
Imazethapyr (10% SL) 75 g/ ha at 20-25 DAS	2.31 (204.67)	53.02	12.07	1523	59.00	2.46
Quizalofop-ethyl (5% EC) 45 g./ha at 20-25 DAS	2.34 (218.67)	60.48	9.74	1207	57.67	2.08
Imazethapyr (10% SL) 75 g/ha + quizalofop-ethyl (5% EC) 45 g/ha at 20-25 DAS	2.31 (204.67)	21.43	19.48	974	52.00	1.63
Pendimethalin (38.7% EC) 1000 g/ha *fb* imazethapyr (10% SL) 75 g/ha at 20-25 DAS	2.26 (180.87)	23.96	19.06	1948	64.67	2.92
Pendimethalin (38.7% EC) 1000 g./ha *fb* quizalofop–ethyl (5% EC) 45 g/ha at 20-25 DAS	2.21 (160.47)	12.37	21.81	1906	63.67	2.91
Pendimethalin (38.7% EC) 1000 g/ ha *fb* imazethapyr (10% SL) 75 g/ha *fb* 1 intercultivation at 35 DAS	2.02 (105.27)	18.42	20.30	2181	68.33	3.17
Pendimethalin (38.7% EC) @ 1000 g/ ha *fb* quizalofop-ethyl (5% EC) 45 g/ha at 20-25 DAS *fb* 1 intercultivation at 35 DAS	2.18 (149.33)	0.00	25.05	2030	64.67	3.01
Weed free check (interculture at 15, 30 and 40 days after sowing) + 1 hand weeding at 25 DAS	1.80 (68.07)	65.31	8.50	2505	71.33	3.52
Weedy check	2.44 (272.40)	7.03	1.85	850	41.67	1.51
S.E m±	0.06	--	--	185	--	0.23
CD at 5%	0.17			540		0.66

*Values in parentheses are original. Data transformed to square root transformation

CONCLUSION

It was concluded that combination of herbicides were equally effective in reducing weed density and attained maximum yield as compared to farmers practice.

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Integrated weed management in groundnut

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Groundnut is an important oil seed crop of India which is cultivated in nearly 6 million ha area with the production of 7.5 mt and average productivity of 1.27 t/ha. Though India ranks first in the world under groundnut area and there is need to import 8.03 mt of edible oil

(Kalhapure *et al*. 2013). This is due to lower productivity. Weeds are the major cause of minimizing production and yield losses in groundnut to an extent of 13-80% (Gosh *et al*. 2000). For groundnut, there should be a weed free condition up to 40 DAS otherwise the reduction in growth and yield can't be compensated at later stage due to severe weed infestation. Thus a field experiment is being formulated to evaluate suitable integrated weed management practices for increasing weed control efficiency and reducing labour usage in groundnut production.

METHODOLOGY

Field experiment has been conducted on integrated weed management practices at Agricultural Research station, Vaigaidam during *Rabi'*2011-12. The soil of the experimental field was pH (6.5), available N (242 kg/ha), P_2O_5 (11 kg/ha) and K_2O(335 kg/ha). Treatments consisted of pre-emergence application of pendimethalin at 0.75 kg/ha, alachlor at 1.0 kg a.i./ha and oxyfluorfen at 1.0 kg/ha followed by hand weeding on 20 DAS. To control late emerging weeds after 45 DAS layby application of pendimethalin at 1.0 kg/ha and oxyfluorfen at 0.25 kg/ha has been taken up since hand weeding is impossible due to peg penetration at later stage. The experiment was laid out in randomized block design with three replications. Groundnut variety '*TMV-7*' was chosen. Crop was fertilized with 25:50:75 kg NPK ha under surface irrigation. Herbicides were applied using manually operated knapsack sprayer fitted with flat fan nozzle using spray volume of 600 l/ha as per the technical programme. Weed density were recorded at regular intervals of 10, 25, 40 and 60 DAS.

RESULTS

Predominant weeds identified in the experiment were *Chloris barbata, Panicum repens* and *Dactyloctenium ageyptium* among grasses. Among the sedges, *Cyperus rotundus* and *Cyperus esculentus* are predominant. Major broad leaved weeds are *Celosia argentia, Trianthema portulacastrum, Tridax procumbens , Euphorbia geniculata, Digera arvensis, Parthenium hysterophorus, Portulaca oleraceae, Phyllanthus niruri* and *Phyllanthus medraspatensis*.

Table 1. Total weed density, weed control efficiency, yield and economics in groundnut as influenced by different weed management practices

Treatment	Total weed density (no./m^2) on 40 DAS	Weed control efficiency (%) at 40 DAS	Weed control efficiency (%) at 60 DAS	Number of pods /plant	Seed pod yield (kg/ha)	B:C
T_1- PE alachlor at 1.0 kg/ha (sand application) + HW 20 DAS	3.83 (12.7)	88.5	92.6	22	1489	2.50
T_2 - PE alachlor at 1.0 kg/ha + HW 20 DAS	3.42 (9.7)	94.6	94.1	38	1856	3.81
T_3 -PE pendimethalin at 0.75 kg/ha + HW 20 DAS	3.42 (9.7)	95.4	94.3	37	1830	3.63
T_4 -Lay by pendimethalin at 0.75 kg/ha + 0.75 kg/ha after earthing up on 45 DAS	3.27 (8.7)	95.4	98.7	36	1829	3.65
T_5 - PE oxyfluorfen at 0.25 kg/ha + HW on 20 DAS	2.31 (3.3)	97.2	96.8	39	1932	3.85
T_6 - Layby oxyfluorfen at 0.25kg/ha + 0.25 kg/ha after earthing up on 45 DAS	3.06 (7.3)	93.6	97.2	13	978	1.97
T_7 - PE pendimethalin at 0.75 kg/ha + EPOE quizalofop ethyl at 0.25 kg/ha on 20 DAS	4.32 (16.7)	89.2	92.1	22	1279	2.60
T_8 - Hand weeding twice at 15 and 30 DAS	4.28 (16.3)	84.1	88.8	38	1845	2.75
T_9 - Un weeded control	7.57 (55.3)	94.6	91.9	8	927	2.08
LSD (P=0.05)	0.8			9	349	

*Figures in parenthesis are original values. Mention the type of transformation followed.

Total weed density was significantly lowered with pre – emergence application of oxyfluorfen at 0.25 kg/ha followed by hand weeding and layby application of oxyfluorfen at 0.25 kg/ha on 3 DAS and 45 DAS after earthing up over all other treatments. This might be due to consistent control on weeds. Sedge weed density was significantly lowered with pre-emergence application of oxyfluorfen at 0.25 kg/ha on 3 DAS. Weed control efficiency was higher with pre-emergence application of oxyfluorfen at 0.25 kg/ha followed by hand weeding on 20 DAS and pendimethalin at 0.75 kg/ha followed by a hand weeding on 20 DAS at different intervals 10,25,40 and 60 DAS.

Number of pods per plant and seed pod yield was significantly higher with pre-emergence application of pendimethalin at 0.75 kg/ha, alachlor 1.0 kg/ha (hand sprayer) and oxyfluorfen at 0.25 kg/ha followed by hand weeding on 20 DAS . Layby application of pendimethalin at 0.75 kg/ha on 3 and 45 DAS after earthing up is also on par with pre-emergence herbicide followed by hand weeding . This might be due to lesser weed density observed at early crop stage and their consistent control over weeds at later stage. Phytotoxicity symptoms has been observed with layby application of oxyfluorfen at 0.25 kg/ha on 45 DAS after earthing up and crop completely recovered on 7 days after herbicide application (DAHA) and this reflected on lower yield even if this treatment has recorded lesser weed density.

CONCLUSION

Pre-emergence application of oxyfluorfen at 0.25 kg/ha followed by hand weeding on 20 DAS has recorded higher weed control efficiency, yield and economics over other treatments. Phytotoxicity symptoms has been observed with layby application of oxyfluorfen at 0.25 kg/ha on 45 DAS after earthing up and even though groundnut crop recovered from phytotoxicity symptoms at 7 DAHA, but resulted in lower seed pod yield.

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Effect of sulfentrazone in combination with other herbicides against complex weed flora in soybean

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It is very difficult to control a complex weed flora including grasses, sedges and broadleaf weeds in soybean especially under rainfed upland condition with one herbicide or any other single mean.

METHODOLOGY

To test the feasibility of sulfentrazone with other herbicide and cultural practices, a field experiment was conducted during *Kharif* seasons of 2013 and 2014 at the Research Cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was laid out in Randomized Block Design, comprising four replication and eleven treatments which included Sulfentrazone 48 % F 300 g/ha as pre-emergence (T_1), Sulfentrazone 48 % F 360 g/ha as pre- emergence (T_2), Pendimethalin 30 EC 1.0 kg/ha as pre-emergence (T_3), Sulfentrazone 48 % F 300 g/ha as pre - emergence + Imazethapyr 10 SL as Post-emergence (T_4), Sulfentrazone 48 % F 300 g/ha as pre -emergence + one hand weeding (T_5), Imazethapyr 10 SL at 100 g/ha as PoE(T_6), Metribuzin 70 WP at 750 g/ha as PE (T_7), Odyssey (imazethapyr 35% + imazamox 35%) 70 WG at 100 g/ha as PE (T_8), Sulfentrazone 48 % F 300 g/ha as pre -emergence + hoeing (T_9), hand weeding twice at 20 and 40 DAS (T_{10}) and untreated control (T_{11}).

RESULTS

Results revealed that hand weeding twice at 20 and 40 DAS proved to be best in enhancing number of pods/plant, which was found similar to sulfentrazone at 300 g/ha as PE + imazethapyr at 100 g/ha as PoE *fb* sulfentrazone at 360 g/ha as PE. Hand weeding twice at 20 and 40 DAS, produced the maximum seed yield and stover yield, which was significantly superior to rest of the treatments but it was found at par with sulfentrazone at 300 g/ha as PE and sulfentrazone at 360 g/ha as PE and sulfentrazone at 300 g/ha as PE + imazethapyr at 100 g/ha as PoE, Significantly minimum density of total weeds was recorded under hand weeding twice at 20 and 40 DAS. Highest weed control efficiency noted under treatment hand weeding twice at 20 and 40 DAS. Minimum weed index was registered under sulfentrazone at 360 g/ha as PE and sulfentrazone at 300 g/ha as PE + imazethapyr at 100 g/ha as PoE.

CONCLUSION

Use of sulfentrazone at 360 g/ha as pre-emergence (PE) and sulfentrazone at 300 g/ha as PE *fb* imazethapyr at 100 g/ha as post-emergence gave good control of weeds and resulted in yields similar to farmers' practice of hand weeding.

Evaluation different weed control methods in sunflower

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Weeds compete more during *Kharif* season. During *Kharif*, sowing is undertaken with commencement of monsoon. At the same time, number of weeds comes up simultaneously with the emergence of crop seeding. Unchecked weeds cause 33-63% losses in seed yield of sunflower (Saraswat *et al.* 2003). Recently some new low dose, high potent and broad spectrum herbicide like chlorimuron ethyl, imazethapyr and quizalofop ethyl have been developed and extensively used as pre and early post emergence in crops like soybean which is major *Kharif* oilseed crop. Information on the suitability of these herbicides in sunflower crop is lacking. Moreover, in situations where sunflower is raised in soybean based systems, sunflower response to the aforesaid recent herbicides needs to be ascertained.

METHODOLOGY

A field experiment on growth and yield of sunflower as influenced by chemical and non-chemicalweed management practices was carried out to study the weed control efficiency and the economic feasibility of chemical and non-chemical weed management and Integrated Weed Management practices at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the 2005-06 *Kharif* season. The experiment was laid out in Randomised Block Design with three replications and twelve treatments.

RESULTS

In the experimental field, predominant weed species were *Lagascea mollis*, *Euhorbia geniculate*, *Digera arvensis*, *Parthenium hysterophorus*, *Amaranthas viridis* among dicot weeds; *Commelina benghalensis*, *Echinochloa crusgalli*, *Cynodon dactylon* among grasses and sedge *Cyperrus rotundus*. Two hoeings and two hand weedingsrecorded lowest weed dry matter productionwhich was at par with application of imazethapyr PE 1 HW at 40 DAS 1 H + 1 HW at 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest, 1 H + 1 HW at 30 at DAS with crop residue as surface mulch and application of chlorimuron ethyl PE 75.0 t/ha *fb*1 H + 1HW at 40 DAS followed by application of pendimethalin PRE 1.0 kg t/ha *fb* 1 HW + 9.0 t/ha *fb* 1 H + 1 HW 40 at DAS. Two hoeings + two hand weedings recorded over all maximum weed control efficiency. However, season long suppression of weeds was found with non-chemical weed management through 1 Hoeing + 1 Hand weeding 20 DAS in paired row planting + smoother intercrop (green gram) with straw retained as surface mulch after harvest (Table 1).

Two hoeings + two hand weedings recorded significantly highest seed yield (0.91 t/ha) which was statistically equivalent to non-chemical treatments 1 H + 1 HW at 30 DAS with mulching of weed biomass and 1 H + 1 HW at 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest. However, it was at par with application of pendimethalin PRE 1.0 kg/ha *fb* 1 H + 1 HW at 40 DAS and non-chemical weed management treatment1 H + 1 HW at 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest. Additional 0.18 t/ha grain yield of green gram obtained from non-chemical weed management through 1 Hoeing + 1Hand weeding at 20 DAS in paired row planting + smoother intercrop (green gram) with straw retained as surface mulch after harvest due to which it recorded highest GMR (‘. 18033/ha) and net profit (‘10306 /ha) followed 2 H + 2 Hand weeding at 20 and 40 DAS, imazethapyr PRE 75.0 t/ha *fb*1 H + 1 HW 40 DAS and 1 H + 1 HW at 30 DAS with crop residue as surface mulch. The results are in conformity with Anonymous, (2005) in cotton crop.

Table 1. Weed index, Weed control efficiency, yield of sunflower and benefit cost ratio as influenced by different weed control treatments.

Treatment	Weed Dry weight gm^{-2} at harvest	WI (%)	WCE (%)	Seed yield (qha^{-1})	GMR (`.ha^{-1})	NMR (`.ha^{-1})	B:C ratio
T1-Weedy check	340.8	59.52	-	3.72	6995	1464	1.26
T2-Pendimethalin PRE 1.0 kg ha^{-1}	143.5	34.05	57.89	6.06	10909	3791	1.53
T3-Imazethapyr PRE 75.0 g ha^{-1}	148.1	37.54	57.53	5.74	10443	3309	1.46
T4-Chlorimuron ethyl PRE 9.0 g ha^{-1}	160.0	52.44	53.05	4.37	8060	1561	1.24
T5-Pendimethalin PRE 1.0 kg ha^{-1} fb1 H + 1HW 40 DAS	60.0	14.36	82.39	7.87	14031	5779	1.70
T6-Imazethapyr PRE 75.0 g ha^{-1} *fb*1 H + 1HW 40 DAS	47.3	7.72	86.12	8.48	15065	6797	1.82
T7-Chlorimuron ethyl PRE 9.0 g ha^{-1} *fb*1 H + 1HW 40 DAS	67.7	41.24	80.13	5.40	9731	2098	1.27
T8-Quizalofop-p-ethyl POE 50.0 g ha^{-1} 20 DAS *fb*1 H + 1HW 40 DAS	97.0	27.85	71.54	6.63	11934	3741	1.45
T9-1 H + 1HW 30 DAS with mulching of weed biomass	79.7	17.19	76.62	7.61	13517	6382	1.89
T10-1 H + 1HW 30 DAS with crop residue as surface mulch	71.3	11.09	79.06	8.17	14500	6647	1.84
T11-1 H + 1HW 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest	61.5	23.39	81.95	7.04	18033	10306	2.33
T12-2 H + 2 Hand weeding at 20 and 40 DAS	33.6	--	90.12	9.19	16158	8359	2.07
SE (m)±	0.35			0.51			
CD (P=0.05)	1.04			1.52			

CONCLUSION

Two hoeings + two hand weedings recorded over all maximum weed control efficiency and highest seed yield (0.91 t/ha). However, season long suppression of weeds was found with non-chemical weed management through 1 Hoeing + 1 Hand weeding at 20 DAS in paired row planting + smoother intercrop (green gram) with straw retained as surface mulch after harvest. Efficiency and increased GMR (‘ 18033 /ha) and NMR (‘10306 /ha) through bonus intercrop yield caused higher benefit cost ratio (2.33).

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Studies on integrated weed management in soybean

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Soybean is the most important and valuable oil seed crop in Central Vidarbha Zone. Weed infestation in soybean is considered to be one of the major obstacles in its successful cultivation. Recently imazethapyr as a selective early post emergence herbicide has been developed for control of grassy as well as broad leaf weeds in soybean crop. The present study was undertaken to study the efficacy of different herbicides alone and in combination with cultural methods of weed management in Soybean.

METHODOLOGY

A field experiment was carried out during *Kharif* season of 2007-08, 2008-09 and 2009-10 for three years at Zonal Agriculture Research Station, Yavatmal (M.S.) in Randomized Block Design with 10 treatment combinations of weedicides and cultural methods on variety '*JS-335*'. Data on Population of weeds, dry matter accumulation of weed, weed control efficiency, yield performance and economics were recorded.

RESULTS

From the pooled data (Table 1) all the weed control treatments significantly reduced the population of weed at 45 and 90 DAS as compared with weedy check. At 45 DAS post emergence application of imazethapyr at 75 g/ha + one hoeing at 25 DAS (T_6) recorded significantly least number of weeds next to weed free treatment (T_9). Integrated treatment T_8 (post emergence application of fenaxoprop- P-ethyl at 75 g/ha + chlorimuron ethyl at 10 g/ha at 10 DAS + one hoeing at 25 DAS) was the next best treatment after $T_{6,}$ but treatment T_8 was at par with treatment T_7 (*i.e.* post emergence application chlorimuron ethyl at 10 g/ha at 10 DAS + one hoeing at 25 DAS) and T_2 (*i.e.* post emergence application imazethapyr at 75 g/ha). Similar trend was noticed at 90 days after sowing.Similar results were reported byKundu *et al.* 2011 and Tiwari *et al.* 2007. The dry matter production of weeds wassignificantlyreduced by post emergence application of imazethapyr at 75 g/ha + one hoeing at 25 DAS (T_6) next to weed free treatment (T_9). Highest weed control efficiency next to weed free treatment (T_9) was recorded by integrated treatment in which post emergence application of imazethapyr at 75 g/ha + one hoeing at 25 DAS (T_6) *i.e.* 79.71 and 73.8% at 45 and 90 DAS, respectively and it was followed by treatment $T_{8,}$ $T_{2,}$ $T_{7,}$ $T_{4,}$ $T_{5,}$ T_3 and $T_{1.}$

Weed free check (T_9) recorded significantly more seed yield (1.719 t/ha) as compared to all other treatments. However, integrated treatment (T_6) *i.e.* post emergence application of Imazethapyr at 75 g/ha+ one hoeing at 25 DAS (1.506 t/ha) was the next best treatment but it was statistically equal in effect with treatment Fenaxoprop- P-ethyl at 75 g/ha + Chlorimuron ethyl at 10 g/ha+ one hoeing at 25 DAS) that produced 1.476 t/ha.These results are similar to those reported by Shete *et al.* 2007.

Weed free check (T_9) produced significantly highest straw yield (3.16 t/ha) followed by treatment $T_{8,}$ but treatment $T_{8,}$ T_6 and T_7 were statistically equal in effect and produced 2.75, 2.75 and 2.50 t/ha straw yield respectively. The least straw yield was recorded by weedy control treatment (T_{10}). Highest gross monetary returns (Rs.42589 /ha) and net monetary returns ('.23241/ha) were obtained in treatment weed free check (T_9) followed by integrated treatments T_6 and T_8 thesetreatments were at par and obtained '.37205 /ha and '.35594 /ha GMR and '.19250 /ha and '.17501 /ha NMR respectively. These results are inmatch withthose of Kushwah and Vyas, 2006. However the higher B:C ratio (2.20) was obtained in treatment of weed free check (T_9) followed by treatments $T_{6,}$ and T_7 *i.e.* 2.07 and 1.98 respectively.

Table 1. Population of weeds, Dry Matter accumulation of weed (g/m²), Weed control efficiency, Seedyield and economics as influenced by different weed control treatments. (Pooled mean of three years)

Treatment	No. of weeds/m²		Dry weight of weeds (g/m²)		Weed control efficiency (%)		Seed yield	Gross monetary returns (`/ha)
	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS	(kg/ ha)	23488
T_1	7.90 (61.00)	8.39 (70.22)	9.77 (95.55)	11.41 (130.66)	36.14	30.63	948	32774
T_2	6.07 (36.78)	6.52 (42.55)	7.88 (58.99)	9.25 (85.44)	60.53	54.59	1326	26884
T_3	7.36 (54.00)	8.33 (69.33)	9.08 (85.22)	11.02 (121.33)	42.93	35.60	1081	31390
T_4	6.41 (40.77)	7.36 (55.44)	8.22 (67.44)	9.72 (94.11)	54.95	50.07	1269	31781
T_5	6.33 (41.89)	6.97 (48.44)	7.94 (67.33)	10.02 (100.12)	54.98	46.89	1238	37205
T_6	4.32 (18.59)	5.73 (32.58)	5.50 (30.33)	7.03 (49.11)	79.71	73.82	1506	33990
T_7	5.88 (34.44)	6.64 (43.70)	7.52 (59.11)	9.06 (82.11)	60.52	56.42	1374	35594
T_8	5.28 (27.62)	5.94 (35.40)	7.01 (49.22)	8.67 (75.55)	67.10	60.01	1476	42589
T_9	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.00	100.00	1719	15218
T_{10}	10.13 (102.67)	13.04 (169.67)	12.25 (149.77)	13.74 (188.78)	----	--	608	699
LSD (P=0.05)	0.87	0.58	1.41	1.11	--	--	80	5918

Data transformed Öx+0.5, Figures in parentheses are original values; **PPI** – Pre plant soil incorporation**, POE** – Post emergence 15 DAS**, H**– Hoeing, **DAS –** Days after sowing

CONCLUSION

Weed free check (T_9) provided most effective control of weeds resulted in higher seed yield, GMR, NMR and B:C ratio. Among the remaining treatments, the treatment post emergence application of imazethapyr at 75 g/ha+ one hoeing at 25 DAS was the next best treatment. However, this treatment were statistically equal in effect with post emergence application of fenaxoprop-p-ethyl at 75 g/ha + chlorimuron ethyl at 10 g/ha+ one hoeing at 25 DAS.

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Efficacy of sequential application of herbicides for weed control in sunflower

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Sunflower [*Helianthus annuus* L.] is one of the most important oilseed crops in India and it ranks third after soybean and groundnut as a source of edible oil. One of the major constraints in sunflower production is weed competition. The weeds are the major threat resulting in a seed yield loss upto 45-55% (Wanjari *et al*. 2001). The conventional methods of weed control are labour intensive and expensive. Keeping this in view, the present research work was carried out with the objective to evaluate efficacy of different pre- and post-emergence herbicides for efficient weed control in sunflower.

METHODOLOGY

The field experiment was conducted during *Kharif* 2013 at Acharya N. G. Ranga Agricultural University. Sunflower hybrid '*DRSH-1*' was used as test crop. The experiment was laid out in a randomized block design with thirteen treatments. A uniform dose of 60-40-30 kg /ha N-P_2O_5-K_2O in the form of urea, single super phosphate and muriate of potash, respectively were applied. Data on weed growth, yield performance and economics were recorded.

RESULTS

Effect on weeds

Weed density, weed dry matter and weed control efficiency differed significantly with the different weed management practices. At 30 DAS, application of oxyfluorfen at 150 g/ha as PE *fb* hand weeding at 25 DAS was found effective in limiting weed growth by recording significantly lower weed density, weed dry matter of grasses, sedges and broadleaved weeds and higher weed control efficiency and it was on par with pendimethalin at 580 g/ ha as PE *fb* hand weeding at 25 DAS, pendimethalin at 580 g/ ha as PE *fb* paraquat at 600 g/ ha as PoE at 15-20 DAS and oxyflourfen at 150 g/ha as PE *fb* paraquat at 600 g/ ha as PoE at 15-20 DAS compared to weedy check. This might be due to the removal of weeds that emerged at later stages of crop growth by hand weeding or application post-emergence herbicides at 20 days after sowing.

Effect on crop

Significantly highest seed and stalk yields were recorded with weed free condition and it was on par with hand weeding twice at 20 and 40 DAS, application of oxyfluorfen at 150 g/ ha as PE with one hand weeding at 25 DAS, whereas the lower seed and stalk yields were recorded with weedy check. The late hand weeding increased the aeration and enhanced root growth of crop. This might have augmented the absorption of nutrient and moisture from the soil resulting in higher yield. It might be due to control of weeds from the initial growth stage of sunflower, as appeared from drastic reduction in density and dry matter of weeds in weed free condition, which helped in better growth of the crop resulting in significant seed yield of sunflower (Singh and Singh 2006).

Table 1. Weed growth, yield and economics of sunflower as influenced by different weed control treatments.

Treatment	Weed density (no. /m^2)	weed dry matter (g/ m^2)	Weed control efficiency (%)	Seed yield (kg/ ha)	B:C ratio
Pendimethalin at 580 g/ha as PE	5.05 (25.00)	3.16 (10.21)	67.2	914	1.5
Oxyflourfen at 150 g/ha as PE	4.53 (20.10)	2.74 (7.10)	75.9	1021	1.7
Pendimethalin at 580 g/ha as PE + HW at 25 DAS	1.86 (3.00)	1.38 (1.40)	95.9	1555	2.1
Oxyflourfen at 150 g/ha as PE + HW at 25 DAS	1.86 (3.00)	1.30 (1.20)	95.3	1697	2.3
Pendimethalin at 580 g/ha as PE + quizalofop at 50 g/ha as PoE at 15-20 DAS	4.74 (22.00)	2.92 (8.10)	72.4	1281	2.0
Oxyflourfen at 150 g/ha as PE + quizalofop at 50 g/ha as PoE at 15-20 DAS	4.06 (16.00)	2.35 (5.01)	82.8	1340	2.1
Pendimethalin at 580 g/ha as PE + fenoxaprop-p-ethyl at 56.25 g/ ha as PoE at 15-20 DAS	4.85 (23.00)	3.08 (9.02)	69.0	1243	2.0
Oxyflourfen at 150 g/ha as PE + fenoxaprop-p-ethyl at 56.25 g/ha as PoE at 15-20 DAS	4.18 (17.00)	2.56 (6.04)	79.2	1264	2.1
Pendimethalinat 580 g/ha as PE + paraquat at 600 g/ha as PoE at 15-20 DAS	2.48 (5.67)	1.41 (1.50)	94.8	1490	2.1
Oxyflourfen at 150 g/ha as PE + paraquat at 600 g/ha as PoE at 15-20 DAS	2.42 (5.37)	1.41 (1.50)	94.8	1493	2.3
Hand weeding at 20 and 40 DAS	3.24 (10.00)	1.58 (2.00)	86.2	1757	2.1
Weed free	3.89 (14.7)	2.12 (4.01)	93.1	1840	1.9
Control (weedy check)	8.03 (64.00)	5.43 (29.04)	0	625	1.1
LSD (P=0.05)	0.72	0.67		154	

PE: pre-emergence, POE: post-emergence, DAS: Days after sowing, HW: Hand weeding;

Figures in the parenthesis are original values subjected to sqrt(x+1) transformation.

CONCLUSION

Application of oxyfluorfen at 150 g/ha as PE with one hand weeding at 25 DAS resulted in less weed population ,higher seed yield of sunflower and B:C ratio than other treatments.

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Evaluation of pre- and post-emergence herbicides in castor

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Castor (*Ricinus communis*) is an important non- edible oilseed crop of India, having immense industrial and commercial value. India is the world leader in castor production followed by China and Brazil. Castor plant is very sensitive to competition with weedy plants. Weeds are able to grow quickly because of slow initial growth of castor. Chlorimuron ethyl herbicide is selective to castor plants when applied as post-emergence (Sofiatti *et al*. 2012) and this ALS inhibiting herbicide is commonly used only in soybean. Hence the present investigation has been carried out to evaluate post-emergence herbicides namely chlorimuron ethyl and quizalofop ethyl in castor and in comparison with hand weeding and power operated weeding.

METHODOLOGY

Field experiment has been conducted at farmers' field of Yethapur Salem to evaluate suitable integrated weed management practices for improving productivity and profitability in castor hybrid under irrigated condition during *Rabi 2013*. Experimental field is clayey in texture. YRCH 1 castor hybrid has been raised at a plant spacing of 1.2 m x1.2 m. Plot size is 7.2 m x 7.2 m. Fertilizers were applied at the rate of 90 : 45 : 45 NPK kg/ha.

Treatments consists of PE application of pendimethalin followed by hand weeding twice on 20 and 40 DAS, quizalofop ethyl at 0.05 kg/ha on 20 DAS, cholrimuron ethyl at 0.01 kg/ha at 20 DAS and mechanical weeding twice on 20 and 40 DAS. To test the individual efficiency post-emergence herbicides and power operated weeding has been compared with hand weeding twice on 20 and 40 DAS and unweeded check. Nine treatments raised in Randomized Block Design were replicated thrice. Pre - calibrated quantity of herbicides has been applied per plot using knapsack sprayer fitted with flat fan nozzle as per the technical programme. Pendimethalin at 1.0 kg/ha has been applied on 3 DAS and respective early post-emergence herbicides namely quizalofop ethyl at 0.05 kg/ha and chlorimuron ethyl at 0.01 kg/ha has been applied on 2 - 4 leaf stage of weeds

RESULTS

Pre emergence application of pendimethalin at 1.0 kg/ha followed by mechanical weeding twice at 20 and 40 DAS has recorded lower weed density with higher weed control efficiency (84 and 81%) at 30 and 60 DAS. This treatment was followed by pre-emergence application of pendimethalin at 1.0 kg/ha followed by hand weeding twice at 20 and 40 DAS (82 & 80%).

There was no significant difference among different weed management practices on number of nodes to primary raceme and as well as number of spikes. Unweeded control recorded significantly lesser seed yield compared to all other treatments. Among weed management practices, mechanical weeding twice (2.58 t/ha), pre-emergence application of pendimethalin followed by mechanical weeding (2.56 t/ha) and post-emergence application of chlorimuron ethyl at 0.01 kg/ha (2.47 t/ha) recorded numerically higher yield. Post-emergence application of chlorimuron ethyl has recorded higher yield over quizalofop ethyl since the major weeds observed were broad leaved weeds. Mechanical weeding twice (4.4) and application of chlorimuron ethyl alone (4.4) has recorded higher benefit cost ratio due to lesser cost of cultivation as well as higher yield over other treatments.

Table 1. Effect of weed management practices on WCE (%), yield attribute, yield and economics in castor

Treatment	Weed control efficiency (%)		Number of spikes/plant	Seed yield (kg/ha)	Additional cost on weeding (`./ha)	B:C ratio
	30 DAS	60 DAS				
PE pendimethalin at 1.0 kg/ha+ HW twice on 20 and 40 DAS	82	80	14	2371	11,267	2.9
PE pendimethalin at 1.0 kg/ha + quizalofop ethyl at 0.05 kg/ ha on 20 DAS	54	50	14	2279	5977	3.4
PE pendimethalin at 1.0 kg/ha + chlorimuron ethyl at 0.01 kg/ha at 20 DAS	75	67	17	2474	5102	3.9
Quizalofop ethyl alone at 0.05kg/ha on 20 DAS	37	33	13	2199	2600	3.8
Chlorimuron ethyl alone at 0.01 kg/ha at 20 DAS	52	56	16	2434	1600	4.4
Pendimethalin at 1.0 kg/ha + mechanical weeding twice	84	81	15	2567	6348	3.9
Mechanical weeding twice	77	71	13	2582	2952	4.4
Hand weeding twice	78	71	14	2457	8250	3.4
Unweeded check	-	-	11	1533	0	3.0
SEd			2.4	234		
CD (p=0.05)			NS	497		

CONCLUSION

Mechanical weeding twice (2582 kg/ha), pre-emergence application of pendimethalin at 1.0 kg/ha followed by mechanical weeding (2.56 t/ha) and post-emergence application of chlorimuron ethyl at 0.01 kg/ha (2.47 t/ha) have recorded higher yield and benefit cost ratio.

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Influence of cultivars and plant populations on weed growth in early *kharif* groundnut

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Groundnut (*Arachis hypogaea* L.) is mostly cultivated as a rainfed crop during *kharif* and as irrigated crop during *Rabi* and summer in South India. The productivity of *Kharif* groundnut is very low due to aberrations in the rainfall. Sowing of early *Kharif* groundnut from second fortnight of April to first fort night of May in sandy and sandy loam soils under irrigation is the common practice among the groundnut farmers in Southern Agroclimatic Zone of Andhra Pradesh. The crop is experienced heavy weed infestation due to monsoon rains. Varieties differ not only in their production potential, but also differ in competitive ability with weeds. Difference in crop geometry also imparts competitive ability of crop plants with weeds (Singh and Bhan 2002). Therefore, the present investigation was carried out to study the influence of cultivars and plant populations on weed growth in early *kharif* groundnut.

METHODOLOGY

A field experiment was conducted in sandy loam soil at Sri Venkateswara Agricultural College, Tirupati, Andhra Pradesh during early *Kharif*, 2013 to study the influence of cultivars and plant populations on weed growth in a randomized block design with factorial concept. The experiment consisted of four groundnut varieties viz., *Abhaya*, *TAG-24*, *Dharani* and *Kadiri-6* and four plant populations *viz.*, 3.33 (30 cm x 10 cm), 4.44 (30 cm x 7.5 cm), 5.00 (20 cm x 10 cm)and 6.66 lakh/ha (20 cm x 7.5 cm). The sowing and harvesting of groundnut cultivars was done on 13 May and 30 August, 2013 respectively. Straight fertilizers were applied at 30 kg N, 40 kg P_2O_5 and 50 kg K_2O /ha, respectively. The data on weed dynamics and yield of groundnut were recorded at the time of harvest. The pod and haulm yield was expressed in t/ha.

RESULTS

The predominant weed flora associated with early *Kharif* groundnut was *Cyperus rotundus* L., among sedges, *Digitaria sanguinalis* L. Scop. among grasses and *Boerhavia erecta* L., *Cleome viscosa* L.,*Celosia argentea* L., *Commelina bengalensis* L., and *Trichodesma indicum* R.Br. among broad leaved weeds. Among all the varieties, the lowest density and dry weight of all the categories of weeds were recorded with groundnut cultivar, *Kadiri-6* due to its long statured growth habit coupled with dense foliage whereas the highest density and dry weight of weeds were associated with groundnut cultivar *TAG-24* due to its short statured growth habit and poor ground coverage. The highest pod yield was obtained with groundnut variety *Dharani* due to better partitioning of photosynthates to pods whereas the highest haulm yield was associated with *Kadiri-6 (*Table-1*)*.These findings were in accordance with Soumya *et al.* (2011). Among the plant populations tried, the lowest density and dry weight of weeds with higher haulm yields were associated with plant population of 6.66 lakh/ha (20 cm x 7.5 cm), which were comparable with 5.00 lakh/ha (20 cm x 10 cm) due to lack of sufficient solar light for the germinating weed seeds and maintenance of higher plant populations/unit area. However, the highest pod yield was obtained with 5.00 lakh/of 5.00 lakh/ha was up to 14.0% compared to 6.66 lakh/ha.

Table- 1. Influence of varieties and plant populations on weed dynamics and yield of early *Kharif* groundnut

Treat.	Weed density (no./m^2)				Weed dry weight (g/m^2)				Pod yield	Haield
	Grasses	Sedges	BLWs	Total	Grasses	Sedges	BLWs	Total		
Varieties										
Abhaya	3.34 (10.65)	4.42 (19.0)	3.46 (11.5)	6.45 (41.2)	1.80 (2.74)	2.31 (4.83)	1.86 (2.95)	3.31 (10.5)	1.99	5.27
TAG-24	4.69 (21.49)	6.65 (42.5)	4.51 (19.9)	9.18 (83.9)	2.49 (5.70)	3.42 (11.2)	2.40 (5.26)	4.75 (22.2)	2.86	3.82
Dharani	3.64 (12.74)	4.22 (17.3)	3.7 (13.2)	6.61 (43.2)	1.97 (3.38)	2.25 (4.56)	1.99 (3.46)	3.44 (11.4)	3.45	5.61
Kadiri-6	3.01 (8.56)	3.04 (8.74)	2.37 (5.11)	4.78 (22.4)	1.57 (1.96)	1.58 (1.99)	1.37 (1.37)	2.41 (5.32)	2.34	6.15
LSD	0.465	0.54	0.464	0.496	0.224	0.260	0.214	0.263	0.08	0.26
Plant Populations (lakh/ha)										
3.33	4.08 (16.14)	5.86 (33.8)	4.38 (18.7)	8.31 (68.6)	2.11 (3.95)	2.96 (8.26)	2.24 (4.51)	4.14 (16.7)	2.75	4.37
4.44	3.66 (12.89)	4.70 (21.6)	3.93 (14.9)	7.06 (49.4)	2.01 (3.54)	2.54 (5.95)	2.14 (4.07)	3.52 (11.9)	2.63	4.78
5.00	3.63 (12.67)	4.06 (15.9)	3.04 (8.74)	6.15 (37.4)	1.90 (3.11)	2.10 (3.91)	1.68 (2.32)	3.13 (9.34)	2.83	5.44
6.66	3.23 (9.93)	3.64 (12.7)	2.69 (6.73)	5.46 (29.4)	1.81 (2.77)	1.97 (3.38)	1.55 (1.90)	2.92 (8.05)	2.43	6.26
LSD	0.465	0.54	0.464	0.496	0.224	0.260	0.214	0.263	0.08	0.296

Original figures in parenthesis were subjected to square root transformation ($\sqrt{X + 0.5}$) before statistical analysis

CONCLUSION

It was concluded that the groundnut cultivar *Kadiri-6* was associated with the lowest weed density and dry weight whereas the highest pod yield was obtained with groundnut cultivar *Dharani.* Plant population of 5.00 lakh/ha recorded the highest pod yield and the lowest weed dry weight was associated with plant population of 6.66 lakh/ha in early *Kharif* groundnut on sandy loam soils of Andhra Pradesh.

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Weed management in *Kharif* groundnut

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A field experiment entitled "Effect of post emergence herbicide in *Kharif* groundnut" was conducted at Oilseed Research Unit Dr. PDKV, Akola during *Kharif* season 2013-2014. Nine treatments were compared which are as under T_1 (Unweeded check (control)), T_2 (Weed free check), T_3 (Post emergence application of Propaquizafop 10 EC at 100 gha), T_4 (post-emergence application of quizalofop-ethyl 5 EC at 50 g/ha), T_5 (Post emergence application of quizalofop-ethyl 5 EC at 100 g/ha), T_6 (post-emergence application of Imazethapyr10 % SL at 50 g/ha), T_7(Post emergence application of Imazethapyr10 % SL at 100 g/ha), T_8 (Post emergence application of Imazethapyr+Imazamox 70% WG at 100 g/ha), T_9 (Pre emergence application of Pendimethalin 30 EC 1000 g/ha).

The herbicidal treatments, the lowest weed index (3.26 %) was observed under Propaquizafop10 EC at 100 g/ha followed quizalofop ethyl 5 EC at 100 g/ha (9.74 %).The minimum weed count, dry weight of weeds was also recorded in these treatments, which was significantly lower than all other treatments. Maximum weed control efficiency (96.4%) was recorded in Propaquizafop 10 EC at 100 g/ha and minimum weed control efficiency recorded under pre emergence application of Pendimethalin 30 EC at 1000/ha (81.64%). This clearly indicated that weeds were controlled effectively under post emergency herbicide. The highest dry pods yield (29.27 kg/ha) was recorded with hand weeding (20 and 40 DAS) and the lowest (15.20 kg/ha) was under unweeded check. However, post-emergence applications of Propaquizafop 10 EC at 100 g/ha and quizalofop ethyl 5 EC at 100 g/ha was found to be most effective for controlling weeds and improvement of dry pods yield of *Kharif* groundnut.

Effect of combined use of herbicide and insecticide on insect and weed population and productivity of soybean

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The initial flush of weeds and insects during early period of soybean cause severe damaged and difficult to control both problem by separate practices. To save time and labour the experiment was planned and conducted at Research cum Instructional Farm of Indira Gandhi KrishiVishwavidyalaya, Raipur during *Kharif* season of 2013 and 2014 to evaluate the combined effect of herbicide and insecticide against the weeds and pests. All the treatments were found superior over control. All the treatments were non-significant in controlling the leaf miner. However, the lowest number of larvae plant^{-1} was observed under the combined application of Rynaxypyre 20 EC at 100 ml/ha + Imazathapyr 10 SL at 1.0 l/ha (0.70 larvae/plant). The lowest weed biomass (1.63 g/plant) and the highest weed control efficiency (94.8%) were recorded with Imazathapyr 10 SL at 1.0 l/ha followed by Indoxacarb 14.5 EC at 300 ml/ha + Imazathapyr 10 SL at1.0 l/ha.Yield attributes, *viz.* seeds/pod, seed index and harvest index were found non-significant. Application of Imazathapyr 10 SL at 1.0 l/ha recorded the highest grain yield, stover yield, net monetary returnsand B:C ratio, which was found at par with remaining pesticides.

Effect of chlorimuron-ethyl against weed flora in soybean

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Soybean is a crop of multiple qualities as it is both a pulse and oilseed crop. It is third largest oilseed crop of India after rapeseed-mustard and groundnut. Being a *Kharif* season crop, it suffers from severe infestation of weeds which rob it of essential nutrients, space and moisture, causing substantial loss in yield (33-55%) depending on the weed flora and density (Kewat *et al*. 2000).The competition stress between weeds and crop for the nutrients, water, light and space are responsible for poor yield of soybean. The stress is mainly due to presence of annual grassy weeds *viz*, *Echinochloa colonum*, *Echinochloa crusgalli*, *Cyperus rotundus*,*Cynodondactylon*, *Cyperus iria* and dicot weeds such as *Phyllanthusniruri*, *Euphorbia* spp., *Commelinabengalensis*, *Eclipta alba and Corcorusacutangulus etc.* (Sharma and Shrivastava, 2002). Hand weeding is widely practiced for eliminating the weeds, though it is costly and time consuming. Hence, since last two decades chemical weed control has become the potential tool for curbing the weed menace. Use of Chlorimuron-ethyl 25% WP as early post- emergence is very common to get rid of weed notoriety in soybean.

METHODOLOGY

The experiment carried out in *Kharif* season 2012, on clayey soil which was neutral in reaction, medium in organic carbon, available nitrogen and phosphorus and high in available potassium. The investigation was aimed to study the effect of chlorimuron-ethyl against weed flora in soybean (*JS 97-52*). The experimental area has the natural weed flora comprising of grassy as well as broad leave weeds. Nine treatments comprised of chlorimuron-ethyl 12, 24, 36, 48 and 72 g/ha, weed free treatment (Hand weeding at 20 and 40 DAS), mechanical weeding at 20 DAS, combined application of Chlorimuron-ethyl 24 g/ha + mechanical weeding, and weedy check were laid out in RBD with three replications.

RESULTS

Pre-dominant weed infesting the soybean crop were *Echinochloa colona, Cyperus iria* among monocot while *Alternanthera philoxiroides, Eclipta alba, Commelina benghalensis* and *Phyllanthus niruri* among the dicot weeds. Application of Chlorimuron-ethyl 24 g/ha as early post-emergence along with mechanical weeding was most effective in paralyzing the weed growth to that of chlorimuron-ethyl (12, 24, 36, 48 and 72 g/ha) and mechanical weeding at 20 DAS.After the application of the herbicide weeds are controlled. But, in weedy check plots highest intensity of monocot weeds were recorded at 45 DAS and harvest. Among monocot *Echinochloa colona* (26.2 and 21.1%) was the most dominant weed followed by *Cyperus iria* (11.5 and 14.7%) at 45 DAS and harvest respectively, whereas dicot weeds like *Eclipta alba* (9.34 and 12.5%),*Commelina benghalensis* (4.82 and 8.91%), *Alternanthera philoxiroides* (16.37 and 14.89%) and other weeds (31.61 and 23.65%) were present in lesser number in soybean ecosystem.

Application of Chlorimuron-ethyl herbicide at 24 g/ha as early post-emergence along with mechanical weeding was significant superior for growth parameters, yield attributes and seed yield (1.60 t/ha) of soybean than rest of the treatments and also found more remunerative in terms of NMR (Rs 20023.8) and B-C ratio (2.06) than application of Chlorimuron-ethyl herbicide at 12 g/ha to 72 g/ha, as early post-emergence.

Table 1. Effect of weed control treatments on weed biomass, weed control efficiency and weed index in soybean.

Treatment	Weed biomass (g/m^2)		Weed control efficiency (%)		Weed index
	45 DAS	At Harvest	45 DAS	At Harvest	
T_1 - Chlorimuron-ethyl 12 g/ha	19 (59.4)	23.3 (89.9)	76.2	71.9	30.2
T_2 - Chlorimuron-ethyl 24 g/ha	18 (52.7)	22.1 (80.5)	78.9	74.8	12.4
T_3 - Chlorimuron-ethyl 36 g/ha	17.5 (52.1)	21.6 (77.2)	79.2	75.8	11
T_4 - Chlorimuron-ethyl 48 g/ha	16.9 (48.8)	21 (72.9)	80.5	77.2	10.4
T_5 - Chlorimuron-ethyl 72 g/ha	16.5 (46.8)	20.6 (70)	81.3	78.1	9.7
T_6 -Hand weeding (20 & 40 DAS)	4.3 (0.00)	8.1 (8.5)	100	97.3	0
T_7 - Mechanical weeding (20 DAS)	17.4 (52)	21.7 (78.2)	79.2	75.5	12.2
T_8- Chlorimuron-ethyl 24g/ha +W (40 DAS)	15.6 (42.5)	20.1 (66.3)	83	79.2	5.3
T_9 - Weedy check	38.8 (250)	43.9 (319.8)	0	0	36
SEm±	0.02	0.02	-	-	-
CD at 5%	0.04	0.06	-	-	-

CONCLUSION

Application of Chlorimuron-ethyl 24 g/ha as early post-emergence along with mechanical weeding was most effective in paralyzing the weed growth to that of rest of treatments.

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Integrated weed management in sesame

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India is the world's largest producer of sesame (*Sesamum indicum* L.) accounting for nearly 35% of the total production in the world but productivity is very low. Lack of proper weed management is one of the main constraints for poor yield of sesame. Yield loss due to crop weed competition in sesame have been estimated to be 50-75%. The period from 15-30 DAS is the most critical period of crop weed competition in sesame. Manual weeding is the common practice to control weeds in sesame. However, hike in labour wages as well as scarcity of labourers compels farmers to search for other alternative methods of weed management. Therefore, the present attempt has been made to study integrated weed management in sesame.

METHODOLOGY

The field experiment was carried out during *Kharif*, 2013 at Agricultural College farm, Raichur, Karnataka. The soil of the experimental site was medium black with 223, 33 and 195 kg /ha available N, P_2O_5 and K_2O, pH of 8.21,. The experiment was laid out in completely randomized block design (CRBD) with three replications and eight treatments. The crop was fertilized with entire quantities of 50 kg N, 25 kg P_2O_5 and 25 kg K_2O/ha. Density and biomass of weeds were recorded at 20, 40, 60 DAS and at harvest with the help of 50 cm x 50 cm quadrat by throwing it randomly at four places in each plot. Data related to weed density and weed dry matter were put to transformation before analysis.

RESULTS

Weed free check recorded the lowest weed density and weed dry weight. Among the herbicidal treatments, the lowest weed density (41.66 /m^2) and weed dry matter (61.53 g/m^2) were noticed in alachlor at 0.75 kg/ha as pre-emergence(PRE) application + HW at 30 DAS + IC at 45 DAS and was followed by quizalofop ethyl at 40 g/ha as post-emergence (PoE) application at 20 DAS + IC at 45 DAS which were on par with each other (Table 1). Joseph *et al.* (2006) had obtained similar effect of herbicides.

The highest weed control efficiency (74.24%) was recorded in recommended practice *i.e.*,alachlor 50 EC at 0.75 kg/ha as (PRE) application + HW at 30 DAS + IC at 45 DAS followed by quizalofop ethyl 5 EC at 40 g/ha as (POE) application at 20 DAS + IC at 45 DAS.The higher weed control efficiency is attributed to lower dry weight of weeds. This might be due to the combination of both cultural and chemical methods which was found to be more effective in suppressing the weed density as well as weed dry matter. The highest weed index (85.11%) was recorded under imazethapyr at 75 g/ha as PoE application at 20 DAS + IC at 45 DAS because of the severe phytotoxicity of this herbicide to sesame.

Table 1. Weed growth, yield and economics of sesame as influenced by different weed control treatments.

Treatment	Weed density/ m^2 at harvest	Dry wt of weeds at harvest (g/m^2)	WI (%)	WCE (%)	Seed yield (kg/ha)	Stalk yield (kg/ha)	Cost of cultivation (`./ha)	Gross returns (`./ha)	Net returns (`./ha)	B-C ratio
Unweeded check	11.09 (122.00)	2.38 (238.87)	68.95	0.00	180	1267	19,548	21,560	2,012	1.10
Weed free check (HW at 15 DAS + IC at 30 and 45 DAS)	1.00 (0.00)	0.30 (0.00)	0.00	100.0	588	2520	27,618	70,600	42,982	2.56
Recommended practice (alachlor 50 EC at 0.75 kg/ha as PRE application + HW at 30 DAS + IC at 45 DAS)	6.53 (41.66)	1.80 (61.53)	16.89	74.24	480	2356	28,118	57,600	29,482	2.05
Pendimethalin 30 EC at 1 kg/ha as PRE application + HW at 30 DAS + IC at 45 DAS	8.31 (67.34)	2.00 (97.37)	52.71	59.23	273	1683	28,755	32,800	4,045	1.14
Pendimethalin 38.7 CS at 1 kg/ha as PRE application + HW at 30 DAS + IC at 45 DAS	7.94 (62.00)	1.98 (93.85)	51.78	60.70	283	1750	28,937	34,000	5,063	1.17
Butachlor 50 EC at 1 kg/ha as PRE application+ HW at 30 DAS + IC at 45 DAS	7.09 (49.33)	1.93 (83.36)	36.20	60.91	367	2100	28,194	44,000	15,806	1.56
Quizalofop ethyl 5 EC at 40 g/ha as POE application at 20 DAS + IC at 45 DAS	6.78 (44.67)	1.84 (69.67)	28.95	70.83	410	2239	21,868	49,200	27,332	2.25
Imazethapyr 10 SL at 75 g/ha as POE application at 20 DAS+ IC at 45 DAS	7.46 (54.67)	1.94 (85.10)	85.11	64.26	86	713	22,176	10,360	-11,816	0.47
LSD (P=0.05)	0.34	0.04	12.50	3.08	75	145	-	8956	8956	0.33

The highest seed yield (0.588 t/ha) and stalk yield (2.52 t/ ha) were recorded in weed free check and was followed by alachlor at 0.75 kg/ha as PE application + HW at 30 DAS + IC at 45 DAS and quizalofop ethyl at 40 g /ha as PoE application at 20 DAS + IC at 45 DAS. Parvender Sheoran *et al.* (2012) obtained higher seed yield of sesame with herbicide application. Significantly higher net returns (Rs.42,982 /ha) was recorded in weed free check and was followed by recommended practice, *i.e.* alachlor at 0.75 kg/ha as PE application + HW at 30 DAS + IC at 45 DAS and quizalofop ethyl at 40 g/ha as PoE application at 20 DAS + IC at 45 DAS. On the other hand, significantly lower net returns (Rs -11,816 /ha) was recorded in imazethapyr at 75 g/ha as PoE application at 20 DAS + IC at 45 DAS (T_8) due to phytotoxicity of the chemical which led to lower seed yield of sesame.

CONCLUSION

It can be concluded that pre-emergence application of alachlor at 0.75 kg/ha + HW at 30 DAS + IC at 45 DAS produced significantly higher seed yield, gross and net returns in sesamum.

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Weed management studies in groundnut

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Groundnut is the main oilseed crop grown in India, plays a vital role in oilseed production. Groundnut crop is highly susceptible to weed infestation because of its slow growth in its initial stages up to 40 days, short plant height and underground pod bearing habit. It is a unique crop, combining the attributes of both oilseed crop and legume crop in the farming system of Indian agriculture. Groundnut weeds comprise diverse plant species from gasses to broad leaf weeds and sedges and cause substantial yield loses (15-75 %).

METHODOLOGY

The field experiment was conducted on sandy loam soils in a Randomised Block Design with three replications to know the effect of integrated weed management in irrigated groundnut during *Kharif*, 2013 at College of Agriculture, Raichur. Pendimethalin was sprayed as a pre-emergence herbicide on the day of sowing, imazethapyr and quizalofop-ethyl was sprayed as a post- emergence herbicide at 20-25 DAS. Interculturing was done at 25 and 35 DAS.

RESULTS

Weed control treatments had significantly lower weed population than weedy check. Treatments which received the application of herbicides with cultural practices recorded lower weed population than weedy check. This is due to application of herbicides which might have prevented the germination of susceptible weed spp., and also reduced the growth of germinated weeds by inhibiting the process of photosynthesis Muzik, (1970).Weed free check recorded lesser weed dry weight when compared to all other treatments, which was mainly because of maintenance of minimum weeds throughout the crop growth enabled the crop to utilize the nutrients, moisture, space and light effectively compared to rest of the treatments. Similar results were obtained by (Kori *et al.* 2000).

Weed control efficiency was 91.0% in weed free check. The higher weed index was observed in weedy check (65.31%). This reduction in yield is attributed to higher density of mon ocots, dicots and higher dry matter production of weeds under weedy check. The highest pod yield and haulm yield was recorded in weed free check and was on par with pendimethalin 1000 g/ha *fb* IC at 25 and 35 DAS, pendimethalin 1000 g/ha *fb* imazethapyr 75 g/ha *fb* IC at 35 DAS and pendimethalin 1000 g/ha *fb* quizalofop-ethyl 45 g/ha *fb* IC at 35 DAS. This might be due to timely and effective control of weeds by pre-emergence herbicides coupled with post-emergence herbicides along with the IC which provided weed free environment to the groundnut crop. Significantly higher net returns (99,518 ¹ /ha) was recorded in weed free check and was followed by pendimethalin 38.7 CS 1000 g/ha *fb* imazethapyr 75 g/ha *fb* IC at 35 DAS and pendimethalin 1000 g/ ha *fb* IC at 25 and 35 DAS.The highest B:C ratio (3.52) was obtained from weed free check and was followed by pendimethalin 1000 g/ha *fb* imazethapyr 75 g/ha *fb* IC at 35 DAS.

Table 1. Effect of Integrated weed control treatments on yield and economics of groundnut

Treatment	Total weed count (m^2)	weed dry weight (g/m^2)	WCE (%)	WI (%)	pod yield (kg/ ha)	Haulm yield (kg/ ha)	Net returns (`./ha)	B:C ratio
Pendimethalin (38.7% CS) @ 1000 g/ha^{-1} *fb* 2 intercultivation at 25 and 35 DAS	7.04 (43.33)	0.99 (7.70)	87.33	15.32	2099	2414	80830	3.14
Imazethapyr (10% SL) @ 75 g ha^{-1} at 20-25 DAS	8.23 (60.00)	1.36 (21.20)	66.67	36.93	1523	2126	53336	2.46
Quizalofop-ethyl (5% EC) @ 45 g. ha^{-1} at 20-25 DAS	8.85 (61.33)	1.52 (31.55)	50.00	53.02	1207	2044	38872	2.08
Imazethapyr (10% SL) @ 75 g ha^{-1} + Quizalofop-ethyl (5% EC) @ 45 g ha^{-1} at 20-25 DAS	9.60 (75.67)	1.52 (31.55)	51.33	60.48	974	1687	23391	1.63
Pendimethalin (38.7% CS) @ 1000 g ha^{-1} *fb* Imazethapyr (10% SL) @ 75 g ha^{-1} at 20-25 DAS	7.76 (52.33)	1.29 (31.00)	72.33	21.43	1948	2287	72699	2.92
Pendimethalin (38.7% CS) @ 1000 g ha^{-1} *fb* Quizalofop–ethyl (5% EC) @ 45 g ha^{-1} at 20-25 DAS	8.14 (53.00)	1.36 (17.63)	67.00	23.96	1906	2263	71163	2.91
Pendimethalin (38.7% EC) @ 1000 g ha^{-1} *fb* Imazethapyr (10% SL) @ 75 g ha^{-1} *fb* 1 intercultivation at 35 DAS	5.38 (29.67)	0.97 (21.20)	87.67	12.37	2181	2496	84274	3.17
Pendimethalin (38.7% CS) @ 1000 g ha^{-1} fb Quizalofop-ethyl (5% EC) @ 45 g. ha^{-1} at 20-25 DAS fb 1 intercultivation at 35 DAS	7.90 (53.33)	1.15 (12.73)	81.00	18.42	2030	2359	76703	3.01
Weed free check (interculture at 15, 30 and 40 Days after sowing) + 1 Hand weeding at 25 Days after sowing	1.42 (2.00)	0.85 (5.51)	91.00	0.00	2505	2633	99518	3.52
Weedy check	13.06 (173.67)	1.82 (64.60)	0.00	65.31	850	1453	17768	1.51
S.Em±	0.01	0.05	2.70	7.03	185	64	8421.21	0.23
CD at 5%	0.03	0.14	7.88	20.53	540	188	24580.97	0.66

CONCLUSION

Weed menace is the serious bottle-necks for increasing the yield in groundnut. Competitional stress of weeds causes reduction in pod yield. Therefore adoption of an integrated approach is essential.

Efficacy of herbicidal weed control in groundnut at varying levels of sulphur

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Groundnut (*Arachis hypogaea* L.) is the fourth most important edible oilseed crop of the world. Its kernels contain high quality edible oil (48%), easily digestible protein (26%) and carbohydrates (20%). Groundnut accounts 40% of the area and 30% of the production of total oilseeds grown in India. It was grown on 3.97 lakh hectares in Rajasthan with a production of 4.18 lakh tonnes and average productivity of 1051 kg/ha which is very low. Among different biotic constraints, heavy weed infestation is the most serious menace in groundnut production that has been reported to cause as high as 70-80% losses in crop yield (Giri *et al.* 1998). Thus weed control is vitally important not only to check the yield losses caused by them but also to increase the fertilizer use efficiency. Sulphur is one of the indispensable plant nutrients in which most of the Indian soils are deficient (Tandon 1986). It is an essential nutrient which is best known for its role in the synthesis of oil and various amino acids. The present investigation was, therefore, undertaken to study the efficacy of different herbicidal and mechanical methods in controlling weeds and increasing its productivity at various levels of nitrogen.

METHODOLOGY

A field experiment was conducted under loamy sand soil during *Khairf*, 2013 at Agronomy farm, S.K.N. College of Agriculture, Jobner. The treatments comprising six weed control treatments (weedy check, one HW at 25 DAS, pendimethalin at 0.75 kg/ha, fluazifop-p-butyl at 0.20 kg/ha and imazethapyr at 100 g/ha) and four levels of S (0, 20, 40 and 60 kg/ha) assigned to main and sub plots of spilt plot design, respectively, were replicated thrice. Groundnut variety '*RG-382*' was used as a test crop. Pendimethalin and imazethapyr were applied through stomp 30EC and fervent 10 SL as pre-emergence, whereas, fluazifop-p-butyl through fusillade 13.4 EC as post-emergence at 25 DAS. Sulphur was applied through gypsum as per treatments at the time of sowing and mixed properly into the soil.

RESULTS

Results showed that application of pendimethalin at 0.75 kg/ha and one HW at 25 DAS resulted in significant reduction in weed density, weed dry matter and nutrient depletion by weeds in comparison to most of the treatments. These treatments controlled the weeds to the extent of 83.2 and 80.0% at harvest stage, respectively. Remaining at par with each other, these two treatments also proved their superiority in improving crop dry matter, number and weight of nodules/ plant, pods/plant, kernels/pod and seed index of groundnut over most of the treatments. After weed free (1.97 t/ha), the highest pod, haulm and kernel yields (1.85, 3.45 and 1.33 t/ha) with the highest shelling percentage of 71.36 were obtained with pendimethalin at 0.75 kg/ha. Producing 79.1, 82.2 and 97.4% higher pod, haulm and kernel yields than weedy check and attaining 70.78% shelling, one HW at 25 DAS was also found equally effective treatment. These two treatments also witnessed substantially lower weed competition indices of 8.26 and 11.28% as compared to weed free. It was further noted that pendimethalin at 0.75 kg/ha and one HW at 25 DAS were found statistically similar and significantly better treatments in enhancing nutrient concentration in kernel and haulm and their uptake by crop, protein and oil content in kernel and oil yield. Fetching the net returns of Rs. 62319 /ha and B:C ratio of 2.13, pendimethalin at 0.75 kg/ha was found as remunerative as weed free treatment. Increasing the net returns by Rs 35809 /ha over weedy check, one HW at 25 DAS also found equally effective. These treatments were accompanied by imazethapyr at 100 g/ha and fluazifop-p-butyl at 0.20 kg/ha in order of their effectiveness.

Results also showed that application of 60 kg S/ha in groundnut recorded the highest dry weight of weeds at all the stages, N, P and K concentration in weeds and nutrient depletion by weeds at harvest stage. Every increase in level of S upto 60 kg/ha resulted in significant improvement in growth and yield attributes over preceding levels except seed index. It also registered 120.1, 98.3 and 150% higher pod, haulm and kernel yields than control and shelling percentage of 73.40. The highest concentration of S in kernel and haulm, nutrient uptake by crop, protein and oil content as well as oil yield were also obtained at this level of S. Providing the maximum net returns of Rs 68330 /ha with the highest B:C ratio (2.25), it was found the most remunerative level of S fertilization.

CONCLUSION

Pendimethalin at 0.75 kg/ha (PE) combined with 60 kg S/ ha was found the most superior treatment combinations for obtaining higher pod yield and net returns in groundnut.

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Integrated weed management in sesame at different levels of nitrogen fertilization

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Sesame (*Sesamum indicum* L.) has been known to be one of the earliest domesticated edible oilseeds used by mankind. After groundnut and mustard, it is 3rd important edible oilseed crop in the country. Its oil content varies from 46-52% and protein content between 20-26%. Because of its excellent quality characters, sesame oil is also sometimes referred to as "poor man's substitute for ghee". India is the largest producer and acreage holder (26%) of sesame in the world. Despite of being such an important oilseed crop, the average productivity in Rajasthan (293 kg/ha) is quite low. Among various constraints, heavy infestation of weeds is major bottleneck in realizing the full yield potential of this crop. Weeds take a heavy toll of the native and applied nutrients. Losses due to uncontrolled weed growth in sesame have been reported as high as 50% (Dungarwal *et al.* 2006). Manual weeding is not only time consuming but labour intensive also. Hence, exploring the possibility of suitable weed management practices involving a selective and cost effective herbicide deserves attention. Poor nourishment especially of N, is another factor of low productivity of sesame. It is a universally deficient plant nutrient in most of the Indian soils particularly the light textured ones where most of the sesame growing area is confined. The present investigation was therefore, undertaken to study the efficacy of different herbicidal treatments at varying levels of sulphur in sesame.

METHODOLOGY

A field study was undertaken under loamy sandy soil at S.K.N. College of Agriculture, Jobner during *Kharif,* 2010. The soil of the experimental field was alkaline in reaction, low in organic carbon (0.18%), available nitrogen (127.1 kg/ha) and medium in available phosphorus (16.4 kg/ha) and potassium (156.7 Kg/ha). The treatments comprising seven weed management practices (weedy check, one HW at 20 DAS, two HW at 20 & 40 DAS, alachlor at 1.5 kg/ha, alachlor at 1.5 kg/ha + HW at 30 DAS, imazethapyr at 0.15 kg/ha and imazethapyr at 0.15 kg/ha + HW at 30 DAS) and three levels of N (0, 20 and 40 kg/ha), thereby making twenty one treatment combinations were replicated thrice in randomized block design. Alachlor was applied through Alachlore and imazethapyr through Fervent as pre emergence treatments. Nitrogen was applied through urea. A uniform basal dose of 25 kg P_2O_5/ha was drilled at the time of last ploughing through SSP. Sesame variety "*RT-127*" was under test. Overall, 393.1 mm of rainfall was received during crop period and no irrigation was applied.

RESULTS

Results showed that pre emergence application of imazethapyr at 0.15 kg/ha + HW at 30 DAS and two HW at 20 and 40 DAS significantly reduced the weed density, weed dry matter and nutrient depletion by weeds in comparison to rest of the treatments except alachlor at 1.5 kg/ha + HW at 30 DAS in nutrient depletion. These treatments controlled the weeds to the extent of 81.9 and 81.3%. The highest grain and stalk yield (0.85 and 2.97 t/ha) and harvest index (22.4%) were obtained with imazethapyr at 0.15 kg/ha + HW at 30 DAS. Producing the grain and stalk yield of 818 and 2933 kg/ha with harvest index of 21.81% and recording the minimum weed competition index (4.31%), HW twice at 20 and 40 DAS was also found equally effective treatment (Saudy 2009). These treatments also showed their superiority in enhancing N, P and K concentration in grain and stalk, oil content, oil yield and nutrient uptake by crop. Being at par with HW twice, imazethapyr at 0.15 kg/ha + HW at 30 DAS fetched the maximum net returns of Rs 27797 /ha and B: C ratio (1.86) and was found the most remunerative treatment. These treatments were followed by alachlor at 1.5 kg/ha + HW at 30 DAS, One HW at 20 DAS and imazethapyr at 0.15 kg/ha in increasing yield and net returns.

Results further indicated that application of 40 kg N/ha in sesame recorded the highest density and dry weight of weeds at all the stages. Every increase in level of N upto 40 kg/ha brought significant improvement in growth and yield attributes over lower levels except branches/plant, grains, capsule and test weight. It also registered 28.4 and 26.7% higher grain and stalk yield over control. The highest concentration of N, P and K in grain and stalk and their uptake by crop, protein and oil content in grain as well as oil yield were also obtained at this level of N. Fetching the maximum net returns of Rs 25090 /ha with the highest B:C ratio (1.77), it was found the most remunerative level of N fertilization..

CONCLUSION

Pre emergence application of imazethapyr at 0.15 kg/ha + HW at 30 DAS and 40 kg N/ha, independently were found the most effective treatments for obtaining higher grain yield and net returns in sesame.

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Determination of critical period of crop-weed competition in rainfed groundnut

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Competitional stresses of weeds lead to 17-84 % reduction in pod yield of groundnut (Guggari *et. al.*, 1995).Knowledge about competitive aspects of weeds and the critical stages at which the weeds compete to the maximum with the crop is an important aspect. Hence the studies were taken up to determine the exact critical period of weed competition in rainfed groundnut for planning weed management programme.

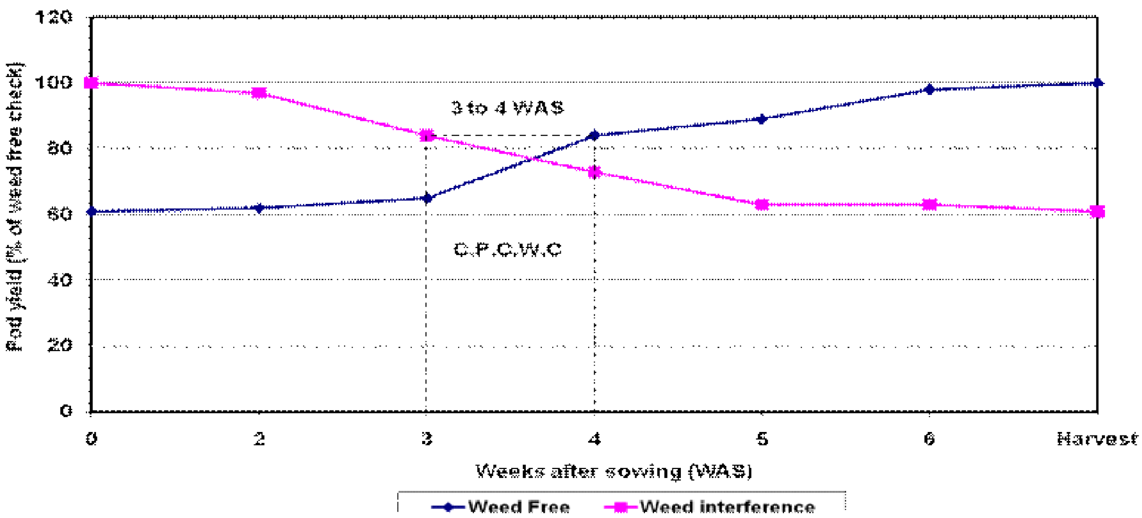
METHODOLOGY

Experiment was conducted during *Kharif*, 2005 at dryland Farm of S.V.Agricultural College, Tirupati,in a randomized block design, with 3 replications .The soil was sandy clay loam, low in organic carbon and available nitrogen and medium in available phosphorus and potassium. The treatments consisted of weed free conditions (WFC), up to 2, 3, 4, 5 and 6 WAS (weeks after sowing) and weed interference (WI), up to 2, 3, 4,5 and 6 WAS along with weed free and weedy check.The test cultivar was Narayani (TCGS-29). The crop was supplied with 20 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha. The critical period of crop weed competition was determined by taking the dataon yield reduction under different treatments from the yield of weed free check.

RESULTS

The highest pod yield was obtained when weed free condition was maintained throughout the crop growth, which was closely followed by WFC up to 6 (WAS) and WI up to 2 WAS (Fig.1). Significant reduction in pod yield over completely weed free check was observed when weeds were allowed to grow with the crop up to 3 WAS. The pod yield was further declined when the time of weed removal was prolonged for 3 to 4 WAS. Per cent reduction decreased as the duration of crop weed competition reduced.Weed interference up to 2 WAS did not cause any significant loss in pod yield of ground nut. Weeds were allowed to remain beyond 2 weeks or longer the pod yield tended to reduce progressively. The pod yield was statistically at par with weed free check when weed interference was allowed only up to initial 2 weeks. Weedy check resulted in 39% reduction in the pod yield compared to weed free check. The presence of weeds for the first 4 weeks caused 26.9% reduction in yield, indicating that initial weed infestation was harmful to the crop. In contrast crop kept weed free for initial 4 weeks recorded only 15.9 % reduction probably because weed emerged after 4 weeks did not pose any adverse effect on crop yield. Therefore, the most critical period of crop weed competition(CPCWC) appeared to be between 3 and 4 weeks after sowing. If chemical methods of weed control are to be adopted for control of weeds, the herbicides should have extended lethal effect so as to last up to the end of this critical period.

Fig. 1 : Interpretation of critical period of crop weed competition in rainfed groundnut



CONCLUSION

The present study indicated that the critical period of crop weed competition was from 2-6 WAS and the most critical period was between 3 and 4 weeks of sowing rainfed groundnut.

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Bioefficacy of pre- and post-emergence herbicides for weed control in soybean

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Slow initial growth and wider inter-row spaces provides a congenial environment for weeds to grow in soybean. Repeated manual hoeing is not a viable option due to rising labour wages. The herbicides presently available for use in soybean in Northern India are either pre-emergence or pre-plant incorporated and have a narrow spectrum of weed control and lower residual activity. The performance of pre- and post-emergence herbicides, used alone or in sequence, for long-term site-specific weed control in soybean was investigated.

METHODOLOGY

A field study was carried out on loamy sand soil during summer season of 2013 at Punjab Agricultural University, Ludhiana, India. Ten treatments- pendimethalin at 450 g as pre-emergence alone, and followed by (*fb*) imazethapyr + imazamox at 70 g or quizalofop at 37.5 g/ha at 4 weeks after sowing (WAS), imazethapyr + imazamox at 60 and 70 g/ha each at 3 and 4 WAS, quizalofop at 37.5 g/ha at 3 WAS, weedy check and weed free check- were evaluated in randomized complete block design in four replications. Soybean (*SL-744*) was sown manually on June 8, 2013 using 100 kg seed/ha in 45 cm spaced rows. The crop was harvested on October 29, 2013. Data were analysed using the GLM procedure in SAS version 9.3 to evaluate differences between treatments. Data of weed biomass were square root transformed.

RESULTS

The predominant weed species included *Dactyloctenium aegyptium, Digitaria sanguinalis, Acrachne racemosa, Commelina benghalensis, Digera arvensis* and *Cyperus rotundus*. All the herbicidal treatments recorded significantly lower dry matter of grass weeds than weedy check. Imazethapyr + imazamox alone or in combinations, at all doses and timings, recorded complete control of broadleaf weeds. Sequential use of pendimethalin and quizalofop recorded lower broadleaf weeds dry matter as compared to when these herbicides were applied alone.Imazethapyr + imazamox at both the levels at 3 WAS significantly reduced dry matter accumulation of sedges. The weedy check accumulated significantly higher total weed dry matter than all weed control treatments (Table 1). The herbicides had differential effects on different weed species which reduced the total weeds dry matter as compared to weedy check. Season long weed infestation reduced soybean seed yield by 37%. All the weed control treatments significantly increased soybean seed yield than weedy check. Soybean seed yield with all the herbicidal treatments, except pre-emergence pendimethalin and post-emergence imazethapyr + imazamoxat 60 g/ha at 4 WAS used alone, were similar to weed free check. All the herbicides were safe to soybean and did not show any residual effect on succeeding crops (Yadav and Bhullar 2014).

Table 1. Effect of different herbicidal treatments on weeds dry matter and soybean seed yield.

Treatments	Weed Dry weight at 40 DAS (g/m^2)	WCE (%)	Seed yield (kg/ha)
Pendimethalin 450 g/ha	13.5(182)*	36.3	1728
Imazethapyr + imazamox 60 g/ha at 3 WAS	5.9(34)	88.1	1981
Imazethapyr + imazamox 60 g/ha at 4 WAS	8.0(65)	77.3	1688
Imazethapyr + imazamox 70 g/ha at 3 WAS	5.6(30)	89.3	1853
Imazethapyr + imazamox 70 g/ha at 4 WAS	7.7(60)	78.9	1868
Pendimethalin 450 g/ha fb Imazethapyr + imazamox 70 g/ha at 4 WAS	5.9(34)	87.9	1983
Quizalofop 37.5 g/ha at 3 WAS	13.7(188)	34.2	1875
Pendimethalin 450 g/ha fb quizalofop 37.5 g/ha at 4 WAS	10.4(107)	62.3	1787
Weedy check	16.9(285)	-	1275
Weed free check	-	-	2025
CD (p=0.05)	1.5	-	237

CONCLUSION

Post-emergence applications of imazethapyr + imazamox and quizalofop alone or in sequence with pre-emergence pendimethalin, depending on the weed flora present in the field, are good options for site-specific weed management in soybean.

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Effect of integrated weed management on growth, yield and quality of soybean

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With the primary objectives to study the suitable and effective weed management practices to control weeds during critical period of crop-weed competition. To evaluate the bio-efficacy of different herbicides and to study the economics of weed control practices.

METHODOLOGY

A field experiment was conducted at post graduate institute instruction farm, Mahatma Phule Krishi Vidyapith; Rahuri during *Kharif*, 2013-2014.The experiment was laid out in randomized block design with 8 treatments replicated thrice. These treatments were T_1- pendimethalin38.7 % cs at 677.25 g /ha *fb* 1HW at 30 DAS, T_2- metribuzin at 525 g/ha *fb* 1 HW at 30 DAS, T_3- pendimethalin 38.7 % at 677.25 g/ha *fb* (bentazone + fenoxaprop-p-ethyl) at (1000+80) g, T_4- metribuzin at 525 g/ ha *fb* (bentazone+ fenoxaprop-p-ethyl) at (1000+80) g/ha, T_5- pendimethalin 677.2 g/ha *fb* (imazethaypr + propaquizafop-ethyle) at (80+60 g/ha), T_6-metribuzin at 525 g/ha *fb* (imazethaypr + propaquizafop-ethyl) at (80+60) g/ha, T_7- weed free one hoeing at 15 DAS and 2 HW at 25 and 45 DAS and T_8- unweeded control.Weed density (no./m^2) and dry weight of weeds (g/m^2) were recorded by putting a quadrate of 1 m^2 at 3 random spot in each plot,weed control efficiency and weed index and herbicide efficiency index was calculated by standard formula.. The data on weed count and dry weight of weed were square root"x+1 transformed.

RESULTS

Among combination of herbicide with mechanical method, PE application of treatment metribuzin at 525 g/ha + 1 HW at 30 DAS (T_2), recorded the lowest weed population and weed dry matter over rest of herbicide treatments, except PE application of treatment pendimethalin at 677.25 g/ha + 1 HW at 30 DAS (T_1), metribuzin at 525 g/ha *fb* imazethapyr + propaquizafop-ethyl at (80 + 60) g/ha (T_6).(Pandya *et al*. 2004). Higher weed control efficiency and lowest weed index were observed in weed free treatment. Among combination of herbicide with mechanical method, PE application of treatment metribuzin at 525 g/ha + 1 HW at 30 DAS (T_2), recorded the highest weed control efficiency and lowest weed index over rest of herbicide treatments, except PE metribuzin at 525 g/ ha *fb* imazethapyr + propaquizafop-ethyl at (80 + 60) g/ha (T_6). This might be due to pre-emergence application of metribuzin prevent emergence of monocot and grassy weeds by inhibiting root and shoot growth while imazethpyr was responsible for inhibition of acetolactate synthases (ALS) or acetohydroxyacide synthesis (AHAS) in broad leaveswhichcaused destruction of these weeds in 3-4 leaf stage and remaining monocot weeds was control by propaquizafop-ethyl and hand weedind at 30 DAS Which was critical period of soybean crop. The lowest weed control efficiency and highest weed index was observed in unwedded control due to high weed competition for growth and yield factors. One hoeing at 15 DAS and two hand weeding at 25 and 45 DAS was recorded highest WCE, lowest weed index, weed dry matter and weed population.One hoeing at 15 DAS and two hand weeding at 25 and 45 DAS (Sankaranarayan *et al*. 2002), (Chintalwar 2004) was found singnifiantly best treatment among all treatments and treatment PE application of treatment pendimethalin 38.7% at 677.25 g/ha + 1 HW at 30 DAS (T_1), metribuzin at 525 g/ha + 1 HW at 30 DAS (T_2), metribuzin at 525 g/ha *fb* imazethapyr + propaquizafop-ethyl at (80+60) g/ha (T_6) at par with it. This might be due to better control of weed in different stages of crop, manual weeding, interculture operation at critical stage of crop reduce crop weed competition and thereby providing better growth (plant height, plant spread/plant, branches/plant, no of leaves, leaf area and dry matter of plant) yield attributing characters (no. of pod/plant, pod weight/plant, no of seed /plant, weight of seed/plant test weight) and ultimate yield. The highest net monetory returns of Rs. 48181 /ha was obtain in metribuzin at 525 g/ha+1 HW at 30 DAS. The highest benefit:cost ratio of 2.24 was observed in metribuzin at 525 g/ha + 1 HW at 30 DAS which was followed by metribuzin at 525 g/ha *fb* imazethapyr + propaquizafop-ethyl at (80+60) g/ha (2.21) and one hoeing at 15 DAS and two hand weeding at 25 and 45 DAS (2.10). B:C ratio is high for herbicide treatment due to low cost of treatment as compare to mechanical method.

CONCLUSION

It concluded that combination of herbicide and mechanical method was most effective for weed control. Metribuzin at 525 g/ha + 1 HW at 30 DAS was found economical viable.

Evaluation of pre- and post-emergence herbicides in linseed under sub-mountain Himalayan region

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Linseed (*Linum usitatissimum* (L.) Griesb.) is one of the most important cultivated plants concerning oil (non-edible and edible oil) and fibre. Linseed is becoming increasingly popular as a nutritional and functional food due to its high content of health promoting substances such as ù 3 fatty acid, soluble and insoluble fibre and lignans. As, linseed is winter season oilseed crop and its initially slow growth habit with less leaf canopy and erect nature of plants, virtually exerts no smothering effect on weeds. Weeds can cause upto 66% yield losses and can further aggravate if weeds are not controlled with in a specific period of time. Due to increased cost of manual weeding, its low efficiency and non-availability of labour during critical period of growth, use of herbicides could be alternative for weed control. Among herbicides, isoproturon is recommended for weed control in this crop but its continuous use may result in the development of resistant biotypes like *Phalaris minor* in wheat. This necessitates the use of some other herbicide molecules either alone or in combination to widen the spectrum of weed control in this crop. Considering the above facts, the present investigation has been undertaken.

METHODOLOGY

A field experiment was conducted during *Rabi* season of 2013-14 at Experimental Farm of Linseed Unit, Department of Crop Improvement, CSK Himachal Pradesh KrishiVishvavidyalaya. The experiment was conducted on silty clay loam soil having pH 5.9 with medium in total available nitrogen, phosphorus and potassium. The experiment was laid out in randomized block design with nine treatments comprising of isoproturon 1.00 kg/ha, clodinafop 60 g/ha and imazethapyr 75 and 100 g/ha as post emergence and pendimethalin 1.0 kg/ha and ready mix of pendimethalin with imazethapyr 0.75 and 1.00 kg/ha as pre emergence including handweeding twice at 25 and 45 DAS and weedy check. The crop variety 'Nagarkot' was sown at 23 cm apart rows using seed rate of 40 kg/ha. The crop was supplied with 50, 40 and 20 kg N, P_2O_5 and K_2O/ha. A knapsack sprayer fitted with flat fan nozzle using 750 litres of water per hectare was used for spraying the herbicide. Data on weed growth, yield performance and economics were recorded. After maturity, the crop was harvested from the net plot area of 2.07 m x 3.0 m =6.21 m^2 and yield was expressed in kg/ha.Economics of the treatments was computed based on prevalent market prices. The market price of the produce was Rs. 28 /kg.

RESULTS

The experimental field was mainly infested with the grassy weeds, *viz. Phalaris minor, Avenaludoviciana and Loliumtemulentum. Viciasativa* and *Anagallis arvensis* were the major broad leaved weeds with less proportion. Pendimethalin 1.0 kg/ha (PE) and ready mix of pendimethalinwithimazethapyr 1.0 kg/ha (Pre.) being at par with hand weeding twice have recorded significantly lowest population and dry matter of total weeds at harvest. Clodinafop 60 g/ha (Post.) was the other best treatment in these regards which was also at par to these said superior herbicidal treatments. This was clearly reflected by higher weed control efficiencies achieved by these treatments which ranged from 88.1-81.8%.

Significantly higher plant stand/ha was recorded in pendimethalin 1.0 kg/ha (PE) treated plots, however, clodinafop 60 g/ha (PoE) and handweeding twice also behaved statistically similar to it. Pendimethalin 1.0 kg/ha (PE), ready mix of pendimethalinwithimazethapyr 1.0 kg/ha (PE) and clodinafop 60 g/ha (PoE) being at par with each other have recorded significantly higher values of different yield attributes which were statistically alike to hand weeding twice. However, except for secondary branches per plant isoproturon 1.0 kg/ha was also at par to these treatments for all other recorded yield attributes. This has contributed in getting significantly higher seed yield of linseed with pendimethalin 1.0 kg/ha (PE) and clodinafop 60 g/ha (PoE), which was statistically comparable to the yield obtained with handweeding twice (Table 1). The percent increase in the seed yield due to application of these herbicides was 91.5 and 85.9%, respectively over weedy check, while the corresponding increase with two hand weedings was 88.7%. The increase in the yield was due to better weed control with significantly higher plant stand/ha and yield attributes.

Table 1. Effect of treatments on weed count, weed dry weight, yield attributes& yield and economics of Linseed as influenced by different weed control treatments

Treatment	Weed count (no./m^2)	Weed dry matter (g/m^2)	Plant stand (000/ha)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of Cap-sule/ plant	Seed Yield (t/ha)	WCE	Net returns (x10^3 /ha)	B:C
Pendimethalin 1 kg/ha (Pre.)	4.82 (22.67)*	5.22 (26.36)*	2678	5.00	4.00	30.93	1.36	82.96	20.31	1.14
Pendimethalin + Imaz 0.75 kg/ha (Pre.)	6.48 (41.33)	6.80(45.36)	2041	4.73	3.60	27.60	1.02	70.68	10.92	0.62
Pendimethalin + Imaz 1.00 kg/ha (Pre.)	4.57 (20.00)	4.97(23.80)	2409	4.87	3.80	29.80	1.23	84.62	16.30	0.90
Isoproturon 1 kg/ha (Post.)	6.69 (44.00)	6.64(43.40)	2412	4.87	3.67	28.60	1.18	71.95	16.13	0.96
Clodinafop 60 g/ha (Post.)	5.08 (25.33)	5.38(28.02)	2635	5.13	3.73	31.27	1.32	81.89	19.63	1.13
Imazathpyr 75 g/ha (Post.)	7.45 (54.67)	7.22(51.35)	1707	4.60	3.60	28.00	0.93	66.81	8.65	0.49
Imazathpyr100 g/ha (Post.)	5.68 (31.33)	6.41(40.19)	2128	4.87	3.60	28.20	1.17	74.03	14.68	0.82
Hand weeding twice	3.78 (13.33)	4.36(18.32)	2615	5.07	3.73	31.60	1.34	88.16	14.15	0.60
Weedy check	13.35 (177.3)	12.47 (154.7)	1155	4.53	3.27	21.67	0.71	-	4.02	0.25
LSD (P=0.05)	1.05	0.97	216	0.27	0.32	3.03	0.11	-	3.01	0.17

With regard to economics, significantly higher net returns and B:C ratio over rest of the treatments was obtained with the application of pendimethalin 1.0 kg/ha (PE) and clodinafop 60 g/ha (PoE) which were at par to each other.

CONCLUSION

It was concluded that among herbicides, pendimethalin 1.00 kg/ha as pre-emergenceand clodinafoppropargyl 60 g/ha as post emergencewere most effective for controlling weeds, improving seed yield and profitability of linseed under irrigated conditions.

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Efficacy of different herbicides against weed flora in soybean

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Weed competition is one of the most important causes of low yield which estimated to be of 31-84% (Kachroo *et al*. 2003) in soybean.Reduction in the yield due to weeds varies from 35-50%, depending upon the type of weeds, their intensity and time of crop weed competition. The traditional method of weed control is expensive, tedious and time consuming. Under such circumstances, use of effective herbicides gives better and timely weed control. Hence the present investigation was undertaken.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during the *Kharif* season of 2014. The experiment was laid out in randomized block design with eight treatments replicated thrice. The experimental site was fairly uniform in topography with clayey in texture and slightly alkaline in reaction. Overall the rainfall and its distribution were satisfactory for crop. Sowing of soybean JS-335 was done on 12 July2014. Herbicidesdoses were applied as per the treatments.

RESULTS

All the herbicidal treatments significantly minimized the weed number and weed dry matter when compared with unweeded control. None of the herbicide under study showed any phytotoxicity symptoms on crop. In all parameters under study weed free treatment recorded best results but among the various herbicidal combinations lowest total weed count was observed under treatmentImazethapyr 10 SL at 0.100 kg/ha PoE + Quizalofop ethyl 5 EC at 0.050 Kg/ ha PoE 15 DAS (*Tank mix*) .This might be due to combination of both herbicides that have longer effect on controlling both monocot and dicot weed population in tank mix solution similar trend was also observed in weed dry matter and weed control efficiency. These results are in agreement with the results reported by Halvankar *et al.* (2005). Higherseed yield (q/ha), NMR (Rs/ha)was also recordedin weed free treatment followed by Imazethapyr 10 SL at 0.100 kg/ha PoE + Quizalofop ethyl 5 EC at 0.050 Kg/ha PoE 15 DAS (Tank-mix) while highest B:C ratio was also recorded in same treatment combination.

Table 1. Various parameters as influenced by weed controltreatments in soybean

Treatments	Weed population m^{-2} at harvest	Weed dry matter gm^{-2} at harvest	Weed control efficiency (%)	Seed yield (q/ha)	NMR (`/ha)	B:C Ratio
T_1: Pendimethalin 30 ECat 1.0 kg/ha PE	29.00	14.79	53.32	1845.93	30346	2.12
T_2: Quizalofop ethyl 5 EC at 0.050 kg/ha PoE 15 DAS	39.67	17.06	46.16	1751.11	27432	2.01
T_3: Imazethapyr 10 SL at 0.100 kg/ha PoE 15 DAS.	29.33	14.96	52.79	1930.37	32922	2.21
T_4: Imazethapyr 10 SL at 0.100 kg/ha PoE + Quizalofop ethyl 5 EC at 0.050 Kg/ha PoE 15 DAS (*Tank mix*)	20.33	8.34	73.68	2201.48	39820	2.39
T_5: Imazethapyr + Imazamox (*premix*) 70 WG at 0.070 kg/ha PoE 15 DAS.	26.67	12.53	60.46	1964.44	33740	2.23
T_6: Quizalofop ethyl 5 EC at 0.050 kg/ha PoE 15 DAS + Chlorimuron ethyl 25 WP at 0.010 kg/ha PoE 15 DAS (*Tank mix*)	25.67	9.31	70.62	1931.85	32851	2.21
T_7:Weed free	0.00	0.00	100	2223.70	39890	2.36
T_8: Weedy check	64.67	31.69	-	1274.07	14340	1.57
LSD P= 0.05	4.06	1.98	-	439	12829	-

CONCLUSION

Imazethapyr 10 SL at 0.100 kg/ha PoE + Quizalofop ethyl 5 EC at 0.050 Kg/ha PoE 15 DAS (*Tank mix*) was found better in controlling weeds, dry matter accumulation, weed control efficiency, seed yield, NMRand B:C ratio of soybean. Same treatment recorded 172% increase in seed yield over weedy check.

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Efficacy of different herbicides against weed flora in sunflower

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Unchecked weeds cause 33-63% losses in seed yield of sunflower (Saraswat *et al*. 2003). Pre and post emergence weed control method is becoming popular and regarded potentially as one of the most labour saving innovation in modern agriculture. Spraying of pre-emergence herbicides helps to minimize the crop weed competition during such critical growth stages resulting in higher crop yields. Hence the present investigation was undertaken.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during the *summer* season of 2014. The experiment was laid out in randomized block design with sevev treatments replicated thrice. The experimental site was fairly uniform in topography with clayey in texture and slightly alkaline in reaction. Overall the rainfall and its distribution were satisfactory for crop. Sowing of sunflower TAS-82 was done on 24 February, 2014. Herbicides doses were applied as per the treatments. Phytotoxicity symptoms due to herbicides on crop was recorded by using a visual score scale of 0-10.

RESULTS

All the herbicidal treatments significantly minimized the weed number and weed dry matter when compared with unweeded control. None of the herbicide under study showed any phytotoxicity symptoms on crop. Among the various treatments lowest total weed count was observed under treatment weed free followed by Fluazifop-p- butyl at 0.125 kg a.i/ha + Quizalofop ethyl at 0.075 kg/ha PoE 15 DAS which has recorded significantly lowest weed count at harvest. This might be due to combination of both herbicides that have longer effect on controlling both monocot and dicot weed population in sequential application similar trend was also observed in weed dry matter.Lowest weed index was also recorded in the same treatment. These results are in agreement with the results reported by Saraswat *et al.* (2003).

Table 1. Weed population m^{-2}, Weed dry matter gm^{-2}, Weed index (%) and seed yield (q/ha) as influenced by weed control treatments in sunflower

Treatments	Weed population m^{-2} at harvest	Weed dry matter gm^{-2} at harvest	Weed index (%)	Seed yield (q/ha)
T_1 - Weed free	0.71 (0.00)	0.00	-	12.34
T_2 - Weedy check	9.06 (81.67)	31.08	60.37	4.89
T_3 -MAHNA-04 at 2.5 kg/ha PE	7.31 (53.00)	19.07	35.81	7.92
T_4 - Pendimethalin at 1 kg/ha PE	6.77 (45.33)	16.35	17.50	10.18
T_5 - Fluazifop-p- butyl at 0.125 kg/ha PoE 15 DAS	6.75 (45.00)	15.84	25.93	9.14
T_6 - Quizalofop ethyl at 0.075 kg/ha PoE 15 DAS	6.82 (46.00)	17.60	24.79	9.28
T_7 -Fluazifop-p-butyl at 0.125 kg/ha + quizalofop-ethyl at 0.075 kg/ha PoE 15 DAS	6.44 (41.00)	14.35	10.77	11.01
LSD (P= 0.05)	0.25	3.97	-	1.19

Higher seed yield (q/ha) was also recorded in weed free treatment but among different chemical treatments under study highest yield was recorded under Fluazifop-p- butyl at 0.125 kg/ha + Quizalofop ethyl at 0.075 kg/ha PoE 15 DAS treatmentstatistically found at par with weed free treatment.Different weed management practices significantly improved the seed yield over weedy check; this might be due to the better weed control associated with decrease in weed population and improvement in yield contributing characters in said treatments.

CONCLUSION

Treatment combination of Fluazifop-p- butyl at 0.125 kg/ha + Quizalofop ethyl at 0.075 kg/ha PoE 15 DAS was found better in controlling weeds, dry matter accumulation, weed index and seed yield of sunflower under scarcity of labor.

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Efficacy of herbicides on quality, yield and economics of soybean

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Weeds are not controlled during critical period of weed crop competition, there is reduction in the yield of soybean from 35-50% depending upon the weed lora and density. Hand weeding is a traditional and effective method of weed control, but untimely and continues rains as well as unavailability of labour during peak period of demand, are the main limitations of manual weeding. Keeping this fact in view, the present investigation is undertaken to study the efficacy of pre-emergence and post-emergence herbicide in soybean crop and its yield attributes and yield.

METHODOLOGY

The present investigation was conducted during *kharif* 2013 at P. G. Research Farm, Agronomy Section, College of Agriculture, Dhule. Experiment consisted of nine treatments laid out in randomized block design with three replications. The different weed control treatments comprised of recommended practices: 1 HW + 2 hoeing, weedy check, pendimethalin 1.0 kg/ha at (PE), quizalofop-p-ethyl 75 g/ha at 15 DAS (POE), imazethapyr 100 g/ha at 15 DAS (POE), chlorimuron ethyl 9 g/ha at 15 DAS (POE), pendimethalin 0.75 kg/ha at (PE) + quizalofop-p-ethyl 50 g/ha at 15 DAS (POE), pendimethalin 0.75 kg/ha at (PE) + imazethapyr 75 g/ha at 15 DAS (POE) and pendimethalin 0.75 kg/ha at (PE) + chlorimuron ethyl 6.75 kg/ha at 15 DAS (POE) were used in this experiment. The soil of the experimental field was clay in the texture, with low in available nitrogen and available phosphorus and rich in available potassium.

RESULTS

The quality character like protein and oil yield, seed and straw yield of soybean was found to be significantly higher in treatment of recommended practices- 1 HW + 2 hoeing (T_2). This was followed by application of pendimethalin at 0.75 kg/ha at (PE) + imazethapyr at 75 g/ha at 15 DAS (POE) (T_6). While treatment T_6 was found at par with pendimethalin at 0.75 kg/ha at (PE) + quizalofop-p-ethyl at 50 g/ha at 15 DAS (POE) (T_4) (2503 and 3395 kg/ha). Treatments T_4 also found at par with pendimethalin at 0.75 kg/ha at (PE) + chlorimuron ethyl at 6.75 g/ha at DAS (POE) (T_8). Among the herbicide treatments tried in the experiment, application of per-emergence herbicide *i.e*. pendimethalin at 0.75 kg/ha followed by post-emergence herbicide *i.e*. imazethapyr at 75 g/ha at 15 DAS treatment was found significantly better than application of herbicide alone in respect of seed and straw yield of soybean may probably be due to better weed management resulting in improvement in all growth and sink parameters which contributed higher yield owing to favourable condition in absorbing soil moisture, nutrient content and sunlight penetration during crop period. The protein, oil, seed and stover yield was significantly lowest under weedy check treatment (T_1). However, net monetary returns were maximum under recommended practice-1 HW + 2 hoeing but lowest B:C ratio as compared to application of pendimethalin at 0.75 kg/ha at (PE) + imazethapyr at 75 g/ha at 15 DAS (POE) due to higher cost of manual labour for weeding. These results are in conformity with those of Habimana *et al*. 2013 and Jha and Soni (2013).

Table 1. Effect of different weed management treatments on quality, yield and economics of Soybean

Treatment	Protein yield (kg/ha)	Oil yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Net returns (`/ha)	B:C ratio
T_1: Weedy check	384.10	181.06	1063	1406	5211	1.24
T_2: Recommended practices	1293.39	648.14	3223	4286	42823	2.09
T_3: Pendimethalin 1.0 kg (PE)	617.71	293.04	1611	2448	14962	1.57
T_4: Pendimethalin 0.75 kg (PE) + Quizalofop-p- ethyl 50 g at 15 DAS	970.50	484.58	2503	3395	33258	2.08
T_5: Quizalofop-p-ethyl 75 g at 15 DAS (POE)	709.86	352.06	1851	2846	19935	1.73
T_6: Pendimethalin 0.75 kg (PE) + Imazethapyr 75 g at 15 DAS (POE)	1112.99	558.18	28.12	3669	40620	2.30
T_7: Imazethapyr 100 g at 15 DAS (POE)	778.85	390.84	2023	2983	24868	1.92
T_8: Pendimethalin 0.75 kg (PE) + Chlorimuron ethyl 6.75 g at 15 DAS (POE)	888.94	448.14	2297	3120	30045	2.05
T_9: Chlorimuron ethyl 9 g at 15 DAS	667.04	326.88	1748	2640	19770	1.79
CD (P=0.05)	39.44	38.99	328.48	487.24	-	-

CONCLUSION

Sequential use of per-emergence spray of pendimethalin at 0.75 kg/ha followed by post- emergence spray of imazethapyr at 75 g/ha at 15 DAS is found beneficial from economical point of view.

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Effect of different herbicides on diverse weed flora and productivity of Indian mustard

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Rapeseed and mustard are the major group of oilseed crops grown in Jammu region on a sizeable acreage in Jammu region on an area of more than 28000 ha. The average productivity of the state is 801 kg/ha in 2013-14 which is far below the national average productivity of 1176 kg/ha. Weeds are one of the major factors which cause considerable reduction in the yield of Indian mustard which ranges to an extent of 30-70% and more (Kachroo and Bazaya 2006). There are limited options available for the farmers thereby increasing the risk for development of herbicide resistance in weeds of mustard crops in the future thereby necessitating research for finding new herbicides which can be used for control of diverse weed flora of rapeseed mustard crops thereby helping in management of weeds as well as development of herbicide resistance in weeds in rapeseed mustard

METHODOLOGY

Field experiment was conducted at the Research farm, Chatha, Jammu during the *rabi* season of 2012-13 to evaluate the effect of different herbicides on diverse weed flora and yield of Indian Mustard (*Brassica juncea*) under irrigated conditions of Jammu. The experiment consisting of 12 treatments which were arranged in a randomized block design with 3 replications. The crop variety '*RSPR 01*' was sown in lines 30 cm apart with plant to plant distance of 10 cm on 25/10/2012 and harvested on 19/3/2013. The crop was raised using standard package and practices recommended for the region. Data on weed growth, yield performance and economics were recorded using standard procedure.

RESULTS

The data revealed that weeds caused 66.81% reduction in grain yield of Indian mustard when compared with weedy check plots. The major weeds present in the experimental field were *Medicagodenticulata, Euphorbia helioscopia, Phalaris minor, Ranunculusarvensis, Rumexretroflexus, Anagallis arvensis, Cirsiumarvensis, Cannabis sativa, Parthenium hysterophorus and Avenaludoviciana.*Among the different herbicides treatments, pre emergence application of oxyfluorfen at 0.15 kg/ha (PE) though being at par with either application of pendimethalin at 1.0 kg/ha (PE), pendimethalin at 0.75 kg/ha (PE)stomp extra 38.7 CS or trifluralin at 0.75 kg/ha (PPI) significantly reduced the total weed population and total weed biomass besides significant reduction in nitrogen uptake by weeds and higher weed control efficiency and lowest weed index than weedy check in comparison thereby resulting in significant increase not only in the yield attributes and nitrogen uptakeof Indian Mustardbut also the grain yield of Indian mustard. Maximum B:C ratio was observed with application of oxyfluorfen at 0.15 kg/ha. However, post emergence application of quizalofop at 0.06 kg/ha and clodinafop at 0.06 kg/ha resulted in significant control of grassy weeds only.

Table 1. Effect of different herbicides on weed density, yield and economics of India Mustard

Treatment	Total weed density (no./m^2) at 60 DAS			Weed control efficiency (%)	Grain yield (kg/ha)	Weed Index (%)	Net returns (`/ha x 10^3)	B:C ratio
	Broad leaf	Grasses	Total					
Oxidiagryl @ 0.09 kg/ha (Pre.)	6.70 (46.67)	3.37 (10.67)	7.44 (57.33)	48.81	1295	19.01	18.35	1.31
Trifluralin @ 0.75 kg/ha (PPI)	2.87 (8.00)	2.95 (8.00)	4.04 (16.00)	85.71	1487	7.00	22.58	1.55
Oxyfluorfen @ 0.15 kg/ha (Pre.)	2.49 (5.33)	1.82 (2.67)	2.95 (8.00)	92.86	1513	5.38	23.38	1.62
Quizalofop @ 0.06 kg/ha (Post)	7.10 (54.67)	2.49 (5.33)	7.51 (60.00)	46.43	1290	19.32	17.64	1.21
Clodinafop @ 0.06 kg/ha (Post)	7.46 (57.33)	3.20 (9.33)	8.09 (66.67)	40.47	1241	22.39	16.70	1.17
Isoproturon @ 1.0 kg/ha (Pre.)	3.95 (14.67)	4.24 (17.33)	5.72 (32.00)	71.43	1363	14.76	20.29	1.47
Isoproturon @ 1.0 kg/ha (Post)	4.82 (24.00)	5.0 (25.33)	6.9 (49.33)	55.96	1322	17.32	19.25	1.40
Pendimethalin @1.0 kg/ha	2.75 (6.67)	2.49 (5.33)	3.61(12.00)	89.29	1502	6.07	92.16	1.53
Pendimethalin @0.75kg./ha	4.11 (17.33)	4.57 (20.00)	6.12 (37.33)	66.67	1343	16.01	20.93	1.31
Pendimethalin (Stomp Extra 38.7 CS) @0.75 kg/ha	8.0 (2.95)	9.33 (3.20)	4.26 (17.33)	84.53	1483	7.25	22.70	1.55
Weedy check	7.61 (60.00)	7.22(52.00)	10.49 (112.00)	0.0	907	43.28	18.53	0.69
Weed free	1.0 (0.00)	1.0 (0.00)	1.0 (0.00)	100	1599	0	22.03	1.10
LSD (p=0.05)	1.98	2.28	4.26	-	122.25	-	-	-

*Figures in parenthesis are original values subject to "x+1 square root transformations

CONCLUSION

It was concluded that application of Oxyfluorfen at 0.15 kg/ha, pendimethalin at 1.0 kg/ha (PE), pendimethalinstomp extra 38.7 CS at 0.75 kg/ha (PE) and trifluralin at 0.75 kg/ha (PPI) was most effective in controlling weed flora and increasing the grain yield as well as profitability of Indian mustard in Jammu region.

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Effect of tank-mix herbicides to control weeds and enhance yield of soybean

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Soybean (*Glycine max* L.) is popularly known as miracle 'Golden bean' in twenty first century due to its high protein (40%) and oil (20%) contents and is now playing pivotal role in Indian agriculture. The crop suffers severely due to competitional stress of grasses, sedges and broad leaved weeds which causes considerable yield reduction (35-50%), depending upon the type of weeds, their intensity and time of crop- weed competition. The effectiveness and economical weed management may not be possible through manual or mechanical means due to heavy and continuous rainfall in *Kharif*, labour shortage during peek periods, high labour cost and time consuming. These problems can be overcome by the use of herbicidal weed control which is effective, easer, cheaper and faster than the conventional practices of weed control. Hence, the present investigation was undertaken with the object to study the efficacy of tank mix herbicides on weed density, weed biomass, yield attributes and yield of soybean

METHODOLOGY

The present investigation was conducted at the Product Testing Unit, Department of Agronomy during two consecutive years 2012 and 2013. The soil of experimental field was sandy clay loam analysing medium in nitrogen and phosphorus, potash content, normal in reaction and neutral in electrical conductivity. The experiment was laid out in randomised block design with five treatments (Propaquizafop (10 % EC) at 625 ml/ha, Imazethapyr (10 % SL) at 750 ml/ha, Propaquizafop (10 % EC) + Imazethapyr (10 % SL) at 625 +750 ml/ha, Hand weeding twice and Weedy Check)replicated four times. Sowing of soybean JS 97- 52 was done by using recommended agronomic practices during Kharif Season in the respective years. The herbicides Propaquizafop (10%EC) at 625ml/ha and Imazethapyr(10% SL) at 750ml/ha alone and in combination were applied as Post emergence (20DAS) through Knapsack sprayer using flat fan nozzle. Hand weeding was performed twice at 20 and 40 DAS. Observations on weeds (weed flora, species wise weed population and weed biomass) and crop (pods/plant, seeds/pod, seed index and seed yield) were recorded.Finally WCE, weed index and grain yield (q/ha) were worked out.

RESULTS

All the herbicide treatments significantly minimized the weeds density and weed dry biomass when compared with unweeded control. However, hand weeding eliminated the weed growth to the maximum extent to that of all the herbicidal treatments.Among the various treatments, application of Propaquizafop (10% EC) at 625ml/ha + Imazethapyr (10% SL) at 750 ml/ha resulted in higher seed yield.The seed yield under above treatment was significantly superior in comparison to their alone application and weedy check.However, the hand weeding twice gave the maximum grain yield over the herbicidal treatment.The higher yield under combined application of the herbicides was owing to higher WCE, minimum weed indexand higher pods/plant, Seeds/pod and seed index. Secondly the better control of weed under this treatment might have enhanced the availability of nutrients to the crop resulting in higher yield.

Table 1. Effect of Propaquizafop 10% EC + Imazethapyr 10 % SL on weed control efficiency and weed index yield attributing characters and yield of soybean (mean of 2012 and 2013)

Treatments	WCE (%)	WI (%)	Pods/plant	Seeds/pod	Seed index (g)	Grain yield (q/ha)
Propaquizafop (10 % EC) 625 ml/ha	69.98	27.22	50.56	2.06	7.62	20.34
Imazethapyr (10 % SL) 750 ml/ha	87.38	18.08	59.53	2.15	8.27	23.40
Propaquizafop (10 % EC) + Imazethapyr (10 % SL) 625 +750 ml/ha	89.52	8.51	67.25	2.26	8.89	26.41
Hand weeding twice (20 and 40 DAS)	100.00	0.00	68.59	2.31	9.56	28.60
Weedy Check (Control)	00.00	41.93	45.41	1.95	7.44	15.42
LSD (p=0.05)	–	--	0.58	0.17	0.45	3.19

CONCLUSION

Based on the two years result, it could be concluded thattank mix herbicide (Propaquizafop 10%EC at 625 ml/ha + Imazethapyr 10% SL at 750 ml/ha was found effective for control of grassy and broad leaved weeds as well as higher grain yield of Soybean.

Integrated weed management in soybean

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Soybean has emerged as a potential crop for changing the economical position of the farmers in India particularly Maharashtra. Soybean crop grows slowly during the initial period, which results into vigorous growth and proliferation of weeds. In *kharif* season, the weed competition is one of the most important causes of low yield which estimated to be of 31-84% (Kachroo *et al*. 2003). Hand weeding is traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour during peak period of demand, are the main limitations of manual weeding. Some of the post-emergence herbicides have been found effective in controlling weeds in soybean. Hence, present investigation has been carried out to find out performance of pre and post emergence herbicides for weed control in soybean.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Ramkrishna Bajaj College of Agriculture, Pipri during the *Kharif* season of 2014. The experiment was laid out in randomized block design with nine treatments replicated thrice. The experimental site was fairly uniform in topography with clayey in texture and slightly alkaline in reaction. Overall the rainfall and its distribution were satisfactory for crop. Sowing of soybean JS-335 was done on 26 July 2014. Herbicides doses were applied as per the treatments. Phytotoxicity symptoms due to herbicides on crop was recorded by using a visual score scale of 0-10. The observation recorded from 1 m^2 area from each plot at 20, 40, 60, 80 DAS and at harvest.

RESULTS

The major weed flora during kharif season in soybean crop in the selected area comprised of weed species viz;,*Commelina benghalensis, Dinebra Arabica, Poa annua,Echinochloa crusgalli, Eragrostis major, Cynodon dactylon,Cyperus rotundus, Lagasca mollis, Euphorbia hirta, Digeraarvensis, Tridex procumbense, Parthenium hysterophorus,Celosia argentea, Euphorbia geniculata, Alysicarpusrugosus, Alternanathera triandra, Xanthium strumarium,, Portulaca oleracae, Amaranthis viridis*. None of the herbicide under study showed any phytotoxicity symptoms on crop. Among the various treatments lowest total weed count, weed control efficiency was observed under treatment Imazethapyr at 0.100 Kg/ha *fb* 1HW 35 DAS. The highest seed yield was also recorded in treatment Imazethapyr at 0.100 Kg/ha *fb* 1HW 35 DAS over control, this might be due to the better weed control associated with decrease in weed population.

Table. Various parameters as influenced by weed control treatment in soybean

Treatments	Weed control efficiency (%)	Seed yield	B:C Ratio
T_1 - weedy check	-	7.00	1.19
T_2 - Recommended 1H 15 DAS *fb* 1HW 35 DAS	72.37	13.68	1.87
T_3 – Pendimethalin @ 1.0 kg/ha	47.69	10.23	1.54
T_4 – Fenoxyfop ethyl @ 0.075 kg/ha	61.96	12.05	1.76
T_5 - Quizalofop ethyl @ 0.075 kg/ha	55.33	11.24	1.65
T_6 – Imazethapyr @ 0.100 kg/ha	66.70	13.28	1.92
T_7 – Fenoxyfop ethyl @ 0.075 kg/ha *fb* 1 HW 35 DAS	75.88	14.42	1.86
T_8 - Quizalofop ethyl @ 0.075 kg./ha *fb* 1 HW 35 DAS	73.89	14.01	1.75
T_9 – Imazethapyr @ 0.100 kg/ha *fb* 1 HW 35 DAS	78.65	16.80	2.15
C.D. at 5%	-	2.70	-

CONCLUSION

Treatment Imazethapyr at 0.100 Kg a.i./ha *fb* 1HW 35 DAS was found better in controlling weeds, dry matter, weed control efficiency and seed yield of soybean under scarcity labour.

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Diversification of herbicide use for effective weed control and enhancing productivity of Indian mustard

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Indian mustard {*Brassica juncea* (L.) Czernj. &Cosson} is a major crop of rapeseed-mustard group, which occupy more than 75% of the area under this group of crops. Moreover, there is need to identify herbicides for post-emergence use in this crop, as due to busy schedule of sowing of winter season crops, farmers fail to spray the pre-emergence herbicide within the time frame and due to dry surface soil, pre-emergence application of pendimethalin may not be very effective.Keeping these aspects in view present study was conducted.

METHODOLOGY

A field experiment was conducted during the winter (*rabi*) seasons of 2011–12 and 2012–13, at the Division of Agronomy, Indian Agricultural Research Institute, New Delhi, under AICRP on Rapeseed-mustard to evaluate pre and post-emergence herbicides for weed control in Indian mustard.Crop was grown under recommended practices except weed management treatments. Of the various herbicides, trifluralin at 0.75 kg/ha as pre-plant incorporation, pendimethalin at 1kg/ha, oxyfluorfen at 0.15 kg /ha and isoproturon at 1.0 kg/ha as pre-emergence whereas oxadiargyl at 0.09 kg/ha,quizalofop at 0.06 kg/ha (25-30 DAS), isoproturon at 1.0 kg/ha (30 DAS)and clodinafop at 0.06 kg /ha (25-30 DAS) were applied as post emergence. In addition to herbicides spray, weedy check and weedy free treatments were also included. Observation s pertaining to weed flora, and dry weight were recorded at 50 days after sowing. Yield attributes were recorded based on three plant random sampling, seed yield, stover and biological yields were recorded based on net plot and converted into yield/ha basis.

RESULTS

Of the various herbicides used, application of quizalofop at 0.06 kg/ha (25-30 DAS) recorded seed and biological yield at par with weed free maintained with 3 intercultural operations, followed by application of clodinafop at 0.06 kg/ha (25-30 DAS (Table 1). Application of trifluralin at 0.75 kg/ha (PPI) and isoproturon at 1.0 kg/ha P.E recorded seed yield at par with weedy check. It was also observed that higher seed yield of quizlofop and clodinafop in Indian mustard is attributed to its weed control efficiency as well as growth promoting effect of these herbicides on the crop. Dominant weed flora was *Chenopodium* sp., *Cyprus rotundus*, *Cirsiumarvense*, *Melilotusindica* and *Lathyrus* sp. Pre-emergence application of trifluralin was not found effective in controlling weeds, while phyto-toxicity on crop was observed in case of post-emergence application of isoproturon.

Table 1. Effect of chemical weed control on the seed and biological yield of Indian mustard

Treatment	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Pendimethalin (30 EC) at 0.75 kg/ha (P.E.)	2086	8553	24.07
Pendimethalin(30 EC) at 1.00 kg/ha (P.E.)	2098	8514	24.63
Pendimethalin(38.7 EC) at 0.75 kgha (P.E.)	2159	8638	25.06
Oxadiargyl (80 WP) at 0.09kg/ha	2159	8762	24.73
Trifluralin (48 EC) at 0.75 kg/ha (PPI)	2121	8747	24.93
Oxyfluorfen (23.5 EC) at 0.15 kg/ha (PE)	2190	8947	24.41
Quizalofop (5 EC) at 0.06 kg/ha (25-30 DAS	2437	9749	25.07
Clodinafop (15 WP) at 0.06 kg/ha (25-30 DAS	2406	9687	24.84
Isoproturon (50WP) at 1.0 kg/ha P.E.	2221	8885	25.13
Isoproturon (50WP) at 1.0 kg/ha (30 DAS)	2283	9193	24.85
Weedy Check	1915	8121	23.06
Weed free (Three intercultural operation)	2499	9872	25.30
LSD (P=0.05)	116	473	NS

CONCLUSION

Based on the study it is concluded that post-emergence application of quizalofoporclodinafop at 0.06 kg/ha (25-30 DAS), are equally effective with weed free inIndian mustard.

Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean

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Soybean (*Glycine max* (L) Merrill) is called 'Miracle crop' of the 21st century because of its multiple uses. Being a rainy season crop, it suffers severely due to weed stress.If weeds are not controlled during critical period of crop-weed competition; there is identical reduction in the yield of soybean from 58-85%, depending upon the types and intensity of weeds (Kewat *et al.* 2000). Imazethapyr is widely used as post-emergence herbicide for controlling weeds in soybean to a level of satisfaction (Patel *et al.* 2009). However, its efficacy has not been tested with propaquizafop for wide spectrum weed control in soybean under agro-climatic conditions of Jabalpur and other parts of the country. Therefore, a comprehensive field studies wascarried out to adjudge the efficacy of propaquizafop and imazethapyr mixture against weeds in soybean.

METHODOLOGY

A field experiment was carried out during Kharif seasonof 2014 atJNKVV, Jabalpur (M.P.) to judge the efficacy of propaquizafop and imazethapyr mixture against weeds in soybean. Nine treatments comprising of four doses of propaquizafop + imazethapyr mixture (47 + 70, 50 + 75, 53 + 80, 56 + 85g/ha), alone application of propaquizafop (75 g/ha), imazethapyr (100g/ha) and pendimethalin(1000 g/ha), hand weeding twice (20 and 40 DAS) including weedy check, were laidout in randomized block design with three replications. Data on weeds, crop yield and economics were taken using standard techniques

RESULTS

soybean grassy weeds were predominant (65.15%) compared to broad-leaved (23.51%) and sedges (11.34%). *Echinochloa colona* (34.61%) was pre-dominant among the grassy weeds. Herbicidal treatments significantly influenced the density and dry weight of weeds. Among the herbicidal treatments, the reduction in weed density and weed biomass was less when propaquizafop was applied with imazethapyr at low dose (47 + 70 g/ha) but the values of both the parameters were increased identically with the corresponding increase in dose of both the herbicides in mixture being maximum when propaquizafop and imazethapyr mixture was applied at 53 +80 g/ha or higher dose(56 + 85g/ha)and proved significantly superior over weedy check, other mixtures including both the check herbicides propaquizafop 75g/ha and imazethapyr 100g/ha. However, none of the herbicidal treatments whether applied alone and in combination, surpassed the manual hand weeding twice which curbed the weed growth to the maximum extent (98.87%). The unchecked weed growth throughout the season, caused 63.06% reduction in yield of soybean but reduction was checked when weeds were controlled mechanically or chemically. The reduction in yield was checked appreciably (6.89 and 7.95%) when propaquizafop was applied along with imazethapyr at 5 3+ 80 g/ha or at higher dose (56 + 85 g/ha) and these proved practically at par to that of hand weeding twice(20 and 40 DAS). Seed and stover yields including B:C ratio of soybean were minimum when weeds were not controlled throughout the crop season. However, these parameters were superior under propaquizafop and imazethapyr mixture applied at the rate of 53 + 80 g/ha and proved significantly superover weedy check, alone application of propaquizafop(75g/ha), imazethapyr(100g/ha), pendimethalin (1000g/ha) and lower doses ofpropaquizafop+imazethapyr(47+70and 50+75g/ha) but found at par to higher dose ofpropaquizafop + imazethapyr (56 + 85 g/ha) including hand weeding twice.

Table 1. Weed growth, yield and economics of soybean as influenced by different weed control treatments

Treatment	Dose (g/ha)	Weed density (no./m^2)	Weed biomass (g/m^2)	Weed control efficiency (%)	Weed index	Seed yield (t/ha)	Stover yield (t/ha)	B:C ratio
Propaquizafop+Imazethapyr	47+70	11.62(134.67)*	14.41(207.08)*	61.34	33.00	1.59	3.45	2.15
Propaquizafop+Imazethapyr	50+75	10.81(116.33)	13.25 (175.13)	67.30	22.86	1.83	3.99	2.46
Propaquizafop+Imazethapyr	53+80	9.63(92.33)	11.79(138.53)	74.14	7.95	2.19	4.32	2.91
Propaquizafop+Imazethapyr	56+85	8.15(66.33)	9.95(98.60)	81.59	6.89	2.21	4.35	2.92
Propaquizafop	75	11.71(136.67)	14.19(200.99)	62.48	41.44	1.39	3.18	1.97
Imazethapyr	100	11.14(123.67)	14.04(196.71)	63.27	37.54	1.48	3.35	2.02
Pendimethalin	1000	13.04(169.67)	15.77(248.16)	53.67	50.28	1.18	2.71	1.58
Hand weeding	At(20&40 DAS)	4.05(16.00)	2.56(6.07)	98.87	0.00	2.38	4.57	2.23
Weedy check	-	16.73(279.33)	23.15(535.63)	0.00	63.06	0.88	2.44	1.32
SEm ±	-	0.12	0.09	-	-	1.47	2.31	-
CD at 5%	-	0.36	0.28	-	-	4.40	6.93	-

CONCLUSION

It is concluded that post-emergence application of propaquizafop + imazethapyr mixture at 53 + 80 g/ha was most remunerative for controllingweeds insoybean.

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Integrated weed management in soybean + pigeonpea intercropping system

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Soybean is mainly grown in rainy (*kharif*) season. Weed is a serious problem for the crop. Among the various factors responsible for low productivity of soybean, weed infestation during early stages of crop growth is one of the major factors. Weed infestation in soybean results in a less to the extents of 79% (Reddy *et al.* 1990). Soybean growth and seed yield are seriously affected if weeds are not controlled at initial stages (Bhan 1994). Intercropping of oilseeds cereal and legume increases yield on one hand and the soil fertility on the other Chaubey *et al*. (2000) recorded a saving of 25% nutrients through intercropping on *kharif* season.

METHODOLOGY

A field experimental was conducted at National AgriculturalResearch Project,College of Agriculture, Dhule during 2006-07 2007-08, 2008-09, and 2009-10, to study the Integrated weed management in soybean+ pigeon pea (3:1) intercropping system. A randomized block design with three replication was adopted. The treatment details are given in table 1. The plot size was Gross 5.00 x 4.80 m and Net 4.60 x 3.60m. with soybean 30 x 10 cm and pigeon pea 60 x 20 spacing between row to row and plant to plant. The soil was black cotton soil (vertisol) having 292 kg/ha in available N, 22 kg/ha in available P_2O_5 and 664 kg/ha high in K_2O with P_H 7.8.

RESULTS

The weed free intercropping (upto 45 DAS) of soybean+ pigeon pea (3:1) treatment recorded significantly highest soybean equivalent yield followed by treatment Pendimethalin pre emergence at 1.0 kg/ha + hoeing at 20DAS + 1H.W. at 45 DAS and one hoeing at 20 DAS + 1H.W.30 DASwhich were at parover the season.

Among the integrated weed management treatments Pendimethalin pre emergence at 1.0 kg/ha +hoeing at 20 DAS +1 H.W. at 45DAS gave significantly highest soybean equivalent yield (2881 kg/ha) than rest of the treatments except treatment Fluchlorin PPI at 1.0 kg/ha+2 hoeing at 20 and 40 DAS.

The weed free intercropping (upto 45 DAS) of soybean+ pigeon pea (3:1) treatment recorded significantly highest gross monetary, net monetary returns and B:C ratio (Rs. 71982, Rs. 47733/ha, 3.37) followed by treatment Pendimethalin pre emergence at 1.0 kg/ha + hoeing at 20 DAS + 1H.W. at 45DASand one hoeing at 20 DAS + 1 H.W. 30 DASwhich were at par over the season. Among the integrated weed management treatments Pendimethalin pre emergence at 1.0 kg/ha +hoeing at 20DAS+1H.W. at 45DAS gave significantly highestgross monetary, net monetary returns and B:C ratio (Rs.62725, Rs.36326/ha, 3.37)than rest of the treatments except treatment Fluchlorin PPI at 1.0 kg/ha+2 hoeing at 20 and 40 DASandFluchlorin PPI at 1.0 kg/ha which were at par.

Table 1. Soybean grain equivalent yield, Gross, Net Monetary Returns, B: C ratio, Dry weed weight, Weed Index and Weed control Efficiency as influenced by various Integrated Weed Management Treatments

Treatment	SEY kg/ ha	GMR `/ ha	NMR ` /ha	B:C ratio	Dry weed weight (kg /ha)	Weed index (%)	Weed control efficiency (%)
T_1: Weedy check (sole soybean)	1222	24665	8122	1.62	1156	45.85	00
T_2: Weed free sole soybean (upto 45 DAS)	2120	45794	25496	2.37	00**	00**	100**
T_3: Weedy check inter cropping	1531	33190	12946	2.13	1120	53.09	00
T_4: Weed free inter cropping (upto 45 DAS)	3005	71982	47733	3.37	00**	00**	100**
T_5: One hoeing at 20 DAS + 1H.W. 30 DAS	2750	59925	37443	3.25	576	15.41	47.27
T_6: Pendimethalin pre emergence at1.0 kg/ha	2268	49314	27500	3.00	768	30.51	24.18
T_7:Fluchoraline PPI emergence at1.0 kg/ha	2126	46122	24516	2.76	733	34.63	23.48
T_8: Pendimethalin pre emergence at1.0 kg/ha+ 2 hoeing at 20 DAS & 40 DAS	2458	54563	29068	2.89	449	24.11	31.85
T_9: Fluchoraline PPI emergence at1.0 kg/ha + 2 hoeing at 20 DAS & 40 DAS	2464	53550	30830	2.84	563	30.71	36.14
T_{10}Pendimethalin pre emergence at1.0 kg/ha+ hoeing at 20 DAS + H.W. at 45 DAS	2881	62725	36327	3.12	550	14.35	35.63
T_{11}: Fluchoralin PPI emergence at1.0 kg/ha + 1 hoeing at 20 DAS + 1 H.W. at 45 DAS	2355	51129	27188	2.57	510	28.90	37.95
LSD (P=0.05)	563	15078	13370	0.99	431	20.26	18.34

In the inter cropping of soybean+ pigeon pea (3:1) cropping system the significantly highest dry weed weight was recorded with weedy check followed bytreatmentFluchlorin PPI at1.0 kg/ha and Pendimethalin pre emergence at 1.0 kg/ha.

Among theinter cropping treatment the weed free treatment recorded significantly lowest weed index (0.00) followed by Pendimethalin pre emergence at 1.0 kg/ha + hoeing at 20 DAS + 1 H.W. at 45 DAS and one hoeing at 20 DAS + 1 H.W. 30 DASwhich were at par over the season.

The weed free treatment up to 45 DAS recorded significantly highest Weed control efficiency (100%). Among the integrated weed management treatmentsFluchlorin PPI at 1.0 kg/ha + 1 hoeing at 20 and 1H.W. at 45DAS recorded numerically highest weed control efficiency. All the integrated weed management treatments are at par with each other.

CONCLUSION

The cultivation of the intercropping of soybean+ pigeon pea (3:1) weed free upto 45 DAS recorded significantly highest soybean equivalent yield, gross monetary, net monetary returns and B:C ratio than other treatments followed by Pendimethalin pre emergence at 1.0 kg/ha + hoeing at 20 DAS + 1H.W. at 45DAS.

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Effect of chlorimuron-ethyl against weed flora in soybean

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Soybean is a crop of multiple qualities as it is both a pulse and oilseed crop. It is third largest oilseed crop of India after rapeseed-mustard and groundnut. Being a *kharif* season crop, it suffers from severe infestation of weeds which rob it of essential nutrients, space and moisture, causing substantial loss in yield (33-55%) depending on the weed flora and density Reference missing.The competitionstress between weeds and crop for the nutrients, water, light and space are responsible for poor yield of soybean. The stress is mainly due to presence of annual grassy weeds, *viz. Echinochloa colonum, Echinochloa crusgalli, Cyperus rotundus, Cynodondactylon, Cyperus iria* and dicot weeds such as *Phyllanthusniruri, Euphorbia spp., Commelinabengalensis, Eclipta alba and Corcorusacutangulus etc*. (Sharma and Shrivastava 2002).Hand weeding is widely practiced for eliminating the weeds, though it is costly and time consuming. Hence, since last two decades chemical weed control has become the potential tool for curbing the weed menace. Use of Chlorimuron-ethyl 25% WP as early post-emergence is very common to get rid of weed notoriety in soybean.

METHODOLOGY

The experiment carried out in *kharif* season 2012,on clayey soil which was neutral in reaction, medium in organic carbon, available nitrogen and phosphorus and high in available potassium. The investigation was aimed to study the effect of chlorimuron-ethyl against weed flora in soybean(variety JS 97-52). The experimental area has the natural weed flora comprising of grassy as well as broad leave weeds. Nine treatments comprised of chlorimuron-ethyl 12, 24, 36, 48 and 72 g/ha, weed free treatment (Hand weeding at 20 and 40 DAS), mechanical weeding at 20 DAS, combined application of Chlorimuron-ethyl 24 g/ha + mechanical weeding, and weedy check were laid out in RBD with three replications.

RESULTS

Pre-dominant weed infesting the soybean crop were *Echinochloa colona, Cyperus iria* among monocot while *Alternanthera philoxiroides, Eclipta alba, Commelina benghalensis and Phyllanthus niruri* among the dicot weeds. Application of Chlorimuron-ethyl 24 g/ha as early post-emergence along with mechanical weeding was most effective in paralyzing the weed growth to that of chlorimuron-ethyl (12, 24, 36, 48 and 72 g/ha) and mechanical weeding at 20 DAS.After the application of the herbicide weeds are controlled. But, in weedy check plots highest intensity of monocot weeds were recorded at 45 DAS and harvest. Among monocot *Echinochloa colona (26.27* and 21.18%) was the most dominant weed followed by *Cyperus iria* (11.59 and 14.70%) at 45 DAS and harvest respectively, whereas dicot weeds like *Eclipta alba* (9.34 and 12.58%), *Commelina benghalensis* (4.82 and 8.91%), *Alternanthera philoxiroides* (16.37 and 14.89%) and other weeds (31.61 and 23.65%) were present in lesser number in soybean ecosystem.

Table 1. Effect of weed control treatments on weed biomass, weed control efficiency and weed index in soybean.

Treatment	Weed biomass (g/m^2)		Weed control efficiency (%)		Weed index
	45 DAS	At harvest	45 DAS	At harvest	
Chlorimuron-ethyl 12g/ha	19 (59.4)	23.3 (89.9)	76.2	71.9	30.2
Chlorimuron-ethyl 24g/ha	18 (52.7)	22.1 (80.5)	78.9	74.8	12.4
Chlorimuron-ethyl 36g/ha	17.5 (52.1)	21.6 (77.2)	79.2	75.8	11
Chlorimuron-ethyl 48g/ha	16.9 (48.8)	21(72.9)	80.5	77.2	10.4
Chlorimuron-ethyl 72g/ha	16.5 (46.8)	20.6 (70)	81.3	78.1	9.7
Hand weeding (20 and 40 DAS)	4.3 (0.00)	8.1 (8.5)	100	97.3	0
Mechanical weeding (20 DAS)	17.4 (52)	21.7 (78.2)	79.2	75.5	12.2
Chlorimuron-ethyl 24g/ha + MW (40 DAS)	15.6 (42.5)	20.1 (66.3)	83	79.2	5.3
Weedy check	38.8 (250)	43.9 (319.8)	0	0	36
SEm±	0.02	0.02	-	-	-
LSD (P=0.05)	0.04	0.06	-	-	-

Application of Chlorimuron-ethyl herbicide at 24 g/ha as early post-emergence along with mechanical weeding was significant superior for growth parameters, yield attributes and seed yield (1.608 t/ha) of soybean than rest of the treatments and also found more remunerative in terms of NMR (Rs 20023.8) and B:C ratio (2.06) than application of Chlorimuron-ethyl herbicide at 12 g/ha to 72 g/ha, as early post-emergence.

CONCLUSION

Application of Chlorimuron-ethyl 24 g/ha as early post-emergence along with mechanical weeding was most effective in paralyzing the weed growth to that of rest of treatments.

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Canopy height-to-row spacing ratio as a simple and practical on-site index to determine the time for terminating *Ipomoea coccinea* control in soybean

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The alien annual *Ipomoea coccinea* has invaded soybean (*Glycine max* [L.] Merr.) fields and is causing serious weed problems in Japan, which reduce the yield up to 40-50%. The most problematic characteristic of *I. coccinea* is the consecutive emergence of seedlings during the soybean-growing season, which makes it difficult for growers to determine whether further weed control is needed. Thus, we tried to identify an on-site measurement that can serve as an index to determine the time for terminating *I. coccinea* control.

METHODOLOGY

Field experiments were conducted at the NARO Agricultural Research Center in 2010 and 2011. Two experimental fields (HA9 and NB2) were prepared for 2-row spacing experiments. In 2010, 60-cm row spacing was used in HA9, while in NB2 the row spacing was 36 cm. Conversely, in 2011 60-cm row spacing was used in NB2, while in HA9 the row spacing was 36 cm. In each experiment, soybeans (cv. '*Hatayutaka*'; determinate growth-habit type) were seeded at 3 different times (June, July, and August). The intra-row spacing was 15 cm for all plots.Along with soybean seeding time and row spacing, seeding time of *I. coccinea* after soybean seeding was also tested. Seeds were planted in 3 randomly selected areas within each soybean plot at 0, 5, and 7 weeks after soybean seeding (WAS) in 2010, and every week between 0 and 7 WAS in 2011. In each plot area, 10 seeds of *I. coccinea* were manually seeded at a depth of 1.5 cm in the middle of inter-row spacing with a space of 5 cm between seeds. In each treatment, plant height and main-stem length of 10 randomly selected soybean plants were measured at 3 randomly selected areas every week. The relative photosynthetic photon flux densities (PPFD) were obtained by measuring the PPFD at the soil surface in the middle of the inter-row, and outside the soybean, between 11:30 to 12:30 am, once per week.

RESULTS

In the 60-cm row spacing, all *I. coccinea* plants seeded at 6 WAS died. The difference in frequency distribution of the relative PPFD (photosynthetic photon flux density) under the canopy at seedling emergence between fates (Alive and Dead or Weak) of *I. coccinea* seedlings was shown. To determine the cut-off point for the relative PPFD at emergence, and thereby evaluate seedling fate, we performed linear discriminant analysis between 'Alive', and 'Weak' or 'Dead'. Thus, *I. coccinea* seedlings emerging at a relative PPFD of <49% were unable to grow normally; most of these seedlings eventually died.

Although it may be important for growers to know when relative PPFD reaches 49%, the WAS at the time varied between 3 and 7 and was affected by row spacing. Canopy height and main stem length were compared among all plots, except August plots. In order to reduce the effect of row spacing, canopy height-to-row spacing ratio (CHRSR) and main stem length-to-row spacing ratio (MSLRSR) at a relative PPFD of 49% were also compared. As a result, coefficient of variation (CV) for CHRSR was lower than that of other traits. In addition, the mean CHRSR of 1.05 is a convenient value for growers to terminate *I. coccinea* control when canopy height reaches a value equal to row spacing value.Although the WAS at a relative PPFD of less than 49% was also significantly variable between cultivars, CHRSR values did not differ significantly between cultivars.

CONCLUSION

In general, growers can terminate *I. coccinea* control in soybean fields when relative PPFD is approximately 50% using CHRSR of 1.0 as an on-site index, although fine adjustments may be needed based on the soybean growing system that used.More detailed information about this study will be available in a very new paper currently in press (Kurokawa *et al.* 2015).

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Efficacy of weed management techniques in sesame

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Sesame is cultivated from rainy season to irrigated situations under various agro-climatic regions with heavy losses from weeds. The yield losses on the black soils of high rain fall areas are very high and weeds completely suppressthe Sesame crop to such an extent that only weeds are visible with no signs of Sesame plants and the yield loss is complete. The weeds problem is very high in Madhya Pradesh, Uttar Pradesh, Gujarat and Maharashtra during kharif season where management is minimal to very low. The problem during continuous and cyclonic rains during seedling stage will be very high.

METHODOLOGY

To develop effective weed control methods various techniques involving conventional hand weeding to new herbicides combinations are tried at Jabalpur and other centers, since location specific special modules are needed for various agro production situations of sesame growing seasons and regions.

RESULTS

The dominant weed flora in rainy season are *Commelina benghalensis, Phyllanthus niruri, Physalis minima, Ageratum conyzoides* the broad leaved weeds; *Cynodon dactylon* of grasses and *cyprus rotundus* among sedges. During semi rabithe broad leaved weeds are *Melilotus* species, *Anagallis arvensis*, *Chenopodium album*; grasses *cynodon dactylon* and sedges *cyprus rotundus*. The critical period of weed competition is from 15-45 days.

Effect of weeds on seed yield and weed index indicated **w**eed free up to 15 DAS resulted in seed yield of 668 kg/ha with weed index 42.4 %; Weed free up to 30 DAS - yield 960 kg/ha - weed index 17.2 %; Weed free up to 45 DAS - yield 1122 kg/ha - weed index 3.2 %; Weed free up to 60 DAS - yield 1138 kg/ha - weed index 1.8 %; Weed free up to 75 DAS - yield 1146 kg/ha - weed index 1.1%.

In another experiment revealed weed infestation up to 15 DAS gave seed yield 1058 kg/ha with weed index 8.7%; Weed infestation up to 30 DAS - yield 932 kg/ha - weed index 19.6%; Weed infestation up to 45 DAS- yield 762 kg/ha - weed index 34.3%; Weed infestation up to 60 DAS - yield 624 kg/ha - weed index 46.2%; Weed infestation up to 75 DAS - yield 498 kg/ha - weed index 57.0 %; Weed free up to harvest- yield 1159 kg/ha; Weed infestation up to harvest - yield 422 kg/ha with weed index 63.6 %.

Weed management treatments on disease incidence and seed yield exhibited weedy check - weed no/m^2 371 - weed dry weight 4470 kg/ha - disease incidence 11.0% - yield 80 kg/ha; Hand weeding 15 and 30 DAS- weeds 103 no/m^2 - weed dry weight 1560 kg/ha - weed control efficiency - 65.1% - disease incidence - 8.0% - yield 398 kg/ha; Mechanical weeding at 20 and 35 DAS - weeds 194 no/m^2 - weed dry weight 3020 kg/ha - weed control efficiency 32.4% - disease incidence 8.5% - yield 218 kg/ha; Pendimethalin 1.5 kg/ha - weeds 266 no/m^2 - weed dry weight 3540 kg/ha - weed control efficiency 20.8% - disease incidence 8.5% - yield 137 kg/ha; Pendimethalin 1.25 kg/ha + Mechanical weeding at 35 DAS - weeds 185 no/m^2 - weed dry weight 2530 kg/ha - weed control efficiency 43.4% - disease incidence 8.0% with yield 274 kg/ha.

At Amreli mean of 3 years unweeded check exhibited weed dry weight 3731 kg/ha with yield 336 kg/ha; Hand weeding at 20 and 30 DAS - weed dry weight 1002 kg/ha - yield 1229 kg/ha; Alachlor 1.5 kg/ha + 1 Hand weeding at 30 DAS - weed dry weight 1225 kg/ha - yield 1116 kg/ha; Pendimethalin 1 kg/ha + 1 Hand weeding at 30 DAS - weed dry weight 2029 kg/ha - yield 845 kg/ha; Metalachlor 2 kg/ha + 1 Hand weeding at 30 DAS - weed dry weight 2166 kg/hawithyield 883 kg/ha.

In another trial results revealed weedy check with yield 185 kg/ha - NMR 173 /ha - BCR 0.98% ; Two hand weedings - 20 and 40 DAS - yield 510 kg/ha- NMR 9062 - BCR 1.69 - WCE 82.0%; Oxyflurofena.i. 0.15 kgha - yield 495 kg/ha - NMR 10354 /ha - BCR 1.93 % - WCE 48.4%; Pendimethalina.i. 0.5 kg/ha + 1 Hand weeding at 40DAS - yield 485 kg/ha - NMR 8617 /ha - BCR 1.69% - WCE 66.3%; Oxyflurofen 0.15 kg/ha + 1 Hand weeding at 40 DAS - yield 500 kg/ha - NMR 9239 Rs/ha - BCR 1.74% - WCE 62.6% respectively.At Jalgaon, it was observed hand weeding + hoeing at 20 and 30 DAS - yield 1239 kg/ha - GMR 26519 Rs/ha - BCR 6.64%; Hand weeding - 20 and 30 DAS - yield 1098 kg/ha - GMR 23705 Rs/ha - BCR 6.26%; Only hoeing at 20 and 30 DAS- yield 1076 kg/ha - GMR 22870 Rs/ha - BCR 6.22%; Pendimethalin + 1 Hand weeding at 30 DAS - yield 937 kg/ha - GMR 20176 Rs/ha - BCR 4.90%; Metalachlor + 1 Hand weeding at 30 DAS - yield 884 kg/ha - GMR 19093 Rs/ha - BCR 4.59%; Unweededcheck- yield 441 kg/ha - GMR 9833 Rs/ha - BCR 3.17% respectively.

In another experiment at Mandore, indicated hand weeding at 20 and 30 DAS - yield 710 kg/ha - NMR 9090 Rs/ha - BCR 3.1%; Alachlor 1.5 kg/ha + 1 Hand weeding at 30 DAS - yield 670 kg/ha - NMR 8180 Rs/ha - BCR 2.8%; Alachlorgranules 20 kg/ha + Hand weeding at 30 DAS - yield 713 kg/ha - NMR 8697 /ha - BCR 2.8%; Unweededcheck- yield 289 kg/ha - NMR 2491 Rs/ha - BCR 1.83% respectively.

CONCLUSIONS

The results revealed two hand weedings/hoeings to be more economical followed by *Pendimethalin*, *Alachlor*or *Oxyflourofen* chemical weedicides for sesame.

Nutrient uptake studies in soybean under weed management and sulphur nutrition

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Soybean is the third largest oil seed crop of India after rapeseed-mustard and groundnut. It plays a pivotal role in meeting the increasing demand of edible oil across the world. Inspite of its high yield potential its productivity is deplorably low in India. Among the factors responsible for low productivity of this crop, inadequate weed management and nutrition are important ones. Yield reductions in soybean due to poor weed management ranges from 35-80% depending on weed flora and their density (Gupta *et al*. 2006). Sulphur fertilization in legumes in general and oil seeds in particular is of prime importance in exploiting genetic potential of these crops which is the fourth major plant nutrient among essential elements. Since the area specific adequate information on post emergence herbicides alone and in combination with hoeing and weeding together with sulphur nutrition is meagre, hence it was felt necessary to conduct an experiment keeping these facts under considerations.

METHODOLOGY

A field experiment on weed management and sulphur nutrition was conducted at Instructional Farm of Rajsthan College of Agriculture, Udaipur (Rajasthan, India) which is consisted of six weed management treatments (weedy check, hoeing and weeding twice 20 and 40 DAS, Chlorimuron ethyl 9 g/ha 15 DAS alone and in combination with hoeing and weeding 40 DAS, Imazethapyr 100 g/ha 15 DAS alone and in combination with hoeing and weeding 40 DAS) and three levels of sulphur (0, 20 and 40 kg/ha supplied through mineral gypsum) thereby, making 18 treatment combinations laid out in Factorial RBD replicated thrice using soybean variety JS 335 in plot size of 5 x 3m.

RESULTS

All the weed control treatments significantly enhanced uptake of N, P and S by the crop compared to weedy check and the highest being recorded under hoeing and weeding twice at 20 and 40 DAS closely followed by imazethapyr 100 g/ha 15 DAS + hoeing and weeding at 40 DAS which might be ascribed to higher weed control efficiency corresponding to 80.39 and 77.04 per cent, respectively under these treatments (Table 1). Higher weed control efficiencies under both these treatments resulted less uptake of nutrients by the weeds thereby resulted into availability of more nutrients for the crop which subsequently resulted into more favourable environment for growth, development and yield of crop plants. Contrary, the uptake of these nutrients by the weeds significantly reduced under all the weed control treatments compared to weedy check. The minimum depletion of N, P and S to the tune of 15.84, 2.38 and 0.90 kg/ha by the weeds was observed in two hoeing and weeding at 20 and 40 DAS closely by imazethapyr 100 g/ha 15 DAS + hoeing and weeding 40 DAS with the corresponding N, P and S uptake values as 18.52, 2.78 and 1.04 kg/ha as against the maximum depletion of these nutrients recorded under weedy check. The uptake of N, P and S by the weeds was estimated as 66.45, 72.71 and 59.26%, respectively of the total removal (weeds + crop) in weedy check and only 11.0, 14.96 and 9.10 and 13.23, 18.0 and 10.95% each of N, P and S under hoeing and weeding twice and imazethapyr 100 g/ha 15 DAS + hoeing and weeding 40 DAS, respectively. Thus, saving of 55.45, 57.75 and 50.16 and 53.22, 54.71 and 48.31% N, P and S was observed, respectively owing to hoeing and weeding twice and imazethapyr 100 g/ha 15 DAS + 40 DAS, respectively component to weedy check.

Data in Table 1 further indicate that except uptake of N by the weeds under the influence of 20 and 40 kg S application, uptake of N, P and S by the crop as well as weeds were increased significantly with each successive increase in S application. The per cent increase in N, P and S uptake by crop and weeds due to 20 kg S/ha over without S application was 14.54, 14.06, 15.66 and 7.39, 10.20, 15.72, respectively while the corresponding per cent increase in uptake of these nutrient under 40 kg S application was 32.94, 33.13, 31.33 and 12.02, 19.07, 30.82, respectively. Increase in uptake of nutrients due to S application might be probably due to improvement in nutritional environment of plants owing to greater availability of nutrients from soil and later on their higher extraction by roots and translocation to plant parts which ultimately resulted into better biological yield of crop under these treatments compared to without S application. It is also a fact that uptake of nutrient is the function of yield and nutrient content.

Table 1. Nutrient uptake by soybean crop and weeds

Treatment	Crop uptake (kg/ha)			Weed uptake (kg/ha)			Biological yield (kg/ha)	Weed control efficiency (%) at harvest
	Nitrogen	Phosphorus	Sulphur	Nitrogen	Phosphorus	Sulphur		
Weed Management								
Weedy check	40.31	4.32	2.99	79.84	11.51	4.35	755	-
Two HW	128.09	135.3	8.99	15.84	2.38	0.90	3466	80.39
Chlorimuron ethyl 9 g/ha	70.99	7.41	5.0	44.60	6.51	2.30	2039	43.18
Chlorimuron ethyl 9 g/ha + HW	99.29	10.27	6.86	20.20	2.98	1.13	2756	74.56
Imazethapyr 100 g/ha	88.41	8.62	5.79	24.03	3.54	1.31	2300	69.99
Imazethapyr 100 g/ha+ HW	121.42	12.66	8.46	18.52	2.78	1.04	3292	77.04
LSD (P=0.05)	7.80	1.02	0.55	2.94	0.51	0.20	204	-
Sulphur (kg/ha)								
0	78.21	8.18	5.49	31.78	4.51	1.59	2239	56.58
20	89.58	9.33	6.35	34.13	4.97	1.84	2497	57.91
40	103.98	10.89	7.21	35.60	5.37	2.08	2804	58.91
LSD (P=0.05)	5.52	0.72	0.39	2.08	0.36	0.14	144	-

CONCLUSION

On the medium fertility clay loam soils of Udaipur hoeing and weeding twice at 20 and 40 DAS performed best in saving of N, P and S uptake by weeds compared to weedy check followed by Imazethapyr 100 g/ha 15 DAS in combination with hoeing and weeding 40 DAS and the crop should also be fertilized with 40 kg S/ha.

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Effect of post-emergence application of propaquizafop and imazethapyr alone and in combination on weeds in soybean

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Weeds infestation is one the major constraints in the cultivation of soybean. If weeds are not controlled during critical periods of crop-weed competition, there is identical reduction in the yield of soybean from 58-85%, depending upon the types and intensity of weeds (Kewat *et al*. 2000). Presently, imazethapyr is reportedly very effective post emergence herbicide for controlling grassy and some broad leaf weeds in soybean but its efficacy has not been tested with propaquizafop for wide spectrum weed control in soybean. Therefore, a comprehensive field study was under taken to find out the suitable dose of propaquizafop and imazethapyr mixture for effective control of weeds in soybean.

METHODOLOGY

A field experiment was conducted during *kharif* seasons 2013 at Live stock Farm, JNKVV, Jabalpur, to evaluate the efficacy of propaquizafop and imazethapyr mixture against weeds in soybean variety JS 97-52. Nine treatments comprising of five doses of propaquizafop and imazethapyr mixture (47 + 66, 50 + 70, 53 + 74, 56 + 78 and 100 + 140 g/ha), alone application of propaquizafop 75 g/ha and imazethapyr 100 g/ha, hand weeding twice (20 and 40 DAS) including weedy check, were laidout in randomized block design with three replications.

RESULTS

Weed control efficiency (WCE) at 30 DAA under different weed control treatments varied significantly (Table 1).The application Species wise weed data was recorded in weedy checkplots of soybean indicated that there was predominance of monocot weeds (82.84%) in the experimental field of soybean. Among the monocots, the *Echinochloa colona* was more rampant (38.60%) due to continuous germination of this weed from seed. Besides, *Dinebra retroflexa* (25.10 %), *Cyperusiria* (10.93%) and *Cynodon dactylon* (08.60 %) also marked their presence in good numbers. However, some dicot weeds like *Eclipta alba*(08.53%) and *Alternathera philoxeroides* (8.24%) were also present in weedy check plots at 30 DAA. Almost similar weed flora associated with soybean was reported by Girothiaand Thakur (2006) and Singhand Kumar (2008).

Table-1 Influence of weed control treatments on weed density (no. /m^2), weed dry weight (g/m^2) and weed control efficiency % at 30 days after application of herbicides

Treatment	Weed density (no/m^2)						Weed dry weight (g/ m^2)						WCE (%)
	Cyperus-irria	*Cynodon dactylon*	*Echinoch-loacolona*	*Dinebr-aretroflexa*	*Eclipta-alba*	*Alternanthera philoxeroides*	*Cyperus-iria*	*Cynodon-dactylon*	*Echinochloa colona*	*Dinebrar-etroflexa*	*Eclip-taalba*	*Alternanthera philoxeroides*	
Propaquizafop+Imazethapyr (47+66 g/ha)	4.02 (15.67)	3.19 (9.67)	5.82 (33.33)	5.02 (24.67)	3.44 (11.33)	3.54 (12.00)	5.94 (34.73)	2.25 (4.57)	9.12 (82.67)	5.96 (34.99)	3.35 (10.74)	3.86 (14.38)	60.96
Propaquizafop+Imazethapyr (50+70 g/ha)	3.72 (13.33)	2.92 (8.00)	5.46 (29.33)	4.78 (22.33)	3.08 (9.00)	3.14 (9.33)	5.49 (29.60)	2.02 (3.60)	8.46 (70.99)	5.68 (31.71)	2.88 (7.80)	3.39 (10.98)	66.83
Propaquizafop+Imazethapyr (53+74 g/ha)	3.14 (9.33)	2.48 (5.67)	4.74 (22.00)	4.26 (17.67)	2.74 (7.00)	2.68 (6.67)	4.57 (20.35)	1.59 (2.03)	7.30 (52.80)	5.02 (24.74)	2.57 (6.12)	2.55 (5.98)	75.35
Propaquizafop+Imazethapyr (56+78 g/ha)	2.80 (7.33)	2.41 (5.33)	4.10 (16.33)	3.94 (15.00)	2.35 (5.00)	2.35 (5.00)	4.01 (15.55)	1.47 (1.65)	6.25 (38.55)	4.81 (22.67)	2.36 (5.05)	2.52 (5.85)	80.77
Propaquizafop+Imazethapyr (100+140g/ha)	2.12 (4.00)	1.68 (2.33)	2.80 (7.33)	2.80 (7.33)	1.68 (2.33)	1.58 (2.00)	2.97 (8.32)	1.10 (0.70)	4.17 (16.93)	3.17 (9.53)	1.71 (2.43)	1.65 (2.21)	91.39
Propaquizafop (75g/ha)	4.34 (18.33)	2.61 (6.33)	5.73 (32.33)	4.81 (22.67)	4.06 (16.00)	3.81 (14.00)	6.60 (43.03)	1.74 (2.53)	8.87 (78.24)	6.08 (36.41)	4.21 (17.22)	4.74 (21.93)	57.44
Imazethapyr (100 g/ha)	4.02 (15.67)	2.92 (8.00)	6.15 (37.33)	5.61 (31.00)	2.74 (7.00)	3.03 (8.67)	5.99 (35.39)	2.02 (3.60)	9.42 (88.19)	6.37 (40.13)	2.69 (6.71)	2.98 (8.40)	61.41
Hand weeding (20 & 40 DAS)	1.96 (3.33)	1.35 (1.33)	1.68 (2.33)	1.68 (2.33)	1.22 (1.00)	1.47 (1.67)	1.15 (0.83)	0.82 (0.17)	1.20 (0.93)	0.96 (0.43)	0.79 (0.13)	0.82 (0.17)	99.42
Weedy check	5.08 (25.33)	4.26 (17.67)	9.63 (92.33)	7.76 (59.67)	4.53 (20.00)	4.34 (18.33)	7.88 (61.61)	3.34 (10.67)	15.57 (241.91)	9.95 (98.47)	5.52 (30.00)	4.93 (23.85)	0.00
LSD (P=0.05)	0.39	0.46	0.40	0.35	0.44	0.40	0.59	0.28	0.58	0.50	0.35	0.41	-

* figure in parenthesis are original values, DAA- days after application, WCE – Weed control efficiency

Density and dry weight of weeds at 30 DAA varied significantly under different weed control treatments (Table 1). The density and dry weight of weeds were maximum under weedy plots at 30 DAA of soybean crop. However, identical reduction in density and dry weight of weeds were observed when weeds were controlled either through chemical or mechanicalmeans.Post emergence application of propaquizafop + imazethapyr mixture at the lowest dose (47 + 66 g/ha) caused marginal reduction in density and dry weight of all the weeds but reduction was more pronounced when propaquizafop + imazethapyr mixture was applied at 53 + 74, 56 +7 8 and 100+140 g/ha. Hand weeding done at 20 and 40 DAS reduced the density and dry weight of weeds to the maximum extent over herbicidal treatments of propaquizafop + imazethapyr mixture at the lowest dose (47 + 66 g/ha) had the lower WCE because of poor control of weeds, but it was well marked when propaquizafop + imazethapyr was applied at higher rate (100 + 140 g/ha).Maximum weed control efficiency (98.14%) was recorded at 30 DAA under hand weeding treatment due to elimination of all sort of weeds.

CONCLUSION

Post emergence application of propaquizafop + imazethapyr mixture at 53 + 74 and 56 + 78 g/ha or higher rates (100 + 140 g/ha) attained higher values of growth parameters, yield attributing traits and yields of soybean.

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Efficacy of different new herbicides against weed flora in soybean

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Soybean is an important oilseed crop of the twentieth century. It has been termed as miracle bean because of higher protein (40%) and oil (20%) content. In Vidarbha, area covered under rainfed soybean is 15.90 Lakh ha with productivity of 1.05 t/ha. The soybean productivity is adversely affected up to 35-80% depending on the weed infestation (Gupta *et al.* 2006). In soybean reduction in the yield due to weeds varies from 35-80%, depending upon the type of weeds, their intensity and time of crop weed competition. Hand weeding is traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour during peak period of demand, are main limitations of manual weeding. Under such circumstances, use of effective herbicide gives better and timely weed control. Therefore, need was felt to explore the possibility of new post emergence herbicides for effective control of weed.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Ramkrishna Bajaj College of Agriculture, Pipri during the *Kharif* season of 2014. The experiment was laid out in randomized block design with eight treatments replicated thrice. The experimental site was fairly uniform in topography with clayey in texture. Overall the rainfall and its distribution were satisfactory for crop. Sowing of soybean JS-335 was done on 25th July 2014. Herbicides doses were applied as per the treatments. Phytotoxicity symptoms due to herbicides on crop was recorded by using a visual score scale of 0-10.

RESULTS

The major weed flora during kharif season in soybean crop in the selected area comprised of weed species, *viz. Commelina benghalensis, Dinebra Arabica, Poa annua, Echinochloa crusgalli, Eragrostis major, Cynodon dactylon,Cyperus rotundus, Lagasca mollis, Euphorbia hirta, Digera arvensis, Tridex procumbense, Parthenium hysterophorus,Celosia argentea, Euphorbia geniculata, Alysicarpus rugosus, Alternanathera triandra, Xanthium strumarium,, Portulaca oleracae, Amaranthis viridis.* None of the herbicide under study showed any phytotoxicity symptoms on crop. Among the various treatments lowest total weed count was observed under treatment Sodium acefulrofen + Clodinafop propagil (Premix) at 0.245 Kg/ha + 1HW 35 DAS which was at par with treatmentImazethapyr + Imazamox (Premix) at 0.070 Kg/ha + 1HW 35 DAS. This might be due to combination of both herbicides that have longer effect on controlling both monocot and dicot weeds population in pre mix solution, similar trend was also observed in weed dry matter and weed control efficiency.

Table 1. Weed count/ m^2, Weed dry matter (g/ m^2), Weed control efficiency (%), Seed yield (q/ha) and B:C ratio as influenced by weed control treatments in soybean

Treatment	Total weed count at harvest	Weed dry matter (g/m^2) at harvest	Weed control Efficiency (%)	Seed yield (q/ha)	B:C ratio
T_1 - weedy check	71.00	35.36	-	7.00	1.16
T_2 - Farmer practices 1H 15 DAS + 1HW 35 DAS	28.67	12.94	63.40	14.50	2.02
T_3 – Quizalofop ethyl at 0.075 kg/ha	33.67	16.42	53.56	10.39	1.50
T_4 – Imazethapyr at 0.100 kg/ha	31.00	14.28	59.62	11.82	1.75
T_5 – Imazethapyr + Imazamox (Premix)at 0.070 Kg/ha	25.33	12.58	64.43	13.28	1.95
T_6 – Sodium acefulrofen + Clodinofop propagil (Premix) at 0.245 Kg/ha	23.00	11.27	68.13	15.20	2.17
T_7 –Imazethapyr + Imazamox (Premix) at 0.070 Kg/ha + 1 HW 35 DAS	21.00	10.29	70.90	16.23	2.08
T_8 –Sodium acefulrofen + Clodinofop propagil (Premix) at 0.245 Kg/ha +1 HW 35 DAS	19.00	9.31	73.67	17.40	2.20

CONCLUSION

Treatment Sodium acefulrofen + Clodinafop propagil (Premix) at 0.245 Kg/ha + 1HW 35 DAS was found better in controlling weeds, dry matter, weed control efficiency and seed yield of soybean under scarcity labour.

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Efficacy of different post-emergence herbicide on weed management in soybean

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Soybean is one of the major crop of Central India which occupies an important position in Agricultural Economy of India. Soybean crop is susceptible for weed competition for first 30-40 DAS. It is essential to keep the crop weed free during initial stage of plant growth to achieve optimum yield. One of the reasons for low productivity of soybean is the poor weed control during early period of crop weed competition. Though, hoeing and hand weeding operations are the most efficient method of weeds control, these operations could not be performed in time due to erratic weather conditions and labour scarcity and high cost. Yield losses due to weeds ranges from 31-84% depending on nature and density of weed duration and time of weed infestation and environmental condition (Kachroo *et al*. 2003). The chemical method of weed control can be very effective in killing the weeds before emergence as well as post emergence. The use of herbicide particularly in intensive agriculture due to their ability of providing quick, effective, selective and economical weed management in term of money and labour.

METHODOLOGY

A field experiment was carried out during *Kharif* season of 2013-14 at Agronomy Farm, College of Agriculture, Nagpur, Maharashtra to study the time of application of Imazethapyr + Imazamox at 43 g/ha and Imazethapyr at 75 g/ha in controlling weeds in terms of growth and yield performance of soybean crop and to workout economics of chemical and cultural weed management practices in soybean.The soil was clayey in texture and slightly alkaline in reaction (pH 7.7), medium in organic carbon, low in available N (291.10 kg/ha), low in available P_2O_5 (24.16 kg/ha) and fairly reach in available K_2O (464.30 kg/ha). The experiment was laid out in randomized block design with eight treatment replicated thrice. Grain yield of soybean was recorded after harvest of the crop from respective treatments and the various economic parameters such as GMR, NMR, and B:C ratio was estimated according to prevailing market value of produce and inputs during the years.

RESULTS

In respect of seed yield of soybean, two hand weeding 15 DAS and 30 DAS (T_2) produced significantly more seed yield and straw yield of 1450 kg/ha and 2156.92 kg/ha, respectively. Amongst the herbicidal application,Imazethapyr + imazamox at 43 g/ha at 10 DAS (T_4) andimazethapyr at 75 g/ ha at 10 DAS (T_3) produced significantly more seed yield with 1391 kg and 1326 kg/ha, respectively over other treatment but found at par with two hand weeding at 15 DAS at 30 DAS (T_2) Vyas and Jain (2003). They reported that cultural methods, herbicidal control and their combination were found to reduce the weed biomass and resulted into increase in seed yield of soybean. About economic evaluation of different weed management practices, weed management with 2 hand weeding at 15 DAS and 30 DAS (T_2) recorded significantly more GMR (Rs. 48948 /ha) and NMR (Rs. 29050 /ha) over rest of the treatments except treatment of imazethapyr + imazamox at 43 g/ha at 10 DAS (T_4) and imazethapyr at 75 g/ha at 10 DAS (T_3). However, these treatments were at par with two hand weeding at 15 and 30 DAS (T_2). Higher seed yield of soybean was attributed due to effective weed management that resulted in higher monetary returns. Smita Mandhre (2005) reported that weed free control recorded highest additional profit followed by Imazethapur + cultural treatments. Maximum benefit:cost ratio (B:C) was obtained with the treatment consisting two hand weeding at 15 and 30 DAS (2.46) followed by imazethapyr + imazamox at 43 g/ha at 10 DAS (2.28) and imazethapyr at 75 g/ha at 10 DAS (2.16). The unweeded control treatment recorded lowest B:C ratio (1.56) as a result of higher crop weed competition which reduced the soybean yield significantly Yadav *et al.* (2009).

CONCLUSION

Weed management by two hand weeding at 15 DAS and 30 DAS (T_2) provided most effective control of weds, throughout the crop growth period of soybean, thereby improving growth and yield contributing characters significantly and consequently recorded highest seed yield, GMR, and NMR /ha followed by application of chemical herbicide imazethapyr + imazamox at 43 g/ha at 10 DAS. Application of imazethapyr + imazamox at 43 g/ha at 10 DAS controlled weed population effectively and expressed lower weed index and higher weed control efficiency comparable with imazethapyr at 75 g/ha at 10 DAS.

Table 1. Weed index, weed control efficiency, seed and straw yield and economics of soybean as influenced by various treatments

Treatment	Weed index	Mean weed control efficiency (%)					Seed yield kg/ha	Straw yield kg/ha	GMR `	NMR `	B:C ratio
		20 DAS	40 DAS	60 DAS	80 DAS	At harvest					
T_1- Control (Weedy check)	49.32	-	-	-	-	-	850	1295	28724	10266	1.56
T_2-2 hand weeding at 15 DAS and at 30 DAS	-	96.27	95.63	93.49	92.03	91.59	1450	2156	48948	29050	2.46
T_3- Imazethapyr at 75 g/ha at 10 DAS	16.99	79.98	76.94	74.83	70.79	68.22	1326	1883	44676	23998	2.16
T_4- Imazethapyr + imazamox at 43 g/ha at 10 DAS	12.87	91.40	88.95	83.24	79.44	77.89	1391	1948	46867	26344	2.28
T_5- Imazethapyr at 75 g /ha, at 20 DAS	31.74	9.23	68.55	66.49	62.55	60.33	1090	1659	36870	16192	1.78
T_6- Imazethapyr + imazamox at 43 g/ha at 20 DAS	29.20	6.41	72.20	69.20	65.06	62.77	1131	1730	38231	17708	1.86
T_7- Imazethapyr at 75 g/ha at 30 DAS	35.70	3.64	55.47	51.34	50.29	48.31	1027	1581	34731	14053	1.68
T_8- Imazethapyr + imazamox at 43 g/ha at 30 DAS	34.83	4.81	57.84	54.92	52.34	50.21	1041	1613	35211	14688	1.72
LSD (P0.05)	-	-	-	-	-	-	197.61	298.71	6675	6675	-

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Weed management in vertisols of sunflower

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Sunflower (*Helianthus annuus* L.) is one of the major oilseed crops grown in India cultivated in 6.91 lakh ha with a total production of 5.47 lakh tonnes with an average productivity of 791 kg/ha during 2013-14. of late, the area in sunflower has been drastically reduced due to several biotic and abiotic factors. Among the several production factors, weeding is the single most critical factor affecting productivity as weeds enhances the pest and disease load, competes with sunflower for nutrients which ultimately decreases yield in sunflower. The critical weed free period is between 20 th and 49th day after sowing (Wanjari *et al*. 2001). Hence, timely weed control is essential for optimizing the yields of sunflower. Incessant rains during the early stage of the crop especially in deep black soils do not allow to take up either inter cultivation or manual hand weeding. In such case, usage of herbicides is the best option which allows timely weed management. Keeping these facts in view, the present investigation was taken up.

METHODOLOGY

A field experiment was carried out at Regional Agricultural Research Station, Nandyal, Andhra Pradesh during late *Kharif* of 2014-15. The experiment was laid-out in randomized block design with three replications with plot size of 4.8 x 5.4 m. There were eight treatments comprising pre-emergence application of pendimethalin at 0.75 kg/ ha (38.7 CS new molecule), pre-emergence application of pendimethalin at 0.75 kg/ ha followed by one intercultivation at 30 DAS followed by hand weeding at 40 DAS, sequential application of pendimethalin at 1.0 kg/ ha as pre emergence and quizalofop-pethyl 10 EC at 37.5 g/ha, propaquizofop at 62 g/ha and fenoxopropethyl at 37.5 g/ha as post emergence respectively at 15-20 DAS, two intercultivations at 20 & 40 DAS and one hand weeding at 30 DAS (farmers practice), weed free and weedy check.The test hybrid, NDSH-1 was sownon 5 September 2014 with a spacing of 60 cm x 30 cm and the crop was fertilized with recommended dose of fertilization *i.e.* 75-90-30NPK kg/ha. Need based irrigation was given and recommended plant protection measures were taken up during the crop growth period. Data on weed dry matter was recorded at harvest by randomly placing a quadrat of 0.5 m x 0.5 m at two places in each plot and drying the weeds in oven at 70 ± 1°C up to 48 h. The data on dry weight was subjected to square root transformation before statistical analysis.

RESULTS

All the treatments were significantly superior for seed yield to weedy checkand at par with oneanother. However, weed free check recorded higher seed yield of 923 kg/ha followed by farmers practice (920 kg/ha). Sequential application of pendimethalin as pre emergence and quizalofop-ethyl as post emergence recorded higher seed yield (874 kg/ha) with a benefit cost ratio of 1.21. The dry weight of weeds recorded at harvest was higher in weedy check (798 g/m^2) and wherever the manual weeding was practised the dry weight of weeds was low compared to weedicide treatments as it allows complete uprooting of weeds. Among the weedicide treatments, lower dry weight (177 g/m^2) of weeds was recorded in sequential application of pendimethalin at 1.0 kg/ ha as pre emergence and quizalofop-ethyl 10 EC at 37.5 g/ha as post emergenceand it was at par with pendimethalin + propaquizofopand pendimethalin + fenoxopropethyl recorded in farmers practice (76.6%) followed by application of pendimethalin at 1.0 kg/ha as pre emergence and fenoxoprop Ethyl as post emergence (64%), intercultivation at 30 DAS followed by hand weeding at 40 DAS (54.3%) and quizalofop ethyl as post emergence (53.9%). Among the weedicide treatments, lowest weed index (WI)was recorded in sequential application of pendimethalinas pre emergence and quizalofop-pethyl as post emergence (5.3) followed bypendimethalin as pre emergence and intercultivation at 30 DAS followed by hand weeding at 40 DAS (10.9%). Further, higher WCE and lowerWI was recorded in sequential application of pendimethalin as pre emergence and quizalofop-pethyl as post emergence (53.9 and 5.3% respectively). This treatment also recorded higher net returns of Rs.5367/ha and B:Cratio of 1.21.Similar results were reported by Kumar *et al*. 2014 .

Table 1. Weed growth,seed yield and economics of sunflower as influenced by different weed control treatments

Treatment	Seed yield (kg/ha)	Weed dry matter (g/m^2)	Weed control efficiency WCE (%)	Weed index WI (%)	Gross returns (`/ha)	Net returns (` /ha)	B : C ratio
Pendimethalin at 0.75 kg/ha (38.7 CS new molecule) as pre-emergence spray	818	250 (15.71)	38.4	11.4	28610	3830	1.15
Pendimethalin at 0.75 kg/ha as pre-emergence spray + one inter cultivation at 30 DAS followed by hand weeding at 40 DAS	823	97 (9.36)	54.3	10.9	28792	2664	1.10
Pendimethalin at 1.0 kg/ha as pre-emergence spray + Quizalofop Ethyl 10 EC at 37.5 g/ha at 15-20 DAS as directed post-emergence spray on weeds	874	177 (13.08)	53.9	5.3	30578	5367	1.21
Pendimethalin at 1.0 kg/ha as pre-emergence spray + Propaquizalofop (Agil) at 62 g/ha at 15-20 DAS as directed post-emergence spray on weeds	796	230 (14.97)	32.9	13.8	27859	2610	1.10
Pendimethalin at 1.0 kg/ha as pre-emergence spray + Fenoxoprop Ethyl (Whip super) at 37.5 g/ha at 15-20 DAS as directed post emergence spray on weeds	796	286 (16.40)	64.0	13.8	27856	2635	1.10
Farmers practice (Two intercultivations at 20 & 40 DAS + one HW at 30 DAS)	920	29 (5.36)	76.6	0.3	32199	6599	1.26
Weed free check	923	0 (0.71)	100.0	0.0	32301	2781	1.09
Weedy check	439	798 (28.2)	0.0	52.4	15360	-8010	0.66
LSD (P=0.05)	184	5.30	-	-	-	-	-

Note: DAS- Days after sowing; Figures in parentheses are square root transformed ("X+0.5) values.

CONCLUSION

The present study indicates, following two intercultivations at 20 and 40 DAS and one hand weeding at 30 DAS is the best option for achieving higher yields with high WCE, B:C ratio and low WI.. Among the weedicide treatments, where the field situation does not allow to take up intercultivation, the next best treatment is sequential application of pendimethalin at 1.0 kg/ha as pre emergence and quizalofop-pethyl at 37.5 g/ha as post emergence which resulted in higher seed yield, WCE, B:C ratio and lower WI.

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Integrated weed management in soybean

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Soybean (*Glycine max*. (L) Merrill) is one of the important pulse and oil seed crops of India which is grown in *kharif* and *Rabi* season. However, soybean is very sensitive to early weed competition. The most critical period for weed interference is initial 15-45 days. Weeds emerging after this period are suppressed by smothering action of crop. The herbicides presently available for soybean crop either PPI or Pre-emergence and post emergence weed control is coming of age and potentially one of the most labour saving innovations in modern Agriculture. On the other hand, herbicides alone are not able to control weeds fully because of their selective scale and hence there could be more effective if supplemented with hand weeding and hoeing Reddy *et al.* (1998).

Recently some new selected early post-emergence herbicides, *viz*. chlorimuron ethyl, Imazethapyr and Quizalolfop ethyl have been developed for control of grassy and broad leaf weeds with no damage soybean crop. The herbicides Imazethapyr and chlorimuron ethyle is one often used as after emergence for the control of weeds in legumes especially soybean crop. However, meager information is available in plane Zone of MPKV, Rahuri hence, this investigation was undertaken.

METHODOLOGY

A field experiment was carried out during the *Kharif* season of 2006 at college of Agriculture, Pune (M.S) to study the effect of different weed control practices on growth, yield, quality and intensity of weed flora in soybean crop. Soil was vertisole in nature (medium Black) with a uniform depth. Soil was clays in texture slightly alkaline in reaction pH (7.6). Eleven treatments consisting Un weeded control, weed free check, Imazethapyr, chlorimuron ethyl and Quizalolfop ethyl with varying does along with hand weeding and hoeing arranged in a randomized block design with three replication. Soybean variety '*DS-228*' was direct seeded in the experimental field with recommended package of practices. Fertilizers was applied uniformly though urea at 50 kg N and 75 kg P_20_5. The data on weed growth, yield performance and economics were recorded.

RESULTS

All the growth attributes, *viz*. plant height, number branches no of leaves, dry matter per plant significantly differ due to different weed control treatments. However, the significantly highest values of yield attributes were observed with weed free check (T2) followed by two hand weeding 15 and 30 DAS. Among IWM, application of Imazethpyr at 0.075 kg/ha + one hoeing at 30 DAS and chlorimuron ethyl at 0.009 kg/ha + one hoeing at 30 DAS also significantly higher growth attributes which could not give much response the yield contributing characters.

The highest seed yield (3.75 t/ha) and straw yield (4.87 t/ha) were observed in weed free check (T2) over all the treatments. Among the herbicides alone, Imazethapyr at 0.075 kg/ha significantly higher seed yield (2.76 t/ha) and straw seed (3.96 t/ha) as compared other to other herbicide treatments. Dubey *et al.* (1996). Weed free check (T2) recovered significantly to lowest weed population /m^2 (3.56) and dry matter of weeds/m^2 (4.79 g) than rest of the treatment. However, the highest weed contract efficiently (94.52%) and to lowest weed index (0.00) were observed in treatment weed free check (T2). The B:C ratio was the highest (2:11) in weed free check (T2) followed by two have weeding 15-30 DAS (T3) (2.10). However, in IWM treatments it was highest in Imazethapyr at 0.75 g + one hoeing at 30 DAS (T7) (1.92)

Table: Weed growth, yield and economics of soybean as influenced by the different treatments

Treatment	Weed density (no/m^2)	Weed matter (g/m^2)	Weed index (%)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation `/ha	B:C ratio
Unwedded control	64.39	88.35	47.85	1.95	3.08	16250.50	1.36
Weed free check	3.56	4.79	-	3.75	4.87	19850.50	2.11
Two hand weedings (15 & 30 DAS)	4.50	16.05	6.21	3.51	4.51	18650.50	2.10
Hand weeding at 15 DAS fallowed by one hoeing at 30 DAS	8.05	29.79	14.18	3.21	4.01	17650.50	2.02
Two hoeing (15 and 30 DAS)	10.05	35.93	17.88	3.08	3.85	16650.50	2.06
Imazethapyr @ 0.075 kg./ha at 15 DAS	15.75	39.93	26.23	2.76	3.96	17630.50	1.76
Imazethapyr @ 0.075 kg/ha at 15 DAS + on hoeing at 30 DAS	9.01	23.29	14.58	3.20	4.48	18630.50	1.92
Chlorimuron ethyl @ 0.009 ka/ha at 15 DAS	12.00	41.33	30.09	2.62	3.80	17130.50	1.72
Chlorimuron ethyl @ 0.009 ka/ha at 15 DAS + one hoeing at 30 DAS	7.15	27.93	19.43	3.02	4.08	18130.50	1.86
Quizalofop ethyl @ 0.05 kg/ha at 15 DAS	21.18	55.25	35.09	2.43	3.57	17198.50	1.53
Quizalofop ethyl @ 0.05 kg/ha at 15 DAS + one hoeing at 30 DAS	15.35	37.13	23.41	2.87	3.94	18798.50	1.71
S E +	0.36	0.27	-	1.3	1.0	-	-
C.D.at 5%	1.08	0.83	-	4.0	3.0	-	-

CONCLUSION

In soybean crop hand weeding at 15, 30, 45 DAS is the best method for weed control. However, if there is labour scarcity IWM treatment Imazethapyr at 0.075 g/ha + one hoeing at 30 DAS is beneficial.

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Weed management strategies in soybean

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Soybean is an important rainy season crop of India. Successful weed control is most important factor for fruitful soybean production, because losses due to weeds have been one of the major limiting factors in soybean production. Weeds compete with crop for light, moisture and nutrients with early-season competition being the most critical. Being a rainy season crop soybean faces severe weed competition during early stages of crop growth, resulting in a loss of about 40-60 per cent of the potential yield, depending on the weed intensity, nature, environmental condition and duration of weed competition (Kachroo *et al.* 2003). Therefore, integrated weed management system is a desired practice that aims at reducing the dosage of herbicide to be applied with mechanical weeding, which will help in managing weeds in a best way for to sustain and boost the production of soybean.

METHODOLOGY

An investigation was conducted during *kharif* season of 2011 at Research Farm, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha-Jammu. The soil was characterized as sandy-loam in texture and alkaline in reaction (pH 7.7). It was low in organic carbon content (0.39%) and nitrogen (240 kg/ha) and medium in phosphorus (12.12 kg/ha) and high in available potassium (134 kg/ha). The experiment comprised of twelve treatments comprising weedy check, weed free check, hand-weeding at 15 and 35 days after sowing (DAS), hoeing at 15 and 35 days after sowing, fluchloralin at 1.0 kg/ha (PPI), pendimethalin at 1.0 kg/ha (PE), imazethapyr at 100 g/ha (PoE), quizalofop-ethyl at 50 g/ha (PoE), fluchloralin at 0.75 kg/ha (PPI) + hoeing at 35 days after sowing, pendimethalin at 0.75 kg/ha (PE) + hoeing at 35 days after sowing, quizalofop-ethyl at 40 g/ha (PoE) + hoeing at 35 days after sowing and imazethapyr at 75 g/ha (PoE) + hoeing at 35 days after sowing were tested in randomized block design with three replications. All the post-emergence herbicides were applied at 15 days after sowing. The herbicide fluchloralin was applied as pre-plant incorporation two days before sowing and pendimethalin as pre-emergence one day after sowing. The soybean variety '*SL-525*' was planted at a row spacing of 45 cm. All the herbicides were applied at standard time of its application by using a knapsack sprayer fitted with flood jet nozzle with spray volume of 500 liters water/ha.

RESULTS

The dominant weed flora in the experimental field were *Digera arvensis*, *Parthenium hysterophorus*, *Celosia argentea*, *Phyllanthus niruri*, *Commelina benghalensis*, *Poa annua*, *Echinochloa crusgalli*, *Cynodon dactylon*, *Cyperus rotundus*, *Argemone maxicana*, *Echinochloa colonum* at all the crop growth stages in weedy plots. All the weed control treatments significantly reduced weed density and dry weight of weeds as compared to weedy check (Table 1). The highest reduction of weed dry matter was found in two hand weeding (15 and 35 DAS) treatment. Amongst the herbicidal and mechanical treatments, imazethapyr at 75 g/ha + one hoeing at 35 DAS decreased weed biomass than other chemical treatments. Maximum seed yield was reduced in weedy check upto 42% and minimum seed yield was reduced in weed free treatment followed by hand weeding at 15 and 35 DAS (1.55%). Among herbicide treatments, minimum seed yield loss (2.84%) was observed in imazethapyr + hoeing at 35 DAS followed by 4.90 per cent loss in quizalofop-ethyl + hoeing at 35 DAS. The highest seed yield (15.52 q/ha) was recorded in weed free followed by hand-weeding at 15 and 35 days after sowing (15.28 q/ha) but it found statistically at par with imazethapyr at 75 g/ha (PoE) + hoeing at 35 days after sowing (15.08 q/ha) and quizalofop-ethyl at 40 g/ha (PoE) + hoeing at 35 days after sowing (14.76 q/ha). Quizalofop-ethyl at 40 g/ha (PoE) + hoeing at 35 days after sowing recorded the highest benefit cost ratio of 1.44, which was comparable with the application of imazethapyr at 75 g/ha (PoE) + hoeing at 35 days after sowing (1.43).

Table1. Effect of different weed control treatments on weed density, weed dry weight, weed index, grain yield and B : C ratio of soybean

Treatment	Weed density at 90 DAS (no./m^2)	Weed dry weight at 90 DAS (g/m^2)	Weed index (%)	Grain yield (kg/ha)	B:C ratio
Weedy check	298.00 (17.27)*	130.27 (11.42)*	41.82	9.03	0.69
Weed free	0.00 (0.71)	0.00 (0.71)	0.0	15.52	1.06
Hand weeding at 15 & 35 DAS	12.00 (3.49)	28.13 (5.35)	1.55	15.28	1.20
Hoeing at 15 & 35 DAS	42.00 (6.51)	30.53 (5.57)	13.40	13.44	1.18
Fluchloralin @ 1.0 kg/ha (PPI)	84.00 (9.18)	47.37 (6.91)	24.87	11.61	1.08
Pendimethalin @ 1.0 kg/ha (PE)	96.00 (9.81)	49.10 (7.04)	27.19	11.30	0.92
Imazethapyr @ 100 g/ha (PoE)	45.00 (6.71)	33.30 (5.81)	27.96	11.18	0.88
Quizalofop-ethyl @ 50 g/ha (PoE)	67.00 (8.21)	45.77 (6.79)	22.55	12.02	1.09
Fluchloralin @ 0.75 kg/ha (PPI) + hoeing at 35 DAS	45.00 (6.72)	36.53 (6.08)	14.50	13.27	1.24
Pendimethalin @ 0.75 kg/ha (PE) + hoeing at 35 DAS	53.00 (7.29)	38.20 (6.22)	15.40	13.13	1.14
Quizalofop-ethyl @ 40 g/ha (PoE) + hoeing at 35 DAS	25.00 (5.03)	29.80 (5.50)	4.90	14.76	1.44
Imazethapyr @ 75 g/ha (PoE) + hoeing at 35 DAS	17.00 (4.15)	27.10 (5.25)	2.84	15.08	1.43
S.Em±	0.27	0.16	-	0.65	-
LSD (P=0.005)	0.79	0.47	-	1.9	-

* Figures in parenthesis are the values transformed to $\sqrt{x+0.5}$ of actual values

CONCLUSION

Based on this study it can be concluded that quizalofop-ethyl at 40 g/ha (PoE) + hoeing at 35 days after sowing or imazethapyr at 75 g/ha (PoE) + hoeing at 35 days after sowing found most suitable herbicides for the control of weeds in soybean crop.

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Integration of pre-emergent herbicides with cultural methods for effective weed management in groundnut

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Groundnut is an important oilseed crop and is grown mainly in kharif season in India. It encounters severe problem of weed infestation especially in the early stages of growth, since the seedling emerges 7-10 days after sowing coupled with the slow growth in the initial stages. The weeds emerge fast and grow rapidly competing with the crop severely for the resources namely nutrients, light, and space and also transpire lot of valuable conserved water from the soil. On an average, the loss of groundnut production in the country due to weeds has been estimated to the tune of 15-75% (Satya *et al*. 2013). The present study aimed to find out the effectiveness of pre emergent herbicides in controlling weeds in groundnut crop when integrated with cultural methods in comparison with recommended herbicide alachlor, farmers' practice and weed free check, and to work out their economics.

METHODOLOGY

The experiment was conducted at University of Agricultural Sciences, MARS, Dharwad for three consecutive kharif seasons of 2012, 2013 and 2014 in RCBD with 9 treatments replicated 3 times. The soil of experimental field was medium deep black soil. The details of treatments are given in table 1. Groundnut variety '*GPBD-4*' was sown with plant spacing of 30 x 10 cm on flat beds. Recommended dose of fertilizers and gypsum were applied as per package of practice. Dry weight of weeds (g/m^2) were recorded by putting a quadrate of square meter in each plot. Weed control index was calculated by standard formulae. The yield was recorded and analyzed. To work out net returns, prevailing market price was used for different outputs and inputs.

RESULTS

Predominant weeds found in experimental groundnut field were: *Commelina benghalensis*, *Digera arvensis*, *Ageratum conyzoides*, *Euphorbia geniculata*, *Corchorus* sp, *Mollugo* spp. among broad leaf weeds(BLWs); *Dinebra retroflexa* among grasses; *Cyperus rotundus* and *Cynodon dactylon* among perennial weeds. Pooled analysis over three years indicated that, all the herbicide treatments followed by two intercultivations and one hand weeding were on par with weed free check and farmers' practice with respect to pod yield, thereby indicating the saving cost incurred on one hand weeding. The weed dry weight was significantly lower with oxyfluorfen and it was on par with all other treatments except pendimethalin. All the herbicide treatments were comparable with weed free check or farmers' practice in terms of net returns. The herbicide molecules like pretilachlor and imazethapyr can be used in groundnut as pre emergence application along with two intercultivations and one hand weeding. Imazethapyr when used as pre emergence spray was not effective against *Commelina benghalensis*, even though it is very much effective against this weed as post emergent spray. Hence, imazethapyr can not be recommended as pre emergence spray for groundnut fields heavily infested with *Commelina benghalensis*. Otherwise all the herbicides employed in the present study can be recommended for groundnut as pre emergence spray. More specifically, butachlor and oxyfluorfen were more promising (Kumar *et al*. 2003).

Table 1. Weed dry weight, WCI, pod yield and net returns as influenced by pre emergent herbicides in groundnut (Pooled over three years 2012, 2013 & 2014)

Treatment	Weed dry weight (g/m^2)	Weed control index (%)	Grain yield (kg/ha)	Net returns (`/ha)
Alachlor 1.5kg/ha	1.50 (1.61)	97.69	2029	46045
Butachlor 1.5kg/ha	1.45 (1.43)	97.83	2126	50387
Pendimethalin (EC) 1.0kg/ha	1.70 (1.92)	97.22	2001	44898
Pretilachlor 1.5kg/ha	1.71 (2.30)	97.18	2006	44654
Oxyfluorfen 0.15 kg/ha	1.45 (1.43)	97.85	2031	45647
Imazethapyr 0.10 kg/ha	1.51 (1.74)	97.53	1992	45580
Weed Free Check	1.28 (1.00)	98.41	2183	48550
Weedy Check	7.42 (57.39)	---	950	16098
Farmers' practice 2 IC+2HW	1.70 (2.30)	97.36	2054	44398
S.Em±	0.05	0.16	51	2188
LSD (0.05)	0.28	0.48	154	6559

1HW and 2IC common for treatments receiving pre emergent herbicides

CONCLUSION

Weed management by integration of butachlor and oxyfluorfen with one hand weeding and two intercultivations was most effective to control weeds resulting in higher yield and net returns in groundnut and they were on par with recommended herbicide alachlor, farmers' practice and weed free check.

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Bioefficacy of chlorimuron-ethyl herbicide against weeds in soybean

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Soybean (*Glycine max*) is the most important oilseed crop of India including Madhya Pradesh. Among the various factors responsible for low productivity, weeds infestation during early growth stage is one of the major constraints in the cultivation of soybean.If weeds are not controlled during critical periods of crop- weed competition, losses in crop yields may occur up to the extent of 20-77% (Kuruchania *et al.* 2001). Weedsare generally managed through hand weeding and hoeing but due to intermittent rainfall during rainy season and scanty labour, timely inter culture becomes very difficult task. Chlorimuron ethyl reportedly gives satisfactory control of post emergent weeds in soybean. Since the information on the efficacy of chlorimuron ethyl against weeds is not available for KymorePlateau and SatpuraHill zones of Madhya Pradesh. Therefore a comprehensive study was under taken.

METHODOLOGY

The field experiment was conducted during kharif 2012 and 2013 at Product Testing unit, Department of Agronomy, JNKVV, Jabalpur. The experiment consisted of 5 treatments namely 3 doses of chlorimuron ethyl (6, 9, and 18 g/ha), hand weeding twice and weedy check, were laid out in randomized block design with four replications. The soil of the experimental field was sandy clay loam with neutral soil reaction, medium in organic carbon (0.64%), nitrogen (372 kg/ ha) phosphorus (17.45 kg/ha) and high in potassium contents (297 kg/ha). Data on weeds, yield attributing traits and yield were taken using standard techniques.

RESULTS

Herbicidal treatments significantly influenced the density and dry weight of weeds as compared to weedy check. The density and dry weight of weeds were maximum under weedy check plots where weeds were allowed to grow throughout the season. But weed growth was checked appreciably in plots receiving early post emergence application of chlorimuron ethyl at 6 g/ha and growth reduction was further improved when applied at at 9 g/ha being at part to 18 g/ha. However, the none of the herbicidal treatment surpassed the hand weeding twice as the reduction in density and dry weight of weeds to the maximum extent and proved significantly superior over chlorimuron ethyl applied between 6-18 g/ha.

Table 1. Effect of Chlorimuron ethyl on weed dynamic, yield attributing characters and yield ofsoybean (mean of 2012 and 2013)

Treatment	Weed density/m^2	Weed biomass (g/m^2)	WCE (%)	Branches /plant	Pods/ plant	Seed index (g)	Grain yield (q/ha)
Chlorimuron ethyl 6 g/ha	6.25 (38.54)*	9.42 (88.15)	66.82	3.23	15.96	7.34	14.23
Chlorimuron ethyl 9 g/ha	5.85 (33.69)	8.51 (71.85)	72.96	3.63	55.15	7.46	15.49
Chlorimuron ethyl 18 g/ha	5.48 (29.54)	8.02 (63.8)	75.99	3.40	63.14	7.56	16.68
Hand weeding twice (20 & 40 DAS)	1.90 (3.11)	3.80 (13.96)	94.75	4.57	71.58	7.84	19.27
Weedy check (control)	14.76 (217.44)	16.31 (265.67)	0.00	2.83	45.48	6.91	9.52
LSD (p=0.05)	1.43	1.86	–	0.33	6.16	0.56	1.44

*Values in parantheses are original. Data transformed to square root transformation

CONCLUSION

It concluded that hand weeding twice and application of Chlorimuron ethyl 9 g/ha found more effective for controllingweeds in soybean.

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Efficacy of herbicides on growth and yield of soybean

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Soybean (*Glycine max.* L.) is one of the important oilseed crop of India having high protein (40%) and oil (20%) content. Intense weed competition in soybean is one of the main constraints for increasing soybean productivity. In *Kharif* season, the weed competition is one of the most important cause of low yield and estimated to be 30-80 per cent. Due to negligence in timely weed control, the crop yield losses to the extent of 20-77% was reported.(Kurchania *et al.* 2001). Soybean suffers from heavy weed competition especially in the early growth stages hence early herbicidal control seems to be a must in this crop for harvesting acceptable yields. Spraying of pre-emergence herbicides like Pendimethalin helps to minimize the crop weed competition during such critical growth stages resulting in higher crop yields. In case where application of pre-emergence herbicides is not possible due to frequent rains, unavailability of labour and more labour cost, use of post emergence herbicides can solve the problem of late emerging weeds in soybean. With this background the study was undertaken to find out the relative efficacy of herbicide and cultural practices on weed control in soybean as well as to study the effect on growth and yield of soybean.

METHODOLOGY

The field experiment was conducted at Research farm of Agronomy Department, Dr.PDKV, Akola (M.S.) during the *Kharif* season of 2011. The experiment was laid out in randomized block design with nine treatment replicated thrice. The treatments comprised of Weedy check (T_1), Recommended Practices- 1HW + 1H (T_2), Pendimethalin 1.0 kg /ha (T_3), Quizalofop ethyl at 0.050 kg/ha (T_4), Quizalofop ethyl at 0.075 kg/ha (T_5), Imazethapyr at 0.075 kg/ha (T_6), Imazethapyr at 0.100 kg/ha (T_7), Imazethapyr at 0.100 kg/ha + Quizalofop ethyl at 0.050 kg/ha (T_8) and Chlorimuron ethyl at 9.0 g/ha (T_9).The soil of experimental field was clayey loam in texture, having slightly alkaline pH (7.8), moderate organic carbon status (0.41%), low nitrogen content (169.6 kg/ha), low available phosphorus content (18.94 kg/ha) and high potassium status (335.82 kg/ha). Soybean (JS-335) was sown on 18th July 2011 at 45 x 5 cm spacing with 30:75:0 kg/ha NPK.

RESULTS

In the experimental field, predominant weed species were *Euphorbia geniculata, Parthenium hysterophorus, Euphorbia hirta, Lagascea mollis, Digera arvensis, Celosia argentea* among the dicot weed, and *Commelina benghalensis, Dinebra arabica, Poa annua, Echinochloa crusgalli, Eragrostis major, Cynodon dactylon, Cyperus rotundus* among the monocot. Lowest monocot and dicot weed count was observed under 1 hand weeding + 1 hand hoeing, followed by and at par with Imazethapyr at 0.100 kg/ha and Imazethapyr at 0.100 + Quizalofop ethyl at 0.050 g/ha as a post emergence application 15 DAS .Similar trend was observed in respect of total weed dry matter at harvest. Cultural weed management through hand weeding and 1 hoeing was found to be most effective in controlling weeds across the crop growth period and at harvest. Among the herbicidal treatment, Imazethapyr at 0.100 kg/ha + Quizalofop ethyl at 0.050 kg/ha was found to be effective in controlling weeds. Maximum weed control efficiency (67.13%) was obtained with cultural treatment (1HW + 1H) followed by Chlorimuron ethyl at 9.0 g/ha PoE. Highest soybean grain yield (2.19 t/ha) was registered in cultural practice of 1 hand weeding + 1 hand hoeing which was followed by post emergence herbicide application of Imazethapyr at 0.100 kg/ ha + Quizalofop ethyl at 0.050 kg/ha. However, post emergence application of Imazethapyr at 0.100 kg/ha was found third best treatment in respect of soybean yield. Thakur (2008). The highest net monetary return(Rs 35755 /ha) and B:C ratio (3.19) was registered in Imazethapyr at 0.100 kg/ha followed by and comparable with 1 hand weeding + 1 hoeing (Rs 35685/ha and 2.98) and combination of herbicides i.e. Imazethapyr at 0.100 kg/ha + Quizalofop ethyl at 0.050 kg/ha (Rs.35294 /ha and 2.98).

Table 1. Weed population, Weed dry matter, Weed control efficiency, soybean grain yield, NMR and B:C ratio as influenced by different treatments

Treatment	Weed population/ m² at harvest		Weed dry matter g/ m² at harvest	Weed control efficiency (%)	Soybean grain yield (kg/ha)	NMR (`/ha)	B:C ratio
	Monocot	Dicot					
T1: Weedy check	29.33	29.67	20.44	-	845	6182	1.43
T2 : Recommended Practices-1 HW + 1 H	18.67	18.00	6.18	67.13	2199	35685	2.98
T3 : Pendimethalin 1.0 kg/ha	20.67	20.67	12.49	32.64	1024	8462	1.51
T4: Quizalofop ethyl at 0.050 kg/ha	19.33	19.00	10.96	25.19	1807	27594	2.68
T5 : Quizalofop ethyl at 0.075 kg/ha	22.33	23.00	16.93	47.66	1894	29283	2.75
T6 : Imazethapyr at 0.075 kg/ha	21.33	21.67	14.30	43.69	1913	30498	2.91
T7 : Imazethapyr at 0.100 kg/ha	21.00	20.67	13.45	31.35	2139	35755	3.19
T8 : Imazethapyr at0.100 kg/ha + quizalofop ethyl at 0.050 kg/ha	19.00	18.33	10.59	37.05	2176	35294	2.98
T9 : Chlorimuron ethyl at 9.0 g/ha	21.33	22.67	16.56	54.25	1928	29830	2.75
LSD P= 0.05	3.13	3.73	4.00	--	79	1861	-

CONCLUSION

Cultural practice of 1 hand weeding + 1 hand hoeing and combination of post emergence herbicides Imazethapyr at 0.100 kg/ha + Quizalofop ethyl at 0.050 kg/ha observed better in controlling weeds and higher soybean grain yield .However, application of Imazethapyr at 0.100 kg/ha as a post emergence herbicide proves economical with higher NMR and B: C ratio compared to these two treatments.

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Evaluation of post-emergence herbicides in groundnut

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Ground nut is grown in tropical and sub tropical regions. Being a rainy season crop, it suffers badly due to severe competition by mixed weed flora. Yield reduction due to weed infestation is of the tune of 53.7%. Hand weeding is a traditional and effective method of weed control, but untimely rains, unavailability of labour at peak time and increasing labour cost are the main limitations of manual weeding. Under such situations, the only alternative that needs to be explored is the use of suitable herbicide/ herbicides which may be effective and economically viable. Application of pendimethalin at 0.75-1.0 kg/ha as pre emergence were effective against weeds in cluster bean (Dhaker *et al.* 2009) but inadequate moisture and westerly winds blowing at time of sowing in this region left little moister for soil applied herbicide to act effectively and results in to poor efficiency of these herbicides in most of the time in arid zone soils. To overcome the problem, recently released post emergence herbicides for pulses and leguminous crops could be tried at the critical period of crop weed competition at 20-30 DAS of cluster bean (Yadav 1998). With these points in view, the present investigation aims to test the efficacy of early post emergence herbicides in cluster bean.

METHODOLOGY

A field experiment was carried out during *Kharif* seasons of 2014 at SK Rajasthan Agricultural University Farm, Bikaner to test the efficacy of different weed control measures against weeds. There are fourteen treatments consisting of pendimethalin at 1000 g/ha (PPI), pendimethalin at 1000 g/ha (PE), imazethapyr+ pendimethalin (Pre-mix) at 800 g/ha (PE), imazethapyr + pendimethalin(Pre-mix) at 900 g/ha (PE), imazethapyr + pendimethalin(Pre-mix) at 1000 g/ha (PRE), imazethapyr at 50 g/ha (at 3-4 leaf stage), imazethapyr at 70 g/ha (at 3-4 leaf stage), imazethapyr + imazamox (Pre-mix) at 60 g/ha (at 3-4 leaf stage), imazethapyr + imazamox(Pre-mix) at 70 g/ha (at 3-4 leaf stage), oxiflourfen at 40 g/ha (at 3-4 leaf stage), fenaxaprop-p-ethyl at 50 g/ha (at 3-4 leaf stage), propaquizafop at 62 g/ha (at 3-4 leaf stage), weed free (hand weeding at 20 and 40 DAS) and weedy check. The treatments were arranged in randomized block design (RBD) with three replications. The soil of the experiment field was loamy sand with low in organic carbon (0.08%), available nitrogen(78 kg/ha) and available phosphorus(22 kg/ha) and medium in available potassium (210 kg/ha) with pH 8.2 groundnut variety *'HNG-10'* was sown on 18 June 2014. Above ground weed biomass was sampled at 60 DAS using a quadrant of 0.5 m x 0.5 m. Plant material was dried at 65°C for 48 hrs before determining dry weight. Standard methods were followed for weed, crop and economics analysis.

Table 1. Effect of weed control measures on weeds and groundnut crop and its economics

Treatment	Weed Count/m^2			WDW (g/m^2)	Pod/ plant	Karnel/ pod	Haulm yield (kg/ha)	Pod yield (kg/ha)	Net return(`)	B:C
	Broad leaved	Grassy	Total weed							
Pendimethiline. 1.0 kg(PPI)	7.19(51.33)	1.00(0.67)	7.24(52.00)	34.30	25.33	1.57	5461	1988	30872	1.47
Pendimethiline. 1.0kg (PE)	7.29(52.67)	1.05(0.67)	7.34(53.33)	25.10						
Vellor 800g (PE)	2.47(5.67)	0.88(0.33)	2.53(6.00)	1.59	33.67	1.67	6593	2840	64875	1.96
Vellor 900g (PE)	1.81(3.00)	0.71(0.00)	1.81(3.00)	0.41	33.33	1.70	6900	2983	71417	2.06
Vellor 1000g (PE)	1.27(1.33)	0.71(0.00)	1.27(1.33)	0.26	40.00	1.73	7231	3413	88112	2.31
imazethapyr -50	1.93(3.33)	1.56(2.00)	2.41(5.33)	15.78	23.33	1.57	6970	2221	46598	1.71
imazethapyr -70	1.56(2.00)	1.46(1.67)	2.03(3.67)	7.45	25.67	1.60	7264	2518	58438	1.89
imazethapyr +Imazamox 60 g	1.79(3.33)	1.34(1.33)	2.16(4.67)	8.28	26.33	1.63	7117	2532	57193	1.85
imazethapyr +Imazamox 70 g	1.46(1.67)	1.05(0.67)	1.66(2.33)	1.56	27.00	1.67	7447	2639	62610	1.93
Oxi-40	5.27(28.00)	1.00(0.67)	5.32(28.67)	27.17	12.67	1.53	5296	1668	18850	1.29
fenaxaprop –p-ethyl. 50g	5.26(28.00)	1.05(0.67)	5.32(28.67)	25.82	13.67	1.53	5004	1712	18930	1.29
Propaqizafop. 62g	5.69(32.00)	1.05(0.67)	5.75(32.67)	25.26	13.33	1.53	5077	1725	19760	1.30
Weed free	1.17(1.00)	0.88(0.33)	1.27(1.33)	0.38	42.00	1.77	7769	3780	103158	2.52
Weedy check	7.42(54.67)	1.93(3.33)	7.64(58.00)	54.49	11.67	1.50	5121	1546	16713	1.27
LSD (P=0.05)	1.01	0.53	4.71	2.62	6.57	0.09	163	52	-	-

RESULTS

The dominant weeds of the experimental site were *Amaranthus spinosiss, Gisekia poiedious, Digera arvensis, Corcorus tridense, Trianthema portualacastrum, Cenchrus biflorus, Eragristis pilosa, Portulacca oleracea* are among the broad leaved weeds, there were rare grassy weeds existence with species *Cenchrus biflorus* and *Digitiria* spp. Among weed control treatments except propaquizafop ethyl, phinoxiprop-p-ethyl, oxiflourfen and pendimathalin as PPI all treatment increased the pod yield of ground nut significantly. Among chemical treatments imazethapyr + pendimathalin at 1000 g/ha gave maximum pod yield, net return and B:C ratio.

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Effect of early post-emergence herbicides on weed growth and yield of yellow sarson (*Brassica campestris*) in lateric soil of West Bengal

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Rapeseed-mustard is one of the most important edible oilseed crops of the eastern India including West Bengal. Yellow sarson is the most widely cultivated oilseed crop under rapeseed-mustard group in West Bengal. But the average yield of the crop in most of the areas in the State is still poor when compared to that of other parts of the country. One of the important reasons for low yield is the infestationofweeds. Yield losses due to crop weed competition in rapeseed-mustard have been estimated to the tune of 10-58% (Kumar *et al.* 2012). The age-old practice of managing weeds in yellow sarsonis manual weeding which is time consuming, expensive and tedious.Timelyweed management may not be possible manually due to non-availability of labours and high rate of wages during peak period of farm operations (Duary *et al.* 2012). Hence, chemical weed management appears to hold a great promise in dealing with effective, timely and economic weed suppression.In general, farmers are using pre-plant incorporated or pre-emergence herbicides for weed management in yellow sarson, but their efficacy is sometimes reduced due to variation in climatic and edaphic factors. They have also the limitation of narrow elasticity intime of application.With this perspective the present experiment was conducted to study the effect ofearly post-emergenceherbicides on weed growth and yield of yellow sarson.

METHODOLOGY

A field experiment was carried out during *Rabi* season of 2014 at Agriculture Farm, Institute of Agriculture, Visva-BharatiUniversity, Sriniketan, West Bengal to study the efficacy of early post emergence herbicides against weeds in yellow sarson.Eight treatments comprisingof isoproturon at 500 g/ha, isoproturon at 750 g/ha, fenoxaprop-p-ethyl at 60 g/ha, oxyfluorfenat 150 g/ha, propaquizofop at 60 g/ha, quizalofop-p-ethyl at 50 g/ha, hand weeding twice at 20 and 40 DAS anduntreated controlwere replicated thrice in a randomised block design. Yellow sarsonvariety *'B-9'* was used in the present experiment.The crop was fertilized with 80 kg N, 40 kg each of P_2O_5 and K_2O /ha. All other recommended agronomic practices and plant protection measures were adopted to raise the crop. The data on weed density and dry weight of weeds per m^2 were recorded at different growth stages of yellow sarson crop. These were subjected to square root transformation to normalize their distribution. Weed control efficiency (%) was computed using the dry weight of weeds. Seed yield of yellow sarson along with yield componentswere recorded at harvest.

RESULTS

The total number of weed species in the experimental field was 8 out of which *Digitaria sanguinalis* and *Echinochloa colona,* among the grassesand *Anagallis arvensis* and *Chenopodium album,* among the broadleaved weeds were present as major weeds throughout the cropping period. No sedge was observed in the experimental field. Unweeded control recorded significantly the highest density and dry weight of all the weed species at 45 DAS. Weed control treatments brought about significantly variation in the density and dry matter production of weeds at 45 DAS (Table 1). The lowest density and dry weight of weeds was registered under hand weeding twice at 20 and 40 DAS. Among the herbicidal treatments application of oxyfluorfen at 150 g/ha at 20 DAS registered the lowest density (2.67 /m^2) and dry weight (0.97 g/m^2) of weeds followed by isoproturon at 750 g/ha. Early post emergence application of oxyfluorfen at 150 g/ha at 20 DAS registered the highest weed control efficiency at 45 DAS among the herbicidal treatments. The results were in conformity with Chauhan *et al. (*2005). There was about 29.65% yield reduction due to weed competition in yellow sarson crop. Among the herbicidal treatments oxyfluorfen at 150 g/haat 20 DAS recorded the lowest weed index (1.59%). This clearly indicated that weeds were managed effectively under oxyfluorfenat 150 g/ha. The highest plant height was recorded under handweeding (20 and 40 DAS) which was statistically at par with all the treatments except unweeded control,isoproturon at 500 g/ha and quizalofop-p-ethyl at 50

Table 1. Effect of treatments on density and dry weight of weeds, weed control efficiency, weed index, plant height, yield components and yield of yellow sarson

Treatment	Weed density (no./m^2) at 45 DAS	Weed dry weight (g/m^2) at 45 DAS	Weed control efficiency (%) at 45 DAS	Weed index (%)	Plant height (cm)at harvest	No of siliquaeper plant	Test weight (g)	Seed yield (kg/ha)
Isoproturon at 500 g/ha	6.47 (41.33)	3.29 (10.17)	60.16	13.05	87	68	2.72	1091
Isoproturon at 750 g/ha	4.88 (23.33)	2.74 (5.80)	77.28	11.92	94	79	2.83	1105
Fenoxaprop–ethyl at 60 g/ha	6.42 (40.67)	3.09 (10.55)	58.66	15.98	93	71	2.70	1008
Oxyfluorfen at 150 g/ha	1.78 (2.67)	0.97 (1.06)	95.86	1.59	102	84	3.04	1235
Propaquizofop at 60 g/ha	6.44 (41.00)	3.15 (10.13)	60.32	13.51	94	69	2.69	1085
Quizalofop-p-ethyl at 50 g/ha	6.65 (43.67)	3.39 (10.89)	57.34	16.99	87	68	2.92	1054
Hand weeding twice	0.71 (0)	0.71 (0)	100	0	104	87	3.07	1255
Unweeded control	8.24 (67.33)	4.83 (25.3)	0	29.65	77	51	2.34	883
LSD (P=0.5)	0.63	0.39	-	-	12.30	13	0.23	121

Figures in parentheses are the original values. The data was transformed to SQRT (x + 0.5) before analysis.

g/ha. The highest number of siliquae per plant and test weightwere recorded with hand weeding at 20 and 40 DAS which was statistically at par with oxyfluorfenat 150 g/ha at 20 DAS. The highest seed yield (1.25 t/ha) was registered with hand weeding (20 and 40 DAS) and it was statistically at par with oxyfluorfen at 150 g/ha at 20 DAS followed by isoproturon at 750 g/ha (1.10 t/ha). Effective and timely weed management under these treatments reduced the density as well as dry weight of weeds which facilitated the crop plants to have sufficient space, light, nutrient and moisture and thus the number of siliquae per plant, number of seeds per siliqua and finally the yield were increased. The lowest seed yield (0.88 t/ha) was recorded under unweeded control.

CONCLUSION

It may be concluded that early post-emergence application of oxyfluorfenat 150 g/ha at 20 DAS appeared to be the most effective for management of broad spectrum weeds andobtaining higherseed yield of yellow sarson.

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Weed management in lentil

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A field experiment was conducted at Agronomy Research Farm, of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) during Rabi season of 2012-13. The experiment was laid out in Randomized Block Design with 10 treatments, *viz*. Oxyfluorfen 0.2 kg/ha (pre-em.), Oxyfluorfen 0.2 kg/ha (pre-em.) followed by clodinafop 0.06 kg/ha (25-30 DAS), Oxyfluorfen 0.2 kg/ha + clodinafop 0.06 kg/ha (25-30 DAS), Pendimethalin 1.0 kg/ha (pre-em.) followed by clodinafop 0.06 kg/ha (25-30 DAS), Pendimethalin 1.0 kg/ha (pre-em.) followed by clodinafop 0.06 kg/ha + imazithaypr 0.075 kg/ha (25-30 DAS), Pendimethalin 1.0 kg/ha (pre-em.) followed by clodinafop 0.06 kg/ha + Oxyfluorfen 0.2 kg/ha (25-30 DAS), Pendimethalin 0.75 kg/ha (pre-em.) followed by one hand weeding (30 DAS), Oxyfluorfen 0.2 kg/ha followed by one hand weeding (30 DAS), weed free and weedy check and replications three times. The soil of the experimental field was silt loam in texture, low in organic carbon and nitrogen & medium in available phosphorus and potassium having pH 8.1 and EC 0.32 dS/m .

The lentil variety '*Naredra lentil-1*' was sown by Tractor drawn seed drill. Nitrogen and phosphorus were applied through Diammonium phosphate as per recommendation. application of pendimethalin 1.0 kg/ha as pre-emergence followed by clodinafop 0.06 kg/ha + oxyfluorfen 0.2 kg/ha (25-30 DAS) reduced the number of weeds and weed dry weight significantly as compared to other treatments but remained at par with weed free and pendimethalin 1.0 kg/ha followed by clodinafop 0.06 kg/ha + imazithaypr 0.075 kg/ha (25-30 DAS). All the growth and yield contributing characters, *viz*. plant height, dry matter accumulation, no. of nodules/plant, fresh weight of nodules plant^{-1}, no. of branches, no. of pods and 1000- grain weight as well as seed and straw yield were significantly higher with weed free and the values were at par with Pre-emergence application of pendimethalin 1.0 kg/ha followed by clodinafop 0.06 kg/ha + oxyflurfen 0.2 kg/ha (25-30 DAS) and pendimethalin 1.0 kg/ha followed by clodinafop 0.06 kg/ha + imazithaypr 0.075 kg/ha (25-30 DAS). The highest net return of Rs. 42757.5 and B:C ratio 1.71 were recorded with pre-emergence application of pendimethalin 1.0 kg/ha followed by clodinafop 0.06 kg/ha + oxyfluorfen 0.2 kg/ha (25-30 DAS).

Thus, it is concluded that pre-emergence application of pendimethalin 1.0 kg/ha followed by clodinafop 0.06 kg/ha + oxyflurfen 0.2 kg/ha applied at 25-30 days after sowing was found to be most effective to control the weeds and economically feasible for higher production of lentil crop.

Weed management through chemicals in groundnut under rainfed conditions

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Groundnut (*Arachis hypogaea L.*) is the important food, feed, fertiliser, oil, fuel and income generating crop in Telangana state . In Andhra Pradesh it is mainly cultivated in Rayalaseema districts, *viz.* Anantapur, Cuddapah, Kurnool and Chittoor districts followed by Telangana and coastal districts. In united Andhra Pradesh it is cultivated in an area of around 13.1 lakh ha with a production of about 8.4 lakh tonnes and a productivity of 646 kg/ha (2011-12). Groundnut kernels are rich in protein and vitamins A, B, *etc.* and can be eaten raw, roasted, fried, sweetened or boiled. The main problem in limiting production of crop are poor cultural practices and inadequate weed management. If early weeding is compulsory, then the weeds that arise later are smothered with the vigorous growth of the crop. Once flowering and pegging formation begins it is advisable to remove weeds by hand pulling rather than by using a hoe as this is less likely to disturb any developing pods. Hand weeding (hoeing) is still by far the most widely practiced cultural weed control technique in field crop production throughout the tropics because of the prohibitive costs of herbicides and fear of toxic residue coupled with the lack of knowledge about their use. Keeping this in view the present study was taken up to investigate the effect different weedicides in groundnut crop.

METHODOLOGY

The study was conducted on Groundnut during *Kharif* season with three consequent years of 2009, 2010 & 2011(Pooled mean of three years) at Regional Agricultural Research Station, Polasa, Jagtial, Karimnagar (T.S) to evaluate the efficacy of different herbicides in the management of weeds treatments against weeds. Eight treatments consisting of two checks (Weedy check (T1) and weed free plot (T2)), pre emergence application of pendimethalin followed by one hand weeding (T3) (30% E.C.) at 1.0 kg/ha (+) one hand weeding at 45 DAS), post emergence application of quizalofop –p-ethyl (T4) ((5% EC) at 50 g/ha (750 ml/ha) at 20 DAS) and imazethapyr (T5) (10% WC) at 75 g/ha (750 ml/ha) at 20DAS) also combination (T6 (T3+T4) & T7 (T3+T5)) with pre emergence application of pendimethalin + one hand weeding at 45 DAS and farmers method (Hand weeding twice at 20 and 40 DAS). All the treatments were in light soils imposed in light soils using groundnut cv. JCG-88 adopting RBD (experiment) replicated thrice with the application of recommended dose of fertilizers (30 kg N, 60 kg P_2O_5,40 kg K_2O and 500 kg gypsum /ha respectively. Herbicide application with recommended doses applied through knapsack sprayer at 600 l of spray fluid / ha. Weed species recorded in each treatment at 30 and 60 days after sowing (DAS). Weeds counts were made by placing the quadrate (0.5 m x 0.5 m) at four random locations of groundnut crop in different treatments in order to obtain good counts of even small weeds. Weed parameters, yield and yield attributes were analyzed statistically.

RESULTS

Based on the three years mean data showed that the predominant weed species found in different treatments were *Cyperus rotundus, Cynodn dactylon, Digiteria sangunalis, Cloem viscosa, Euphorbia geniculata, E. hirta, Commalena bengalensis, Phyllanthus madraspetens, Eclipta alba and Celosia argentia* which were accounteded as narrow and broad leaved weed flora, respectively. Weed population and dry matter accumulation was significantly varied due to herbicidal treatments in groundnut crop. The maximum weed population and dry matter were found in weedy check also. Significantly the lowest weed population and weed dry matter were recorded in the treatment of pre-emergence application of Pendimethalin 30% EC at 1.0 kg/ha +one hand weeding at 45 DAS (T3).These results are in conformity with the findings of Malligwad *et al.* (2000). Next best treatment was recorded in combination of pre emergence application of Pendimethalin 30% EC at 1.0 kg/ha + hand weeding at 45 DAS and post emergence herbicide application of Imazethapyr 10% SL at 75 g/ha (T7) or Quizalofop-ethyl 5 EC at 50 g/ha (T6) followed by farmer's method (T8). The highest weed contrl efficiency and lowest weed index was obtained with weed free check (T2). Whereas significantly higher weed control efficiency was noticed with pre-emergence application of Pendimethalin 30% EC at 1.0 kg/ha + hand weeding at 45 DAS (T3) which was on par with combination of pre emergence application of Pendimethalin 30% EC at 1.0 kg/ha + hand weeding at 45 DAS and post emergence herbicide application of Imazethapyr 10% SL at 75 g/ha (T7) or quizalofop-ethyl 5 EC at 50 g/ha (T6). Similarly significant lower weed index was recorded in herbicide treated plots like pre-emergence application of Pendimethalin 30% EC at 1.0 kg/ha + hand weeding at 45 DAS (T3) which was on par with combination of pre emergence application of Pendimethalin 30% EC at 1.0 kg/ha + hand weeding at 45 DAS and post emergence herbicide application of Imazethapyr 10% SL at 75 g/ha (T7) or Quizalofop-ethyl 5 EC at 50 g/ha (T6) also farmer's practice (T8) which was significantly lower than the other treatments. The study indicated that application of herbicides were significantly reduced the weed population.

Table 1. Weed growth, yield and economics of groundnut as influenced by different weed control treatments

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	Weed control efficiency (%)	Weed index	Dry pod yield (kg/ha)	Dry haulm yield (kg/ha)	Cost of cultivation (`./ha)	Net returns ((`./ha)	B:C ratio
T_1 : Un weeded control (Weedy check)	406.20	196.6	0.0	64.3	752	1609	15428	2628	1.19
T_2 : Weed–free check	0.00	0.0	100.0	0.0	2106	3597	24110	26426	2.21
T_3 :Pre emergence herbicide application of Pendimethalin (30% E.C.) at 1.0 kg/ha (+) 1 HW at 45 DAS	45.20	26.6	65.1	14.4	1803	3142	20611	22661	2.18
T_4 : Post emergence herbicide application of Quizalofop-ethyl (5% EC) at 50 g/ha (750 ml/ha) at 20DAS	95.50	111.4	56.8	43.1	1188	2286	17286	11218	1.71
T_5 :Post emergence herbicide application of Imazethapyr (10% WC) at 75 g/ha (750 ml/ha) at 20DAS	93.42	99.8	55.1	41.6	1216	2044	18047	11145	1.74
T_6 : T_3 (+) T_4	61.53	86.0	63.7	25.5	1499	2668	20945	16623	1.81
T_7 : T_3 (+) T_5	63.53	72.7	63.1	28.4	1565	2708	21229	14747	1.88
T_8 :Farmer'spractice (two Hand weedings at 20 and 40 DAS)	76.07	42.1	33.4	19.6	1692	2860	20640	19976	2.03
LSD (P=0.05)	75.63	60.6	34.1	13.5	298.8	805.58	2694.3	6440.12	0.36

Pre-emergence application of Pendimethalin 30 EC at 1.00 kg/ha + one HW at 45 DAS and Weed-free control enhanced pod yield (1803 and 2.11 t/ha, accordingly) over Unweeded control (0.75 t/ha) followed by Farmer's practice was recorded 1.69 t/ha pod yield. Post-emergence application of Imazethapyr 10 WC at 75 g/ha at 20 DAS (1216 kg/ha) was found significantly superior over the post-emergence application quizalofop-ethyl 5 EC at 50 g/ha at 20 DAS (1188 kg/ha). The pod yield in groundnut was enhanced when Pre-emergence application of Pendimethalin 30% EC at 1 kg/ha + one HW at 45 DAS followed by the post-emergence application of Imazethapyr 10 WC at 75 g/ha. (1.56 t/ha) or quizalofop-ethyl 5 EC at 50 g/ha (1.49 t/ha). The maximum haulm yield (3.59 kg/ha) was recorded in weed free check and (1.61 t/ha) lowest in weedy check. Among the herbicidial treated plots the significantly highest yield (3.12 t/ha) was found in pre-emergence application of pendimethalin 30 EC at 1.00 kg/ha + one HW at 45 DAS (T3) which was on par with (2.86 t/ha) farmers practice (T8), Pre-emergence application of pendimethalin 30% EC at 1 kg/ha + one HW at 45 DAS followed by the Post-emergence application of Imazethapyr 10 WC at 75 g/ha (2668 kh/ha) (T7) and Pre-emergence application of Pendimethalin 30% EC at 1 kg/ha + one HW at 45 DAS followed by the post-emergence application of quizalofop-ethyl 5 EC at 50 g/ha (2.71 t/ha)T6.

Herbicidal treated plots resulted in considerably similar cost of cultivation to the farmers practice but higher than weed free check. The B:C ratio were obtained highest with (T2) weed free check (2.21) which was on par with pre-emergence application of Pendimethalin 30 EC at 1.00 kg/ha + one HW at 45 DAS (T3), farmers practice T8 and Pre-emergence application of Pendimethalin 30% EC at 1 kg/ha + one HW at 45 DAS followed by the Post-emergence application of Imazethapyr 10 WC at 75 g/ha T7. Similarly higher net returns were found with T2 weed free check followed by T3 (pre-emergence application of Pendimethalin 30 EC at 1.00 kg/ha + one HW at 45 DAS).

CONCLUSION

In the present study it was concluded that weed free check T2, pre-emergence application of Pendimethalin 30 EC at 1.00 kg/ha + one HW at 45 DAS T3 *fb* Pre-emergence application of Pendimethalin 30% EC at 1 kg/ha + one HW at 45 DAS followed by the Post-emergence application of Imazethapyr 10 WC at 75 g/ha T7 and Pre-emergence application of Pendimethalin 30% EC at 1 kg/ha + one HW at 45 DAS followed by the Post-emergence application of of Quizalofop-ethyl 5 EC at 50 g/ha T6 were most effective for controlling weeds inturns increasing yield and profitability to the farmers in groundnut crop.

Efficacy of herbicides alone and in combination with cultural methods on soybean

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Soybean is most important and valuable oil seed crop in Central Vidarbha Zone of Maharashtra, it has covered a major kharif area in this region still it has to face some constraints like heavy infestation of weeds. Weed infestation could reduce the seed yield by 18.83-42.37% (Kurmawanshi *et al.*1995). Traditional method of weed control i.e .hand-weeding is expensive, tedious and time consuming, weeding also become difficult due to unfavorable weather, wet soil and unavailability of labour. Under such circumstances, use of effective herbicides in suitable dose remains the pertinent choice for controlling the weeds. A judicious combination of herbicides and cultural methods of weed control would not only reduce the expenditure on herbicides but aslo benefit the crop timely by providing proper aeration and conservation of moisture., hence the present investigation was taken.

METHODOLOGY

A field experiment was carried out during kharif 2007-08 to 2009-10 at Zonal Agriculture Research Station, CVZ, Yavatmal (M.H.) to test the efficacy of different herbicides alone and in combination with cultural methods of weed management in soybean. Ten treatments, *viz.* Fluchloralin PPI 1000 g/ha, Imazethapyr at 75 g/ha. POE at 10 DAS, chlorimuron-ethyl at 10 g/ha,Fenaxoprop-P-ethyl at 75 g/ha + Chlorimuron–ehtyl at 10 g/ha POE at 10 DAS, Fluchloralin PPI 1000 g/ha+ one hoeing at 25 DAS,Imazethapyr at 75 g./ha. POE at 10 DAS + one hoeing at 25 DAS, Chlorimuron-ethyl at 10 g/ha + one hoeing at 25 DAS, Fenaxoprop-P-ethyl at 75 g/ha + Chlorimuron-ethyl at 10 g/ha POE at 10 DAS + one hoeing at 25 DAS, weed free(2 H + 2 HW) and weedy check were arranged in a randomized block design with three replications. Soybean variety '*JS-335*' was sown at 45 cm row spacing on 29, 27 and 30 June in 2007, 2008 and 2009 respectively with recommended package of practices. The crop received recommended dose 30 kg N + 75 kg P /ha. at sowing and data on weed flora and intensity of weed were recorded.

RESULTS

The experiment field was infested with various weed species,consisting both dicot and monocots weeds and sedges. In general dry matter of weeds increased with weed population. Herbicides treatments significantly influenced the population and dry matter production of weeds. From pooled result, highest dry matter of weeds was recorded in weedy check plots, lowest weed dry matter was found with weed free treatment, *viz.* 2 hoeing +2 hand weeding during every year because of weed removal. Among combination of chemical and cultural weed control treatments significantly reduce the dry matter of weeds more effectively by post emergence application of Imazethapyr at 75 g/ha. at 10 DAS +1H at 25 DAS next to weed free treatment (Table 1). Highest weed control efficiency, next to weed free treatment was also recorded by integrated treatment in which post emergence application of Imazethapyr at 75 g/ha at 10 DAS +1 H at 25 DAS.These results are in conformity with the finding of Dhane *et al.* (2010).

Table 1. Weed density, dry matter and weed control efficiency of soybean as influenced by different weed control treatments

Treatment	Weed density (no./m^2) at 45 DAS				Weed dry matter (g/ m^2) at 45 DAS				Pooled Weed control efficiency (%)at 45 DAS
	2007-2008	2008-2009	2009-2010	Pooled mean	2007-2008	2008-2009	2009-2010	Pooled mean	
Fluchloralin PPI 1000 g/ha	7.64 (57.33)*	8.56 (73.00)	7.50 (55.66)	7.90 (61.00)	9.90 (98.33)	9.97 (96.00)	9.61 (92.33)	9.77 (95.55)	36.14
Imazethapyr @ 75 g/ha. POE at 10 DAS	5.68 (31.37)	6.73 (45.66)	5.79 (33.00)	6.07 (36.78)	7.67 (60.67)	7.94 (63.66)	7.28 (52.33)	7.88 (58.99)	60.53
Chlorimuron-ethyl@10 g/ha	7.09 (49.67)	8.00 (64.00)	6.98 (48.33)	7.36 (54.00)	9.41 (91.67)	9.46 (93.66)	8.37 (70.33)	9.08 (85.22)	42.93
Fenaxoprop-P-ethyl @ 75 g /ha+Chlorimuron – ehtyl @ 10 g/ha POE at 10 DAS	6.11 (36.33)	7.04 (49.66)	6.07 (36.33)	6.41 (40.77)	8.18 (66.67)	8.22 (67.33)	8.27 (68.33)	8.22 (67.44)	54.95
Fluchloralin PPI 1000 g/ha+ 1H at 25 DAS	6.17 (37.66)	7.20 (51.33)	5.61 (30.67)	6.33 (41.89)	8.34 (70.00)	7.73 (68.66)	7.49 (63.33)	7.94 (67.33)	54.98
Imazethapyr @ 75 g a/ha. POE at 10 DAS+ 1H at 25 DAS	4.00 (15.77)	5.07 (25.33)	3.90 (14.67)	4.32 (18.59)	5.60 (31.33)	5.70 (32.66)	5.20 (27.00)	5.50 (30.33)	79.71
Chlorimuron-ethyl @ 10 g/ha + 1H at 25 DAS	5.46 (29.33)	6.64 (43.66)	5.56 (30.33)	5.88 (34.44)	7.66 (58.67)	7.62 (58.33)	7.75 (60.33)	7.52 (59.11)	60.52
Fenaxoprop-P-ethyl @ 75 g/ha+ Chlorimuron – ehtyl @ 10 g/ha POE at 10 DAS+ 1H at 25 DAS	5.03 (24.87)	5.84 (33.66)	4.97 (24.33)	5.28 (27.62)	7.40 (50.67)	7.01 (49.00)	6.93 (48.00)	7.01 (49.22)	67.10
weed free(2H+2HW)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100
weedy check	9.67 (93.33)	10.85 (118.0)	9.86 (96.67)	10.13 (102.67)	12.12 (146.67)	12.19 (148.33)	12.48 (154.33)	12.25 (149.77)	---
LSD (P=0.05)	0.92	1.05	1.11	0.87	1.75	1.84	1.37	1.41	---

*Value in parentheses are original. Data transformed to square root transformation.

CONCLUSION

It was concluded that post-emergence application of Imazethapyr at 75 g/ha at 10 DAS +one hoeing at 25 DAS was most effective for controlling weeds, which improve yield.

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Evaluation of bioefficacy of imazethapyrfor weed management in groundnut

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Groundnut (*Arachis hypogea* L.) is known as the '*King*' of the oilseeds and accounts for 33% area and 45% production in India. India ranks first among groundnut growing countries in the world with 6.74 mha area and 7.99 mt production (Bhale *et al*. 2012). Production and productivity especially of *Kharif* groundnut is shown highly fluctuating trends. Walia *et al.* (2007) reported that there is an urgent need to explore the possibilities for increasing the productivity though better understandingof the constraints in production of oilseed crops especially in groundnut. Infestation of heavy weeds in production of *Kharif* groundnut is a major constraint. Sathyapriya *et al.* (2013) reported that groundnut weeds comprise diverse plant species from grasses to broad leaf weeds and sedges and cause substantial losses up to 75%. The critical period of crop weed competition is the premier factor, which decided the growth and yield of groundnut. The productivity of ground nut was reported to be reduced considerably when weed competition occurs during the early stages of crop growth. The most critical period is from three to six weeks after sowing. Under this situation the post emergence herbicide may give the wonderful results against weeds. Thus, the different doses imazethapyr, were tested in the present experiment.

METHODOLOGY

The present field experiment was conducted at RVSKVV, ZARS, Khargone (M.P.) during *Kharif* season of two consecutive years during 2012-13 and 2013-14.The minimum and maximum temperature occasionally reaches in the month of January and May, respectively. The topography of experimental field was uniform. The soil of experimental field was clay loam (medium black soil) in texture. The field experiment was laid out in a randomized block design (RBD) with three replications. The eight weed management treatments were tried under the experiment.The experiment was conducted with the coordination of Agrogill Chemicals Pvt. Ltd. New Delhi.

RESULTS

The results indicated that the significantly lower weed count (17.33 and 28.99 /m^2) was recorded in imazethapyr 10% SL at 200 g ai/ha over all other weed control treatments which was followed by imazethapyr 10% SL at 150 g/ha (24.34 and 35.66 /m^2) at 30 and 60 DAA, respectively. These treatments were more effective against the weeds in groundnut crop to marketed product of imazethapyr 10 SL either applied 100 g or 150 g/ha. The weed dry weight was also found in similar trend as weed count.

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The minimum weed dry (43.65 and 65.00) was recorded in imazethapyr 10% SL at 200 g/ha over all other weed control treatments which was followed by imazethapyr 10% SL at 150 g/ha (65.2 and 79.02) at 30 and 60 DAA, respectively. The maximum weed count (113.66 and 146.66 /m^2 at 30 and 60 DAA, respectively) and weed dry weight were observed in weedy check. Imazethapyr 10% SL at 100 g/ha resulted in (71 and 70%) weed control efficiency and was comparable to marketed product of imazethapyr 10% SL at the same dose with (69% and 68%) at 30 and 60 DAA, respectively. Imazethapyr 10% SL at 200 g/ha (81% and 77%) recordedthe highest weed control Efficiency at 30 and 60 DAA, respectively whereas weedy check was observed minimum (Table.1).Dubey and Gangwar (2012) have also found lower weed biomass and higher weed control efficiency with post emergence application of Imazethapyr.

The highest groundnut pod yield viz., 1824 kg/ha was recorded with application of imazethapyr 10% SL at 200 g a.i/ha followed by 1781 kg/ha of groundnut pod yield obtained with 150 g a.i/ha withimazethapyr 10% SL application. However, the yield was at parwith the yield recorded at 100 g. a.i. /ha. Haulm yield also followed the similar trend and these were significantly superior to yield obtained from imazethapyr 10% SL (standard) at 100 &1500 g a.i./ha or Quizalofop-p-ethyl 5% EC (Table 2). The similar findings was reported by Kalhapure et al. (2013).

Table 1. Weed count, weed dry weight and WCE under different treatments (Pooled over 2 years)

Treatment	Weed count/m^2		Dry wt. (g/m^2)		% WCE	
	30 DAA	60 DAA	30 DAA	60 DAA	30 DAA	60 DAA
Imazethapyr 100 g/ha	30.33	43.00	68.5	86.4	71.02	70.47
Imazethapyr 150 g/ha	24.34	35.66	65.2	79.2	72.41	72.93
Imazethapyr 200 g/ha	17.33	28.99	43.5	65.0	81.59	77.78
Imazethapyr 100 g/ha (standard)	33.67	44.67	71.7	92.7	69.67	68.31
Imazethapyr 150s g/ha (standard)	27.34	39.67	71.5	94.5	69.75	67.70
Quizalofop-p-ethyl 50 g/ha	38.33	49.66	80.5	99.1	65.95	66.13
Weedy Check	113.66	146.6	236.4	292.6	-	-
Weed free check	0.0	0.00	-	-	-	-
LSD (P=0.05)	1.548	1.698	-	-	-	-

DAA- Days After application

Table 2. Pod and Haulm yield of groundnut under different treatments (Pooled over 2 years)

Treatment	Pod Yield (kg ha^{-1})	Haulm Yield (kg ha^{-1})
Imazethapyr @ 100 g/ha	1703	2021
Imazethapyr @150 g/ha	1781	2121
Imazethapyr @ 200 g/ha	1824	2286
Imazethapyr @ 100 g/ha (standard)	1269	1813
Imazethapyr @ 150s g/ha (standard)	1686	1806
Quizalofop-p- ethyl @ 50 g/ha	1721	1992
Weedy check	1056	1611
Weed free check	1837	2229
SEm±	43	62
C.D. at 5%	132	189

CONCLUSION

It was concluded that the different weed control treatments were effectively controlled the weeds in groundnut field as compare to weedy check. The application of Imazethapyr at 100, 150 and 200 g/ha were more effective as compare to Imazethapyr 10% SL (standard) at 100 & 1500 g/ha.

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Efficacy of imazethapyr alone and with cultural method on weed flora and economics of soybean

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Soybean is one of the most important rainy season crop in vidarbha region of Maharashtra, grows slowly during initial period which result in to vigorous growth and proliferation of grassy and broad leaf weeds.In fact crop production in rainy season is largely battle with weeds.Maintain a weed free period until 23 days after emergence in soybean reduced weed dry weight by 85 per cent and the weed count by 70% compared to weedy control. Selective post emergence herbicide imazethapyr has been developed for control of grassy and broad leaf weeds with no damage to soybean (Grieve *et al.* 2003), hence the present investigation was taken.

METHODOLOGY

A field experiment was carried out during kharifseason at Agronomy farm, College of Agriculture, Nagpur (M.H.) to test the efficacy of imazethapyr against weeds. Twelve treatments consisting of Imazetapyr at 75 g/ha and 90 g/ha at 10 DAS, 20 DAS and combination of chemical and weed management practices along with weed free (2 H + 2 HW at 20 and 40 DAS) and control treatmentwere arranged in a randomized block design with three replications. Soybean variety '*JS-335*'was direct sown in experimental field with recommended package of practices. Fertilizers were applied uniformly through urea and single super phosphate at 30 kg N and 75 kg P /ha. Data on weed growth, yield performance and economics were recorded.

RESULTS

Data pertaining weed flora, yield and economics of soybean (Table 1) indicated that, the experiment field was infested with various weed species, consisting both dicot and monocots weeds and sedges. Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal lowest weed density (19.00 m^2) was observed under post emergence application of Imazethapyr at 90 g/ha. at 20 DAS + one hoeing + one hand weeding at 20 days after spraying followed by Imazethapyr at 75 g/ha at 20 DAS + 1 H +1 HW at 20 days after spraying (19.33) (Table 1.). The minimum weed dry matter weight was also recorded in these treatments, which was significantly lower than all other treatments . These results are in conformity with the finding of Kushwah

Table 1. Weed growth, yield and economics of soybean as influenced by different weed control treatments.

Treatment	Weed density (no./m^2)	Weed dry matter g/m^2	Weed control index (%)	Grain yield (kg/ha.)	Straw yield (kg/ha.)	Cost of cultivation (`/ha.)	B:C ratio
Control	7.53 (56.33)*	220.00	50.61	724	1194	8331	1.81
2H+2HW at 20 and 40 DAS	4.37 (18.67)	20.00	–	1466	2318	10425	2.93
Imazethapyr @ 75 g/ha. at 10 DAS	6.27 (39.00)	67.00	32.40	991	1586	9537	2.15
Imazethapyr @ 75 g/ha. at 20 DAS	5.97 (35.33)	70.00	34.52	960	1536	9597	2.08
Imazethapyr @75 g/ha. at 10 DAS + 1H +1 HW at 20 days after spraying	4.94 (24.00)	26.00	4.09	1406	2240	10827	2.70
Imazethapyr @75 g/ha. at 20 DAS + 1H +1 HW at 20 days after spraying	4.45 (19.33)	23.00	14.19	1258	2013	10827	2.42
Hoeing at 15 DAS + Imazethapyr @ 75 g/ha. at 30 DAS	5.17 (26.33)	38.00	13.44	1269	2031	9855	2.68
Imazethapyr @ 90 g/ha. at 10 DAS	5.58 (30.67)	62.00	29.06	1040	1664	9807	2.21
Imazethapyr @90 g/ha. at 20 DAS	5.34 (28.00)	57.00	25.92	1086	1706	9807	2.30
Imazethapyr @90 g/ha. at 10 DAS + 1H +1 HW at 20 days after spraying	4.88 (23.33)	25.57	2.73	1426	2274	11037	2.69
Imazethapyr @90 g/ha. at 20 DAS + 1H +1 HW at 20 days after spraying	4.41(19.00)	22.50	4.77	1396	2235	11037	2.63
Hoeing at 15 DAS + Imazethapyr @ 90 g/ha. at 30 DAS	5.01(24.67)	37.00	7.02	1363	2181	10101	2.81
LSD (P=0.05)	0.50	6.98	--	211.89	369.54		--

*Value in parentheses is original. Data transformed to square root transformation.

and Vyas (2005). Maximum weed index (50.61) was recorded in control check.Among the herbicidal treatments, Imazethapyr at 90 g/ha at 10 DAS + one hoeing + one hand weeding at 20 days after spraying recorded minimum weed index (2.73%).This clearly indicated that weeds were controlled effectively under this treatment.

The highest grain and straw yield (1466 and 2318 kg/ha.) was recorded with two hoeing and hand weeding (20 and 40 DAS)and lowest (724 and 1194 kg/ha.). Application of Imazethapyr at 90 g/ha at 10 DAS + 1 H + 1 HW at 20 days after spraying recorded maximum grain and straw yield (1.42 and 2.27 t/ha), which was at par with lower doses of imazethapyr at 75 g /ha. The B:C ratio was found maximum with Imazethapyr at 90 g/ ha at 10 DAS + 1 H + 1 HW at 20 days after spraying (2.69) fallowed by Imazethapyr at 90 g/ha at 20 DAS + 1 H +1 HW at 20 days after spraying (2.63).

CONCLUSION

It was concluded that post-emergence application of Imazethapyr at 75 to 90 g/ha applied during 10-15 days after sowing + one hoeing + one hand weeding at 20 days after spraying may be preferred for better weed management in soybean.

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Influence of weed control practices on weed growth and yields of groundnut

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Groundnut (*Arachis hypogaea L.)* is an important oil seed crop of united Andhra Pradesh, which has low productivity and high cost of production. Weed infestation at first 4-5 weeks is critical in *Rabi* groundnut. Scarce and expensive labour during critical period of weeding will affect crop growth and yield. Use of pre and post emergence herbicides and combining with physical method of weed control helps in reduced weed competition at initial and later stages of the crop (Shasikala *et al.* 2004, Solanki *et al.* 2005). Therefore the present study was initiated to find out an effective integrated weed control practice in *Rabi* groundnut.

METHODOLOGY

The field experiment was conducted at Acharya N.G. Ranga Agricultural University during *rabi*, 2008-09. The soil was sandy loam, slightly alkaline with available N, P and K content of 252.9, 28.6 and 223 kg/ha. The experiment was laid out in randomized block design with twelve treatments consisted of handweeding, intercultural operations and herbicides pendimethalin as pre emergence and imazethapyr and Quizalofop-p-ethyl as post emergence and un weeded control replicated thrice. The groundnut cultivar (*K-134*) was sown (22.5 cm x 10 cm) and fertilizers were applied at 30 kg N, 40 kg P_2O_5 and 50 kg K_2O /ha. Weed density and dry weight was taken in selected quadrat (m^2) and worked out the weed control efficiency (%).

RESULTS

Predominated weed flora consisted of *Cynodon dactylon, Digitaria sanguinalis, Dactyloctenium aegyptium, Cyperus rotundus, Parthenium hysterophorus, Amaranthus viridis, Amaranthus polygamus, Trianthema portulacastrum, Digera arvensis* and *Celosia argentia*. At 20 DAS, The lower weed density, dry matter and better weed control efficiency was recorded withpendimethalin applied as pre emergence. At 40 DAS lower weed density, dry weight andhigher WCE (%) was recorded in hand weeding twice and pendimethalin *fb* imazethapyr. The pod yield of groundnut was significantly higher with handweeding twice and was on par with intercultivation with star weeder *fb* handweeding.Among herbicides, pendimethalin fb handweeding, imazethapyr *fb* handweeding and pendimethalin *fb* imazethapyr were superior due to minimum weed competition during critical stages of crop growth by effective control of grasses, sedges and broad leaved weeds with integrated weed control practices. These findingsare supported with the findings of Shasikala *et al.(* 2004) and Solanki *et al.* (2005).

Table 1. Study of weed growth and pod yield as influenced by integrated weed management practices in *Rabi* Groundnut

Treatments	Weed density (no/m^2)		Weed drymatter (g/m^2)		WCE (%)		Pod yield (kg/ha)
Un weeded control	16.06 (260)**	17.01 (289.0)	74.0	96	-	-	561
Handweeding (HW) at 20 and 40 DAS*	15.54 (241)	7.26 (52.0)	69.0	20	6.7	79.1	1754
Intercultivation (IC) with star weeder at 20 DAS	15.86 (251)	7.68 (58.0)	66.0	27	1.0	71.9	1084
IC + HW at 40 DAS	15.15 (229)	7.89 (62.0)	67.0	28	9.4	70.8	1729
Pendimethalin @ 1.0 kg a.i/ha as PE*	8.87 (78)	11.22 (125.0)	24.0	36	67.5	62.5	1187
Imazethapyr @ 100 g a.i/ha at 20 DAS	15.80 (249)	10.28 (105.0)	70.0	25	5.4	73.9	1242
Quizalofop-p-ethyl @ 50 g a.i/ha at 20 DAS	15.25 (232)	13.96 (194.1)	68.0	37	8.1	61.4	1141
Pendimethalin as PE + imazethapyr as POE*	8.93 (79)	8.98 (80.0)	22.0	22	70.3	77.1	1649
Pendimethalin as PE + Quizalofop-p-ethyl as POE	9.37 (87)	9.38 (87.1)	26.0	29	64.8	69.8	1450
Pendimethalin as PE + HW at 40 DAS	8.77 (76)	10.29 (105.0)	23.0	27	68.9	71.9	1701
Imazethapyr as POE+ HW at 40 DAS	15.80 (249)	11.39 (129.0)	71.0	37	4.0	61.4	1685
Quizalofop-p-ethyl as POE + HW at 40 DAS	15.81 (249)	14.38 (206.1)	69.0	46	6.7	52.1	1435
SE(m) ±	0.32	0.32	3.3	1.8	-	-	30
CD (P = 0.05)	0.95	0.95	9.6	5.4	-	-	89

*DAS= days after sowing, PE= pre emergence, POE= post emergence ** parenthesis original value

CONCLUSION

The results infer that in the peak periods of labour scarcity to carry out hand weeding followed by intercultivation with star weeder, application of pendimethalin as pre emergence followed by imazethapyr as post emergence are effective weed management practices for rabi groundnut.

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Evaluation of different weed control methods in sunflower

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Crop and weeds comes up simultaneously with the emergence of crop seedings. Weeds compete with the crop for essentials of growth i.e water, plant nutrients, air space and light and thus, adversely affect crop production if they are not controlled at the right time. The degree of yield losses on number of factors such as weed flora, intensity, cultural practices, input used and weather factors. Unchecked weeds cause 33-63% losses in seed yield of sunflower (Saraswat *et al.* 2003). Recently, some new low dose, high potent and broad spectrum herbicide like chlorimuron ethyl, imazethapyr and quizalofop ethyl have been developed and extensively used as pre and early post emergence in crops like soybean which is major *Kharif* oilseed crop. Information on the suitability of these herbicides in sunflower crop is lacking. Moreover, in situations of sunflower raised in soybean based cropping intercropping systems, sunflower response to the aforesaid recent herbicides needs to be ascertained.

METHODOLOGY

A field experiment on Growth and yield of sunflower as influenced by chemical and non-chemicalweed management practices was carried out to study the weed control efficiency and the economic feasibility of chemical and non-chemical weed management and Integrated Weed Management practices at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the 2005 to 2006 *Kharif* season. The experiment was laid out in randomised block design with three replications and twelve treatments.

RESULTS

In the experimental field, predominant weed species were *Lagascea mollis*, *Euhorbia geniculate*, *Digera arvensis*, *Parthenium hysterophorus*, *Amaranthus viridis* among dicot weeds; *Commelina benghalensis*, *Echinochloa crusgalli*, *Cynodon dactylon* among grasses and sedge *Cyperrus rotundus*. Two hoeings and two hand weedingsrecorded lowest weed dry matter productionwhich was at par with application of Imazethapyr PE 1 HW at 40 DAS 1 H + 1 HW at 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest, 1 H + 1 HW at 30 at DAS with crop residue as surface mulch and application of Chlorimuron ethyl PRE 75.0 g/ha *fb* 1 H + 1HW at 40 DAS followed by application of Pendimethalin PRE 1.0 kg/ha *fb* 1 H + 9.0 g/ha *fb* 1 H + 1 HW 40 at DAS. Two hoeings + two hand weedings recorded over all maximum weed control efficiency. However, season long suppression of weeds was found with non-chemical weed management through 1 Hoeing + 1 Hand weeding 20 DAS in paired row planting + smoother intercrop (green gram) with straw retained as surface mulch after harvest.

Two hoeings + two hand weedings recorded significantly highest seed yield (9.19 q/ha) which was statistically equivalent to non-chemical treatments 1 H + 1HW 30 at DAS with mulching of weed biomass and 1 H + 1 HW 20 at DAS in paired row planting + green gram with straw retained as surface mulch after harvest. However, it was at par with application of Pendimethalin PE 1.0 kg/ha *fb* 1 H + 1HW at 40 DAS and non-chemical weed management treatment 1 H + 1 HW at 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest. Additional 1.83 q/ha grain yield of green gram obtained from non-chemical weed management through 1 Hoeing + 1 Hand weeding 20 at DAS in paired row planting + smoother intercrop (green gram) with straw retained as surface mulch after harvest due to which it recorded highest GMR (Rs. 18033 /ha) and net profit (Rs. 10306 /ha) followed 2 H + 2 Hand weeding at 20 and 40 DAS, Imazethapyr PRE 75.0 g/ha *fb* 1 H + 1 HW 40 DAS and 1 H + 1 HW at 30 DAS with crop residue as surface mulch. The results are in conformity with Anonymous (2005) in cotton crop.

Table 1. Weed index, Weed control efficiency, yield of sunflower and benefit cost ratio as influenced by different weed control treatments

Treatment	Weed Dry weight g/m^2 at harvest	WI (%)	WCE (%)	Seed yield (q/ha)	GMR (`./ha)	NMR (`/ha)	B:C ratio
Weedy check-T1	340.8	59.52	-	3.72	6995	1464	1.26
Pendimethalin PRE 1.0 kg/ha– T2,	143.5	34.05	57.89	6.06	10909	3791	1.53
Imazethapyr PRE 75.0 g/ha -T3	148.1	37.54	57.53	5.74	10443	3309	1.46
Chlorimuron ethyl PRE 9.0 g/ha-T4	160.0	52.44	53.05	4.37	8060	1561	1.24
Pendimethalin PRE 1.0 kg/hafb1 H + 1HW 40 DAS-T5	60.0	14.36	82.39	7.87	14031	5779	1.70
Imazethapyr PRE 75.0 g/hafb1 H + 1HW 40 DAS – T6	47.3	7.72	86.12	8.48	15065	6797	1.82
Chlorimuron ethyl PRE 9.0 g/ha *fb* 1 H + 1HW 40 DAS ⁻T7	67.7	41.24	80.13	5.40	9731	2098	1.27
Quizalofop-p-ethyl POE 50.0 g/ha 20 DAS *fb* 1 H + 1HW 40 DAS- T811.09	97.0	27.85	71.54	6.63	11934	3741	1.45
1 H + 1HW 30 DAS with mulching of weed biomass – T9	79.7	17.19	76.62	7.61	13517	6382	1.89
1 H + 1HW 30 DAS with crop residue as surface mulch – T10	71.3	11.09	79.06	8.17	14500	6647	1.84
1 H + 1HW 20 DAS in paired row planting + green gram with straw retained as surface mulch after harvest – T11	61.5	23.39	81.95	7.04	18033	10306	2.33
2 H + 2 Hand weeding at 20 and 40 DAS – T12.	33.6	--	90.12	9.19	16158	8359	2.07
LSD (P=0.05)	1.04			1.52			

WI- Weed Index, WCE- Weed Control Efficiency, GMR- Gross Monetory Returns, NMR- Net monetory ReturnsB:C ratio- Benefit cost ratio, fb- Followed by, PRE- Pre emergence, Poe- Post emergence, H-Hoeing, HW-Hand weeding

CONCLUSION

Two hoeings + two hand weedings recorded over all maximum weed control efficiency and highest seed yield (9.19 q/ha). However, season long suppression of weeds was found with non-chemical weed management through 1Hoeing + 1Hand weeding at 20 DAS in paired row planting + smoother intercrop (green gram) with straw retained as surface mulch after harvest. Efficiency and increased GMR (Rs. 18033 /ha) and NMR (Rs.10306 /ha) through bonus intercrop yield caused higher B:C ratio (2.33).

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Effect of pre-emergence weedicides on yield, quality and nutrient uptake of summer groundnut on Inceptisol

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Groundnut occupies an important position among the oilseeds in India, sown on 6.86 million hectare with a total production of 6.99 million tonnes. Timely weed management practices plays an important role in the successful cultivation of the crop. Removal of nutrients by weeds showed a great impact on the availability of nutrients to the crop, thus, affecting its yield. The conventional methods of weed control are very laborious and expensive. Under such a situation chemical weed control is better alternative to manual weeding during the early stage of crops. But the herbicides have been found to affect the nutrient status. The present investigation was therefore, conducted to find out effect of pre-emergence herbicide on nutrient uptake and consequently on yield of summer groundnut in Inceptisol.

METHODOLOGY

A field experiment was carried out on groundnut in two successive years during summer 2002-2003 and 2003-2004 at Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.) on Inceptisol. The experiment was laid out with fourteen treatments replicated thrice in randomized block design. Groundnut variety '*JL-24*' was sown in the experimental plot. Recommended dose of 100 : 50 : 50 kg/ha N: P_2O_5: K_2O respectively along with 10 t/ha FYM is applied to each plot. The graded levels of pre-emrgence weedicides treatments, *viz.* half of the recommended dose, recommended dose and double of recommended dose of oxyfluorfen, alachlor, pendimethalin and fluchloralin weedicide were given immediately after sowing. Yield and dry matter of the crop was recoded at harvest. The grain and straw samples from each plot were analysed for their nutrient concentration and based upon yield and concentration per hectare nutrient uptake of nitrogen, phosphorous and potassium were calculated.

RESULTS

The pre emergence weedicide in summer groundnut significantly affected the yield. The pod yield of summer groundnut was significantly higher in weeded control treatment.(23.37 q/ha) and it was at par with oxyfluorfen at 0.5 kg/ha (19.62 q/ha) and fluchloralin at 1.5 kg/ha (19.59 q/ha), Whereas, treatments withpendimethalinapplication were recorded the low pod yield.

The application of pre emergence weedicide in summer groundnut were significantly influenced the protein and oil percentage. The weedy check was significantly superior for protein and oil content in summer groundnut (48.35% and 30.49 per cent protein and oil content respectively).The protein per cent by the fluchloralin at 0.75, 1.5 and 3.0 kg/ha were significantly reduced (44.95, 44.75 and 44.43%, respectively). The pendimethalinapplication in summer groundnut slightly increased the protein per cent than the other pre emergence weedicide. Among weedicide treatmentspendimethalin application at 0.75, 1.50 and 3.00 kg/ha were recorded the higher oil contentand closely followed by fluchloralin and oxyfluorfen. Alachlor pre emergence weedicide was slightly reduced the oil percentage in summer groundnut. The pre-emergence weedicides significantly influenced the total nutrient uptake by summer groundnut at harvest. The application of alachlor at 2.0 kg/ha significantly recorded the highest total nitrogen uptake (164.39 kg/ha) than the remaining pre emergence weedicides. It was statistically at par with the alachlor application at 1.0 kg a.i. ha^{-1} and 4.0 kg/ha (154.07 and 154.13 kg/ha, respectively). The highest phosphorus uptake was observed in oxyfluorfen application at 0.5 kg/ha (42.09 kg/ha).However, the application of pendimethalin was found to record the lowest phosphorus uptake at 3.0 kg/ha (25.33 kg/ha). The weedy check treatment recorded the highest total potassium uptake (39.69 kg/ha). The potassium uptake by the summer groundnut was numerically decreased with an increase in levels of weedicide application. It was maximum at recommended dose of weedicide and minimum in higher dose Prasad and Rafey (1995), and Banga *et al.* (2001).

Table 1. Effect of pre emergence herbicide on summer groundnut pod yield, protein and oil content and nutrient uptake of summer groundnut

Treatment	Pod Yield (q/ha)	Protein (%)	Oil content (%)	Nutrient uptake (kg/ha)		
				N	P	K
Oxyfluorfen at 0.5 kg/ha	19.62	46.33	28.30	140.67	42.09	25.54
Oxyfluorfen at 1.0 kg/ha	17.87	47.10	28.48	148.31	38.25	28.26
Oxyfluorfen at 2.0 kg/ha	17.79	46.58	28.05	137.11	34.27	25.15
Alachlor at 1.0 kg/ha	18.94	45.25	28.15	154.07	33.90	27.08
Alachlor at 2.0 kg/ha	18.17	45.07	27.94	164.39	36.26	30.02
Alachlor at 4.0 kg/ha	18.57	45.13	27.61	154.13	33.41	25.14
Fluchloralin at 0.75 kg/ha	19.18	44.95	27.24	152.90	36.09	27.02
Fluchloralin at 1.50 kg/ha	19.59	44.75	28.96	134.63	36.00	28.15
Fluchloralin at 3.0 kg/ha	18.27	44.43	28.67	137.62	31.93	26.18
Pendimethalin at 0.75 kg/ha	16.19	46.70	29.98	131.17	31.48	23.31
Pendimethalin at 1.50 kg/ha	14.08	46.62	29.26	126.41	29.49	20.14
Pendimethalinat 3.0 kgha	16.26	47.55	29.03	135.54	25.33	24.92
Weedy check	9.38	48.55	30.49	205.12	53.37	39.69
Hand weeding	23.37	48.10	28.17	144.86	32.32	27.28
LSD (P=0.05)	3.83	1.283	0.455	26.85	5.62	7.18

CONCLUSION

The use of pre emergence weedicide significantly influenced the yield and nutrient uptake by groundnut. The higher dose of pre emergence herbicide adversely affects the soil nutrient uptake.

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Evaluation of bioefficacy of herbicides in linseed

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Linseed (*Linum usitatissimum* L.) is mostly grown under conserved moisture and limited nutrient conditions with poor management practices. However, its cultivation has been widely extended in irrigated areas because of higher yield potential and increased prices of oilseed in the market. Among the different constraints, weed management is one such issue, because weeds can be a serious problem in linseed if left uncontrolled. Linseed does not compete well with weeds, compared to other crops such as cereal grains.Excessive weed populations reduce availability of water and nutrients to the crop. As linseed is slow to grow, weeds allowed to establish can easily overtop young flax seedlings and lead to substantial yield reductions. As a practice, hand weeding is usually preferred which adds to the cost of cultivation due to higher wages. Moreover, non-availability of labour during peak periodis also a major constraint in realizing higher yields in linseed. With the advancement of agro techniques, chemical weed control has conducted, become an effective and cheap alternative to control weeds. Therefore, herbicides continue to be a key component of weed management programs in flax production as in other crops and hence, an experiment was planned to control weeds chemically so as to make cultivation of linseed viable and remunerative over manual weeding.

METHODOLOGY

A field experiment was conducted under protective irrigation on evaluation of bioefficacy of herbicides in linseed on black clay soilat Main Agricultural Research Station UAS,Raichur, Karnataka during post-rainy season of 2014-15 in randomized block design with 10 treatments in three replications. Treatments details are furnished in Table 1.

RESULTS

The results of the investigation revealedthat among the different herbicide treatments, pendimethalin 30 EC + imazethapyr 2 EC at 1.0 kg/ha as PE recorded significantly higher seed yield (852 kg/ha) over isoproturon 75 WP at 1.0 kg/ha and imazethapyr 10 EC at 75 g/ha and recorded lower weed biomass upto harvest. A lower weed persistence index (WPI) and higher herbicide efficiency index (HEI) values areindicative of efficient weed management. In the present study, the lower WPI was recorded for label dose of clodinafop 15 WP at 60 g/ha, on other the hand higher HEI was recorded with pendimethalin 30 EC + imazethapyr 2 EC at 1.0 kg/ha. The latter treatment also recoded higher net returns while BC ratio was higher with former treatment and both treatments were on par.These findings are in line with Chandrakar *et al.* (2014) regarding seed yield.

Table 1. Weed biomass, seed yield and economics of linseed as influenced by weed control treatments

Treatment	Weed biomass at harvest (g 0.25 / m^2)	WPI	HEI	Seed yield (kg / ha)	Net returns (` / ha)	BC ratio
T_1 : Weedy check (control)	2.07*	1.00	0.00	459	12817	2.26
T_2 : Hand weeding at 25 DAS and 45 DAS (farmers' practice)	1.27	0.61	0.81	904	29061	2.80
T_3: Weed-free**	1.14	0.55	0.92	925	29810	2.81
T_4 : Pendimethalin 30 EC @1.0 kg/ ha (PRE)	1.90	0.91	0.45	779	26732	3.19
T_5 : Pendimethalin 30 EC + Imazethapyr 2 EC @ 0.75 kg/ ha (PRE)	1.84	0.89	0.47	791	27583	3.31
T_6 : Pendimethalin 30 EC + Imazethapyr 2 EC @ 1.0 kg/ ha (PRE)	1.80	0.87	0.53	852	30105	3.41
T_7 : Isoproturon 75 WP @ 1.0 kg/ ha at 2-3 leaf stage of weeds	1.76	0.85	0.48	764	26477	3.26
T_8 : Clodinafop 15 WP @ 60 g/ ha at 2-3 leaf stage of weeds	1.74	0.84	0.51	805	29436	3.72
T_9 : Imazethapyr 10 EC @ 75 g/ ha at 2-3 leaf stage of weeds	1.84	0.89	0.42	741	25610	3.24
T_{10} : Imazethapyr 10 EC @ 100 g/ ha at 2-3 leaf stage of weeds	1.79	0.86	0.48	783	27051	3.24
S.Em.±	0.04	0.03	0.04	29	1461	0.12
C. D. at 5 %	0.12	0.08	0.11	86	4340	0.36

*:Weed biomass (x) data were transformed to log (x+2) **: HW at 25 DAS + IC at 35 DAS + HW at 45 DAS, WPI: Weed Persistence Index, HEI: Herbicide Efficiency Index

CONCLUSION

From the study it can be concluded that pre-emergence application pendimethalin 30 EC + imazethapyr 2 EC at 1.0 kg/ ha would help to realize higher seed yield and net returns. Although BC ratio was next higher to clodinafop 15 WP at 60 g a.i./ha. Pendimethalin 30 EC + imazethapyr 2 EC at 1.0 kg/ha still economical due to higher seed yield, net returns and higher HEI among the herbicides, and yield levels were comparable with weed-free check. Next best herbicide was clodinafop 15 WP at 60 g/ha as POE.

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Evaluation of pre-emergence herbicides in soybean

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Soybean is an important oil seed crop with high protein and oil content. It is known for its high yield potentiality. Hence it is called as "miracle bean". Of the many constraints in its production, weed management poses a greater challenge for the farmers under the present context of scares and costly human labour. Weed management through pre-emergent herbicides is very easy and cost effective and keeps soybean crop free of weeds due to better weed control in the early stage *i.e*. during critical period of weed crop competition. Therefore, different pre-emergent herbicides were evaluated for their efficacy against weeds and for their effect on soybean yield.

METHODOLOGY

A field experiment was conducted at UAS, Dharwad, Karnataka, India during *Kharif* (rainy season) 2014. The soils of experimental site was black soil (vertisols), The experiment was laid out in RCBD with three replications involving 8 treatments. The treatment details are given in Table 1. Soybean variety '*JS-335*' was sown at 30 cm X 10 cm and recommended dose of fertilizers was applied as per package of practices. Observations on weed density and weed dry weight were recorded in 0.5 m^2 area at 60 DAS. The yield data was recorded and phytotoxicity ratings were expressed in the scale ranging between 0 – 10.

RESULTS

The recommended practice of pre-emergence application of alachlor 2.0 kg/ha with one intercultivation and one hand weeding recorded significantly higher grain yield, compared to all other treatments including farmers' practice, but it was on par with oxyfluorfen at 100 g/ha with one intercultivation. Oxyfluorfen with one intercultivation was effective in controlling the weeds as effectively as the recommended practice as indicated by lower weed density and lower weed dry weight.

Table 1. Weed density, weed dry weight, grain yield and phytotoxicity rating in soybean as influenced by different pre-emergent herbicides.

Treatments	Weed density (no./m^2)	Weed dry weight (g/ m^2)	Grain yield (kg/ha)	Phytotoxicity rating (0-10 Scale)
Alachlor 1.5 kg/ha	2.29 (5.00)*	1.44 (1.58)*	1819	0
Butachlor 1.5 kg/ha	2.94 (8.17)	1.67 (2.31)	1719	0
Oxyfluorfen 0.1 kg/ha	2.43 (5.50)	1.47 (1.68)	1825	1
Pendimethalin 1.0 kg/ha	3.52 (9.50)	1.87 (3.05)	1673	0
Pendimethalin 700g/ha	3.69 (13.33)	1.99 (3.47)	1460	0
Imazethapyr 100 g/ha	3.01(3.66)	1.71 (2.40)	1723	0
Chlorimuron Ethyl 10 g/ha	3.02(8.83)	1.70 (2.42)	1746	0
Alachlor 2 .0 kg/ha+1HW+1IC (RPP)	1.97(2.50)	1.39 (1.44)	2133	0
Weedy check	7.83 (61.0)	3.78 (13.83)	860	0
Farmers' Practice (1HW+1IC)	1.70 (2.50)	1.09 (0.72)	1841	0
LSD (0.05)	0.49	0.16	310	-

*Values in parantheses are original. Data transformed to square root transformation; IC – Intercultivation; HW– Hand weeding

CONCLUSION

Oxyfluorfen at 100 g/ha with one intercultivation proved effective in controlling the weeds and it was comparable with the recommended practice (alachlor at 2.0kg/ha + 1 IC + 1 HW). This treatment also resulted in higher grain yield which was on par with recommended weed management practice.

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Bioefficacy of herbicides and integrated weed management practices in groundnut

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The loss of groundnut production in the country due to weeds has been estimated to the tune of 33 per cent (Mani *et al.* 1968) to 70% (Prasad 2002). Though, physical methods of weed control are very effective, but they have certainlimitations such as non-availability of labour during peak period, high labour cost, andunfavourable environmental conditions, such as rainfall during peak period. Under suchconditions, the chemical weed control plays an important role in groundnut and enhances theyield substantially. Looking to the above facts the experiment is planned tomanage the weeds in groundnut with sequential application of pre and post emergence herbicides.

METHODOLOGY

Field experiment was carried out during *Kharif*, 2014 at College Farm, Professor Jayashankar Telangana State Agricultural University, Hyderabad to evaluate the bioefficacy of herbicides and integrated weed management practices in *Kharif* groundnutin sandy loam soil. Different herbicidal combinations and IWM practices tested were, pendimethalin at 1 kg/ha (pre) fb cycloxydym@80 g/ha at 20DAS, pendimethalin at 1 kg a.i ha^{-1} (pre) fb fenoxaprop-p-ethyl at 100 g/ha at 20 DAS, Oxyflourfen 118 g/ha(pre) fb cycloxydym at 80 g/ha at 20DAS, Oxyflourfen 118 g/ha (pre) *fb* fenoxaprop-p-ethyl at 100 g/ha at 20 DAS , Imazethapyr at 100 g/ha at 20 DAS, Imazethapyr + Imazamox at 70 g/ha at 20 DAS, pendimethalin at 1.0 kg/ha (pre) *fb* Hand weeding at 30 DAS, Oxyflourfen 118 g/ha (pre) *fb* Hand weeding at 30 DAS, Hand weeding at 20 and 40DAS, Unweeded Check.The experiment was conducted in RBD with a plot size of 4.5 m×5mwith three replications. The recommended fertilizer dose was 20-40-30 kg of N, P_2O_5 and K_2O ha respectively.Data on weed growth,yield performance and economics were recorded.

RESULTS

Herbicidal treatments significantly influenced the weed control efficiency, weeddry matter,pod yield and haulm yield. Lowest weed dry matter (10.05) as well as higher WCE (88%), pod yield (1.84 t/ha) and haulm yield (2.19 t/ha) was recorded with hand weeding twice at 20 and 40 DAS. Which was at par with Oxyflourfen (pre) followed by hand weeding at 30 DAS and Pendimethlin (pre) *fb* Hand weeding at 30 DASwith high WCE and grain yield indicating that weeds are controlled efficiently with sequential application of herbicides and resulted in higher grain yield over the control.

The gross returns were the highest with hand weeding twice treatment and were comparable with Oxyflourfen as pre-emergence *fb* hand weeding, Pendimethaline as pre-emergence *fb* hand weeding. The benefit-cost ratio was higher with Oxyflourfen followed by hand weeding and was followed by Imazethapyr + Imazamox treatment. This was due to low cost of the chemicals as compared to manual and mechanical practices. The lowest benefit-cost ratio was recorded in control due to severe weed competition, leading to poor pod yield.

Table1:- Weed dry matter, Weed control efficiency, yield and economics of groundnut as influenced by weed management practices.

Treatment	Weed dry matter (g/m^2)	WCE (%)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Cost of cultivation (`/ha)	Gross returns (`/ha)	B:C ratio
Pendimethalin (pre) *fb* Cycloxydym (post) at 20 DAS	33.19	47.40	701	876	17150	29820	0.55
Pendimethalin (pre) *fb* fenoxaprop –p- ethyle (post) at 20 DAS	32.13	50.86	764	1111	17225	32782	0.80
Oxyflourfen (pre) *fb* Cycloxydym (post) at 20 DAS	29.23	58.95	1203	1430	17040	50980	2.28
Oxyflourfen (pre) *fb* fenoxaprop–p-ethyl (post) at 20 DAS	31.11	62.41	1314	1557	17115	55676	2.34
Imazethapyr (post) at 20 DAS	26.14	55.77	1060	1263	16650	44926	1.45
Imazethapyr + Imazamox (post) at 20 DAS 70%WG at 70 g/ha.	18.10	74.56	1486	1690	15550	62847	3.32
Pendimethlin (pre) *fb* hand weeding at 30 DAS	15.07	78.60	1723	1840	18350	72613	2.67
Oxyflourfen (pre) *fb* followed by Hand weeding at 30 DAS	14.01	80.91	1760	2017	18240	74447	3.55
Hand weeding at 20 DAS and 40 DAS	10.05	87.90	1840	2192	19300	77984	3.26
Unweeded check	63.05	0.00	557	647.33	15300	23574	0.54
LSD (P=0.05)	2.93	-	108.80	128.90	-	3083	0.25

CONCLUSION

The application of pre-emergence herbicides oxyflourfen or pendimethalin *fb* hand weeding was most effective controlling weeds, improving pod yield and profitability of groundnut cultivation.

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Effect of herbicides and integrated weed management practices on weed dynamics and weed control efficiency in groundnut

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Groundnut encounters severe problem of weed infestation especially in the early stages of growth, as the seedling emerges 7-10 days after sowing coupled with the slow growth in the initial stages. Weeds emerge fast and grow rapidly competing with the crop severely for resources. On an average the loss of groundnut production in the country due to weeds has been estimated to the tune of 33-70%.

METHODOLOGY

Field experiment was carried out during kharif, 2014 at College Farm, PJTSAU, Hyderabad to evaluate the efficacy of herbicides and integrated weed management practices in *Kharif* groundnutin sandy loam soil. Herbicidal combinations and IWM practices tested were, pendimethalin at 1 kg/ha (pre) *fb* cycloxydym at 80 g/ha at 20 DAS, pendimethalin at 1 kg/ha (pre) *fb* fenoxaprop-p-ethyl at 100 g/ha at 20 DAS, Oxyflourfen 118 g/ha (pre) *fb* cycloxydym at 80 g/ha at 20 DAS, oxyflourfen 118 g/ha (pre) *fb* fenoxaprop-p-ethyl at 100 g/ha at 20 DAS , imazethapyr at 100 g/ha at 20 DAS, imazethapyr + imazamox at 70 g/ha at 20 DAS, pendimethalin at 1 kg/ha (pre) *fb* Hand weeding at 30 DAS, oxyflourfen 118 g/ ha (pre) *fb* hand weeding at 30 DAS, hand weeding at 20 and 40 DAS, unweeded Check.The experiment was conducted in RBD with three replications. The recommended fertilizer dose was 20-40-30 kg of N, P_2O_5 and K_2O ha respectively.

RESULTS

Among the grasses, *Cynodondactylon, Digitaria sanguinalis* and *Dactyloctenium aegyptium* were predominant. *Cyperus rotundus* was the only one predominant sedge species observed. Among the broad leaved weeds, *Parthenium hysterophorus, Amaranthus viridis, Amaranthus polygamus, Trianthema portulacastrum*, *Digera arvensis* and *Celosia argentia* were the major weeds in the experimental field. At 20 DAS, the weed density (number/m^2) was lowest. Treatments having pre-emergence applications of pendimethalin oroxyflourfen effectively controlled broad leaved weeds and certain grasses due to prevention of weed emergence during germination itself and recorded high weed control efficiency. At 40 DAS, significantly lower weed densitywas recorded in the treatments oxyflourfen (pre) *fb* hand weeding at 30 DAS and pendimethalin *fb* Hand weeding at 30 DAS. Supplementing with hand weeding at 30 DAS has shown effective control of all the weeds including sedgesand higher WCE of 79-85%. Application of imazethapyr + imazamox (17 /m^2), hand weeding at 20 and 40DAS (18 /m^2) and imazethapyr (28 /m^2) were next best treatments and were significantly superior in recording less weeds. Significantly higher total weed density (80 /m^2) was recorded in weedy check.

Table 1. Weed density and weed control efficiencyand yield of groundnut as influenced by weed management practices

Treatment	Weed Density (number/sq.m)				Weed Control Efficiency (%)				Pod yield (kg/ha)
	20 DAS	40 DAS	60 DAS	Harvest	20 DAS	40 DAS	60 DAS	Harvest	
Pendimethalin (pre) *fb* Cycloxydym (post) at 20 DAS	4.76 (22)	7.14 (50)	7.66 (58)	7.8 (60)	49.8	37.3	47.4	47.4	701
Pendimethalin (pre) *fb* Fenoxaprop –p- ethyle (post) at 20 DAS	4.96 (24)	7.06 (49)	7.40 (54)	7.54 (56)	38.8	39.3	50.9	49.0	764
Oxyflourfen (pre) *fb* Cycloxydym (post) at 20 DAS	3.57 (12)	6.47 (41)	6.84 (46)	7.20 (51)	71.0	48.4	59.0	53.6	1203
Oxyflourfen (pre) *fb* Fenoxaprop –p- ethyl (post) at 20 DAS	3.77 (14)	6.55 (42)	6.53 (42)	6.78 (45)	66.1	48.8	62.4	58.5	1314
Imazethapyr (post) at 20 DAS	6.05 (36)	5.37 (28)	7.05 (49)	7.41 (54)	6.5	65.1	55.8	50.7	1060
Imazethapyr + Imazamox (post) at 15–20 DAS 70% WG 70 g/ha.	6.09 (37)	4.16 (16)	5.37 (28)	5.56 (30)	5.2	69.8	74.6	71.3	1486
Pendimethlin (pre) *fb* Hand weeding at (30 DAS)	5.14 (26)	3.84 (14)	4.99 (24)	5.35 (28)	33.9	83.3	78.6	76.1	1723
Oxyflourfen (pre) *fb* followed by Hand weeding at 30 DAS	3.87 (15)	3.58 (12)	4.79 (22)	4.97 (24)	62.1	85.7	80.9	77.8	1760
Hand weeding at 20 DAS and 40 DAS	6.39 (40)	4.32 (18)	3.58 (12)	3.98 (15)	5.5	78.5	87.9	84.1	1840
Unweeded check	6.26 (38)	8.99 (80)	10.53 (110)	10.99 (120)	0.0	0.0	0.0	0.0	557
LSD (P =0.05)	0.46	0.5	0.47	0.53					108.8

* Figures in parenthesis are actual numbers which were subjected to square root transformations

At 60 DAS and at harvest, total weed density was significantly lower in the treatments where second hand weeding at 40 DAS was adopted as in case ofhand weeding at 20 and 40 DAS. Next best treatment was oxyflourfen *fb* hand weeding at 30 DAS and was found par with pendimethalin *fb* hand weeding at 30 DAS and imazethapyr + imazamox treatmentswith more WCE Weedy check recorded significantly higher density of weeds at both the stages. Dhadge *et al.* 2014 also repotedbetter weed control with pendimethalin *fb* hand weeding in summer groundnut. Efficient weed management was reflected in terms of higher yield and returns.

CONCLUSIONS

Oxyflourfenfb hand weeding or pendimethalinfb hand weeding or sequential application imazethapyr + imazamox were effective weed management options in controlling wide range of weed species in groundnut.

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Irrigation, fertilizers and weed management for improving productivity and nutrient uptake of mustard

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Mustard [*Brassica juncea* (L.) Czern & Coss] is one of the important oil seed crop among the groundnut, sunflower, castor, linseed, safflower etc. and accounts for 30% of the total vegetable oil production in India. Mustard is mainly grown as a *Rabi* season in North India and brought about perceptible change in the economy of the farmers of Rajasthan, Uttar Pradesh, Assam, Haryana, Gujarat, Madhya Pradesh and Punjab. Recent research findings have clearly established the mustard crop responds very well to fertilizer and irrigations (Singh *et al.* 2011) reported that significant enhancement in seed yield of mustard with increase in fertilizer and irrigation rates. The crop has contended against serious competition from weeds. Weeds are a major constraint and their control is essential for successful crop production. Hand weeding is a very old and effective practice of weed control.

However,this practice is so limitation like that untimely rainfall and unavailability of labour at peak time. The only alternative that needs to explore is the use of herbicides. Pendimethalin is the pre-emergence herbicide. The basic concept of use this herbicide is mainly weed free environment at time of germination and growth stages and secondly, fertilizers and irrigation applied to soil has utilized by the crop plants only due to restricted weed growth from herbicide treatment of mustard crop.

The field experiment was laid down during *rabi* season 2012 at research farm of Janta Vedic College Baraut (Baghpat) U.P. on loam soil in texture having moderate fertility and pH of 7.5, low in organic carbon (.38%) and available N (155 kg/ha), available P_2O_5 (15.6 kg/ha) and available K_2O (149.6 kg/ha). The treatments included fifteen combinations of management systems and weed control measures were included in this study and replicated three times, *viz*. M_1 no fertilizer no irrigation, M_2 50% of the recommended fertilizer doses (N_{40} P_{20} K_{20})+ 1 irrigation at flowering stage, M_3 50% of the recommended fertilizer doses (N_{40} P_{20} K_{20}) + 2 irrigation at 30 DAS & flowering stage, M_4 100% of the recommended fertilizer doses (N_{80} P_{40} K_{40}) + 1 irrigation at flowering stage, M_5 100% of the recommended fertilizer doses (N_{80} P_{40} K_{20}) + 2 irrigation at DAS and flowering stage and three weed management options W_1 weedy check, W_2 hand weeding at 30 DAS, W_3 Pendimethalin at 1.0 kg/ha. The experiment conducted in split-plot design and management option in main plot and weed management option in sub plots. The gross plot size was 17.5 m^2 and net plot size was 12 m^2. After the harvest of *Kharif* crops paddyin October, land preparation was done as per treatment and sowing was done on 29 October 2011 using Pussa mustard-25, variety with a seed rate of 5 kg/ha. The fertilizers applied in furrows as per treatments. The sowing was done at a row-to-row spacing of 45 cm and plant to plant, spacing 15 cm. thus the required plant population was ensured. The crop was harvest on 15 March 2012. The herbicide was spray as pre-emergence a day after sowing using spray volume of 500 l/ha with a knapsack sprayed fitted with flat fan nozzle. The hand weeding was done with the help of kurpi after 30 DAS. The data on weed count and weed biomass was record at 45 DAS with the quadrate of 0.25/m2 at two places under each plot. Data on weed population subjected to square root transformation.

The dominant weed species identified in the experiment of mustard field were *Chenopodium album* (32.8%), *Melilotus alba*(18.0%),*Melilotusindica*(14.0%) under dicot weeds and *Cyperus rotundus* (14.3%), *Cynodon dactylon* (9.0%) under monocot weeds.The data indicate that weed count was significantly higher under the management system (M_5,M_3,M_4,M_2) compared to M_1 (no fertilizer and no irrigation) treatment.

The pre- emergence application of pendimethalin and hand weeding reduced weed count significantly over the weedy check. Thehand weeding was the superior as compare topendimethalinmay be due to the quick dissipation of pendimethalin that 50% of the chemical disappeared within a week of its application. Meena and Sah (2011) showed that as much as 17% of applied pendimethalin was lost in 7 days due to photo-decomposing. This explains why this particular chemical could not be effective as hand weeding in controlling the weeds in experimental field.

Table 1. Weed growth at 45 days after sowing, and yield of Mustard as influenced by management and Weed control measures

Treatment	Weed count no./m^2	Weed dry weight g/m^2	Seed yield q/ha	Stover yield q/ha
Management M_1	3.16 (11.16)	1.23	14.11	52.55
$M_2$3.27	1.17 (11.71)	17.00	59.36	
$M_3$3.86	1.80 (16.08)	18.76	59.91	
$M_4$3.39	1.62 (14.01)	18.80	61.94	
$M_5$3.84	1.94 (16.43)	20.62	65.45	
LSD (P=0.05)	0.16	0.56	1.80	5.45
Weed control				
$W_1$5.37	3.16 (29.07)	15.43	57.55	
$W_2$2.75	0.82 (7.18)	17.20	60.67	
$W_3$2.39	0.67 (5.39)	18.40	61.30	
LSD (P=0.05)	0.11	0.29	1.50	1.69

The management system M_5 resulted in the greatest amount of dry matter accumulation in weeds at 45 DAS stage as compared to rest of the management systems. The next in the order were M_3>M_4>M_2> and then M_1. The significant increase in dry matter accumulation might be due to the fact that weeds and usurped greater quantities of the soil applied fertilizers resulting in improved weeds and higher dry matter production. Khan *et al*. (2000)obtained similar results and opened that fertilizers enhanced the growth of weeds. Bhoyar and Yaduraju (2002) also same findings.

The dry matter accumulate in the weeds was significantly lower under the hand weeding treatment as compared to pendimethalin and weedy check treatment. It may be because of the fact that pendimethalin from this layer on the soil surface, which was responsible for killing of the susceptible weeds as they emerge while in case of hand weeding all the emerged weeds removed mechanically.

From the experiment, results show that management systems had greatly affected the production of seed yield and stover in mustard. M_5 management system was significantly more yield (both seed and stover) than all other treatments. Thisproduction influenced by higher supply of nitrogen, phosphorus, potassium and made available adequate moisture. These findings are agreed with the results of Pandey and Bharti (2005), Reager *et al. (*2006) and Saud and Singh (2011).

The seed and stover yield also increased significantly due to weed management treatments. The seed yield was higher under the hand weeding and next to pendimethain over the weedy check plot.

The amount of nutrients removal was significant influenced by management systems. Maximum uptake of NPK observed under M_5 management systems closely followed by M_4 management systems. This is obvious because the biomass production increased due to this management system over the other management systems. NPK uptake increased with its successive level of fertilizer dose. These findings are in close conformity with those of Singh and Kanaujai (2009). Mustard plants, under pendimethalin application and hand weeding, removed more nutrients than weedy check. Although no variation of a significant order, with respect to NPK removal existed between pendimethalin application and hand weeding but the trend showed higher uptake of nutrients under pendimethalinreduced considerably to crop weed completion for nutrients which reflected in the more dry matter accumulation than hand weeding, resulting more uptake from the soil.

It may be concluded that 100% of the recommended fertilizer dose(N_{80} + P_{40} + K_{40}) +two irrigation(at 30 DAS and flowering stage) and hand weeding at 30 DAS are the recommended for mustard crop because they given better results than other management practices and pendimethalin 1.0 kg/ha.

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Study on weed dynamics in soybean-based intercropping system

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Key words: Soybean, rice, sesame, green gram, black gram, intercropping, weed dynamics.

A field experiment was conducted in the Agronomy farm, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus to study the effect of soybean based intercropping on weed dynamics. Soybean based intercropping with rice, sesame, green gram and black gram in two row ratios (1:1 and 2:1) along with sole crops was studied. The experimental field was laid out in Randomized Block Design with three replications.Additive series of intercropping was followed by planting the intercrops in between the rows of 45x10 cm spacing of soybean. Results indicated that intercropping treatments irrespective of row ratios performed better than the sole crop treatments in suppressing the weed population and thereby reduced weed biomass at 20, 40 and 60 DAS. The dominant weeds species were *Borreria hispida* (Linn)., *Ageratum conyzoides* (Linn.), *Amaranthus viridis* (Linn.), *Mimosa pudica* (Linn.) *and Euphorbia hirta* (Linn.)among thebroad leaf weeds. Among the grasses,*Cynodon dactylon* (Linn.) Pers., *Eleusine indica.* Gaertn.,*Digitaria sanguinalis* (Linn.) Scop., *Seteria glauca* (Linn.) Beauv. and *Echinochloa colonum* (Linn.) Link.were the dominant species. While among the sedges,*Cyperus rotundus* (Linn.) and *Cyperus iria* (Linn.) were the most common species. Among the sole crops, sole rice (T_2) performed better in terms of growth and yield attributes. Among the intercropping treatments 1:1 row ratio of soybean and rice gave the highest economic return with net return of ¹ 1,14,160/ha and a Benefit: Cost ratio of 3.96.

Bioefficacy of sethoxydim on grassy weeds and yield of soybean

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Soybean, the number one oilseed crop in the world has recently occupied an important place in the edible oil and agricultural economy of the country. It contains 40% protein, balanced essential amino acid, 20% oil and 17-19% carbohydrate (Chauhan and Joshi 2005). In the world, the crop covers an area of about 98.8 mha and total production 251.5 million metric tonnes whereas in India, it is grown in 10.69 mha with the product ion of 12.67 mt. Madhya Pradesh is known as 'Soybean State' which covers about 58.12 lakh ha area with the product ion of 66.85 lakh tonnes (Anonymous 2012). Soybean owing to its high potential plays an important role in boosting oilseed production in the country. The soil and climate of Madhya Pradesh are congenial for soybean production but being a rainy season crop it suffers severely due to competitional stress of weeds resulting reduction in the yield of soybean was 51.6, 34.1 and 13.2% due to infestation of grassy, broadleaved weeds and sedges, respectively (Meena *et al.* 2011). Keeping this in view, the investigation was carried out to find out the efficacy of sethoxydim on grassy weeds and yield of soybean.

METHODOLOGY

A field experiment was carried out at The Farm, College of Agriculture, Tikamgarh during *Kharif* season of 2013. The soil of the experimental area was cleyey loam which was medium in organic carbon, low in available nitrogen and phosphorus but medium in potassium content having neutral pH and normal electrical conducitivity. The experiment was laid out in "Randomized Block Design" with seven treatments replicated thrice. The treatments comprised of post–emergence grass weed killer; sethoxydim at 125, 156.25, 187.50 and 312.50 g/ha and quizalofop-ethyl at 100 g/ha and these treatments were compared with two hand weeding at 20 and 40 DAS and weedy check. The soybean variety '*JS-93-05*' was sown on July 13, 2013 with seed rate of 80 kg/ha in rows, 30 cm apart with fertilizer dose of 20:60:30 kg/ha. Post-emergence herbicides were applied at 25 days after sowing. The observations on population of major weeds were recorded by using the quadrate of 1 m^2 was randomly placed at three places in each plot and then the species wise and total weed count was recorded at 28 days after herbicide application.

RESULTS

There was prevalence of monocot weeds in experimental field as they constituted the higher relative density of monocot weeds 75.5% as compared to dicot weeds which had only 24.3% relatxive density. The intensity of *Leptochloa chinensis* was the highest (59.43 %) followed by *Cyperus rotundus* (5.13 %) and *Echinochloa colonum* (3.96%).

The result indicated that grass weed killer sethoxydim was effectively reduced the population of grassy weeds, *viz. Leptochloa chinensis*, *Echinochloa colona*, *Cynodon dactylon*, *Cyperus rotundus* and *Commelina communis* under the different rate of application and was found as effective as quizalofop-ethyl and all these herbicidal treatments were not significantly differ with hand weeding twice which registered the lowest intensity of grassy weeds among all the treatments. Weedy check recorded significantly the highest intensity of all grassy weeds (Table 1).

All the herbicidal treatments and hand weeding significantly reduced the grass weed intensity as compared to weedy check at 28 days after herbicide application. The differences among different rate of application of sethoxydim and quizalofop-ethyl were found not significant. Hand weeding superceded over all the treatments and registered the lowest intensity of grassy weeds.

Hand weeding twice recorded significantly the lowest intensity of total broadleaved weeds over all herbicidal treatments and weedy check, whereas the application of sethoxydim at different rate of application recorded higher intensity of broadleaved weeds, and was at par with quizalofop-ethyl and weedy check. The result of herbicidal weed control treatments on seed yield revealed that it was significantly higher under all the herbicidal treatments compared to weedy check (Table 1). Two hand weeding (20 and 40 DAS) gave significantly the highest seed yield among all the treatments. The weed competition was negligible in hand weeded plots as grassy as well as broadleaved weeds were almost completely removed from inter and intra row spaces. The crop plants grew well in weed free environment with the results that yield attributes attained relatively greater values and finally the highest seed yield. Chauhan *et al.* (2002) reported that two hand weeding at 20 and 35 DAS in soybean crop drastically reduced weed intensity, weed biomass and increased the yield of crop. Application of sethoxydim and quizalofop-ethyl treatments were effective for controlling grassy weeds but the treatment of hand weeding twice at 20 and 40 DAS efficiently reduced grassy and broadleaved weed resulted in higher crop yield. The lowest yield in weedy check was obviously owing to severe weed competitional stress throughout the crop span which was reflected in term of lowest value of all the yield attributes and ultimately the lowest seed yield/ha. Net monetary return

Table 1. Effect of sethoxydim on density of weeds, yield and economics of soybean

Treatments	Total grassy weeds	Total broadleaved weeds	Total weed intensity	Seed yield (kg/ha)	Net monetary retum (?/ha)	B:C Ratio
Sethoxydim @ 125 g/ha	2.67(7.22)	4.25(17.56)	5.04 (24.80)	487.33	9025	1.75
Sethoxydim @ 156.25 g/ha	2.45(5.67)	4.08(16.78)	4.80 (22.48)	499.52	9271	1.77
Sethoxydim @ 187.50 g/ha	2.39(5.34)	4.08(16.24)	4.72 (21.60)	479.03	9046	1.74
Sethoxydim @ 312.50 g/ha	2.03 (4.01)	4.39(18.78)	4.84 (22.82)	467.01	7255	1.56
Quizalofop-ethyl @ 100 g/ha	2.41 (5.33)	4.36(18.56)	4.94 (23.91)	481.90	8742	1.73
Hand weedings (at 20 and 40 DAS)	1.63 (2.23)	1.43(1.56)	2.07 (3.80)	718.61	13622	1.80
Weedy check	7.59 (57.22)	4.29(18.44)	8.75 (75.71)	274.32	1126	1.10
SEm ±	021	0.29	0.32	22.30	-	-
CD (P=0.05)	064	0.89	0.98	68.54		

*Original values are given in parenthesis and benefit cost ratio was higher under hand weeding twice followed by sethoxydim at 156.25 g/ha whereas, it was minimum under unweeded control due to less yield and return.

CONCLUSION

On the basis of results obtained it can be concluded that sethoxydim at all the rates of application and quizalofop ethyl selectively controlled grassy weeds but was not effective against dicot broadleaved weeds. Uncontrolled weeds in soybean resulted in yield loss of 61.85 %. The seed yield, net return and B : C ratio was significantly higher under two hand weeding at 20 and 40 DAS followed by Sethoxydim at 156.25 g/ha.

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Sequential herbicide applications for effective weed management in soybean

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Soybean, an important oilseed crop is known for its higher yield potential. It is called as 'miracle bean' because of high protein and oil content. It is cultivated under assured rainfall conditions where weeds pose a major problem. A wide range of weeds compete with the crop during early stage and later during reproductive phase. To realize higher yields, the crop needs season long weed free conditions. This calls for the use of both pre and post emergent herbicides. Therefore, there is a need to evaluate different pre-emergent herbicides *fb* different doses of imazethapyr as post emergent application for effective weed management in soybean.

METHODOLOGY

A field experiment was conducted at UAS, Dharwad, duringrainy season of 2013. The soil of experimental site was black soil (vertisols). The experiment was laid out in RCBD with three replications involving 11 treatments (Table 1). Soybean variety '*JS-335*' was sown at 30 cm X 10 cm and recommended dose of fertilizers was applied. Observation on weed dry weight was recorded in 1 m^2 area at 30 and 60 DAS. The yield data was recorded.

RESULTS

The sequential applications *viz;* alachlor*fb*imazethapyr, oxyfluorfen *fb* imazethapyr and pendimethalin (EC) *fb* imazethapyr resulted in significantly higher grain yield and these treatments were on par with recommended practice of alachlor + 1 IC + 1 HW and also with farmers practice *i.e.* 2 IC + 2 HW(Meena *et al*. 2009). The weed dry weight was significantly higher with pendimethalin (CS) *fb* imazethapyr. In general, the weed control efficiency was significantly higher with all sequential applications compared to farmers practice. The effect of two doses of imazethapyr was similar in all the sequential applications except that the weed control efficiency at 60 DAS was significantly lower with alachlor*fb*imazethapyr 75g/ha.

Table : Weed dry weight, weed control efficiency and grain yield as influenced by sequential applications of herbicides in soybean

Treatment	Weed dry weight (g/m^2)		WCE (%)		Grain yield (kg/ha)
	30DAS	60 DAS	30 DAS	60 DAS	
Alachlor 1.5 kg/ha *fb* Imazethapyr75 g /ha	1.32(1.43)*	1.13(0.87)*	90.88	77.16	3128
Alachlor 1.5 kg /ha *fb*Imazethapyr 100 g /ha	1.02(0.58)	1.04(0.65)	91.10	87.74	3204
Oxyflurofen 0.1 kg/ha *fb* Imazethapyr 75 g /ha	1.21(1.04)	0.86(0.24)	90.96	83.90	3369
Oxyflurofen 0.1 kg/ha *fb* Imazethapyr 100 g/ha	0.94(0.39)	0.86(0.23)	92.00	90.89	2755
Pendimethalin (CS) 700 g /ha *fb*Imazethapyr 75 g/ha	1.47(1.75)	1.21(0.97)	81.89	83.29	2569
Pendimethalin (CS) 700 g/ha *fb*Imazethapyr 100 g/ha	1.35(1.51)	1.02(0.60)	82.09	85.51	2536
Pendimethalin (EC) 1 kg/ha *fb*Imazethapyr 75 g /ha	1.10(0.74)	1.02(0.57)	83.19	81.85	2823
Pendimethalin (EC) 1 kg/ha *fb*Imazethapyr 100 g/ha	1.25(1.23)	0.91(0.33)	89.83	87.60	2910
Alachlor 1.5 kg/ha *fb* IC and HW (RPP)	0.80(0.14)	0.86(0.24)	85.75	84.69	3385
Farmers' practice (2 IC and 2 HW)	1.21(1.03)	1.18(0.93)	76.23	73.76	2960
Weedy check	4.52(19.99)	3.96(15.29)	-	-	2356
SEm±	0.13	0.13	3.61	2.79	183
CD (P=0.05)	0.40	0.39	10.64	8.24	541

*Values in parantheses are original. Data transformed to square root transformation; IC – Intercultivation; HW– Hand weeding; RPP – Recommended practice (as per package); *fb*- Followed by; EC- Emulsifiable concentrate; CS- Capsulated suspension

CONCLUSION

Sequential applications involving alachlor 1.5 kg/ha *fb* imazethapyr 100g/ha and oxyfluorfen 0.1kg/ha *fb* imazethapyr (75 or 100g/ha) proved effective in controlling weeds in soybean and resulted in higher grain yield.

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Chemical weed control in soybean

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Soybean, the number one oilseed crop in the world has recently occupied an important place in the edible oil and agricultural economy of the country. In the world, the crop covers an area of about 98.8 mha and total production 251.5 million metric tonnes whereas in India, it is grown in 7.8 mha with the production of 6.4 million metric tonnes . Madhya Pradesh is known as Soybean State which covers about 57.30 lakh ha area with the production of 61.70 lakh tonnes. In Tikamgarh, soybean is cultivated in an area of 37.10 thousand ha with the production of 45.4 thousand tonnes (CLRS 2011). The soil and climate of Madhya Pradesh are congenial for soybean production but being a rainy season crop it suffers severely due to competitional stress of grasses, sedges and broadleaved weeds resulting reduction in yield to the tune of 20-71 % depending upon the type and intensity of weeds and their occurrence. This can be overcome by adopting herbicidal weed control, which is effective, easier, cheaper and many a times faster than the conventional practices of weed control.

METHODOLOGY

The experiment was conducted during kharif, 2012 at Research farm, College of Agriculture, Tikamgarh (M.P.) on clay loam soil. The soil of the field was medium in organic carbon, low in available nitrogen and available phosphorus but medium in available potassium content. The experiment was laid out in "Randomized Block Design" with twelve treatments, replicated thrice. The treatments comprised of herbicides pendimethalin at 1 kg/ha , pendimethalin at 1 kg/ha *fb* one hand weeding at 20 DAS, pendimethalin 1 kg/ha *fb* quizalofop-ethyl 50 g/ha pendimethalin 1.0 kg/ha *fb* imazethapyr at 50 g/ha , pendimethalin 1.0 kg/ha *fb* chlorimuron-ethyl 9.0 g/ha, quizalofop-ethyl 50 g/ha, quizalofop-ethyl 50 g/ha *fb* one hand hoeing at 40 DAS, chlorimuron-ethyl at 9 g/ha at 20 DAS, chlorimuron-ethyl at 9 g/ha at 20 DAS + quizalofop-ethyl 50 g/ha at 20 DAS, chlorimuron-ethyl at 9 g/ha at 20 DAS *fb* one hand hoeing at 40 DAS these treatments were compared with two hand weeding at 20 and 40 DAS and weedy check. The soybean variety '*JS-335*' was sown with seed rate of 80 kg ha in row, 30 cm apart with fertilizer dose of 20:60:20 kg/ha .

RESULTS

The major weed species observed in the experimental area were: *Cyperus rotundus, Cynodon dactylon, Sachharam spontanieum, Commelina benghalensis, Phyllanthus niruri and Convolovulous arvensis*. The relative density of monocots was 62.7% at harvest stage while dicots were to the extent of 30.6% of the total weed population. All the herbicidal treatments hand weeding and hand hoeing reduced the weed intensity and weed dry weight as compared to weedy check. Hand weeding twice was most effective and recorded minimum weed density among all the treatments. Among the different herbicidal treatments, pendimethalin *fb* one hand weeding at 20 DAS registered the lowest intensity and dry weight of weeds followed by quizalofop *fb* one hand hoeing at 40 DAS and chlorimuron *fb* one hand hoeing at 40 DAS and these treatments were at par with chlorimuron ethyl + quizalofop ethyl. Among alone application of herbicides, quizalofop-ethyl at 50 g/ha at 20 DAS had significantly lower weed biomass than chlorimuron-ethyl and weedy check. Quizalofop-ethyl at 20 DAS was effective to control grassy weeds including *Cyperus rotundus, Cynodon dactylon* and *Sachharam spontanieum* whereas chlorimuron-ethyl at 20 DAS reduced the intensity and dry weight of broadleaved weeds, *viz. Phyllanthus niruri and Convolovulous arvensis* , but it was not effective against grassy weeds. The effectiveness of quizalofop-ethyl as post-emergence against grassy weed control in soybean was also reported by Idapuganti *et al.* (2005). Hand weeding twice recorded highest WCE of 90.89% followed by pendimethalin *fb* one hand weeding at 20 DAS (86.5%).Seed yield was significantly higher under all the weed control practices over weedy check. Two hand weeding at 20 and 40 DAS recorded the higher seed yield followed by pendimethalin *fb* one hand weeding at 20 DAS. Among the herbicides, quizalofop-ethyl + chlorimuron-ethyl produced significantly higher seed yield than quizalofop-ethyl *fb* hand hoeing at 40 DAS and chlorimuron-ethyl *fb* hand hoeing at 40 DAS and the lowest seed yield was recorded in weedy check. The net monetary return and B:C ratio was maximum under chlorimuron-ethyl + quizalofop-ethyl.

Table 1. Effect of different weed control treatments on weeds, seed yield and economics of soybean

Treatment	Weed intensity (no./m2)	Weed dry weight (g/m2)	Weed control efficiency (%)	Seed yield (kg/ha)	Net monetary return (?/ha)	B:C ratio
T1-Pendimethalinat 1 kg/ha	5.06 (25.29)	6.14 (37.20)	65.38	1588.03	41804	4.08
T2-Pendimethalinat 1 kg/ha *fb* one hand weeding at 20 DAS	3.09 (9.04)	3.44 (11.51)	86.51	1791.00	44858	3.55
T3- Pendimethalin at 1 kg/ha *fb* quizalofop-ethyl at 50 g/ha at 20 DAS	4.14 (16.68)	5.25 (27.02)	73.75	1745.51	45815	4.04
T4- Pendimethalin at 1 kg/ha *fb* imazethapyr at 50 g/ha at 20 DAS	4.51 (19.85)	5.26 (27.25)	73.96	1722.00	45443	4.11
T5-Pendimethalin at1 kg *fb* chlorimuron-ethyl at 9 g/ha at 20 DAS	4.60 (21.66)	5.27 (27.23)	73.35	1640.00	42922	4.01
T6- Quizalofop-ethyl at 50 g/ha at 20 DAS	5.43 (28.93)	6.35 (39.91)	57.09	1533.33	39927	3.95
T7- Quizalofop-ethyl at 50 g/ha at 20 DAS *fb* one hand hoeing at 40 DAS	3.59 (12.43)	4.09 (16.20)	78.36	1732.67	43653	3.60
T8- Chlorimuron-ethyl at 9 g/ha at 20 DAS	5.76 (32.67)	7.28 (52.44)	28.46	1385.67	35558	3.79
T9- Chlorimuron-ethyl at 9 g/ha at 20 DAS+ quizalofop-ethyl at 50 g/ha at 20 DAS	3.96 (15.22)	4.50 (21.63)	78.93	1740.68	46484	4.26
T10- Chlorimuron-ethyl at 9 g/ha at 20 DAS *fb* one hand hoeing at 40 DAS	3.71 (13.33)	4.40 (20.33)	79.17	1729.16	44330	3.78
T11- Two hand weeding at 20 DAS and 40 DAS	2.26 (4.72)	2.99 (8.51)	90.89	1834.33	42212	2.95
T12- Weedy check	7.21 (51.47)	8.67 (74.65)	0.00	739.02	13497	2.14
LSD (P=0.05)	0.43	0.57	4.75	41.86		

CONCLUSION

On the basis of results, it can be concluded that application of pre-emergence pendimethalin *fb* one hand weeding at 20 DAS and post-emergence application of chlorimuron-ethyl + quizalofop-ethyl is effective for control of mixed weed flora in soybean.

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Evaluation of post-emergence herbicides for weed control in rainfed cowpea

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Cowpea (*Vigna unguiculata* L. Walp) is an annual food legume that is widely cultivated during rainy season is usually infested by a number of weed species that compete with the crop right from germination to harvest, affecting the crop yield adversely. Weed density, type, their persistence and crop management practices determine the magnitude of yield loss. Yield loss in cowpea due to weeds was 12.7-60.0% (Li *et al.* 2004). Though most of these herbicides are weed specific, but some to a greater extent are more effective in controlling weeds than the other traditional methods of weed control. Use of post-emergence herbicides may therefore provide a timely and adequate alternative to hand weeding as this will not only remove the drudgery associated with it but also lower the cost of weeding and provide protection for crop against weed competition for longer period.

METHODOLOGY

A field experiment was carried out during *Kharif* 2014 at All India network project on arid legumes (AINP), GKVK, Bengaluru in southern Karnataka under red sandy loam soil to test the efficacy of post-emergence herbicides in cowpea. Seven treatments consisting of four different post-emergence herbicides compared with pre-emergence application of pendimethalin, one hand weeding and unweeded check (Table 1) were laid out in a randomized block design with three replications. Cowpea variety KBC-2 was sown with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash 25 kg N, 50 kg P_2O_5, and 25 kg K_2O/ha, respectively. Data on weed growth, yield performance of cowpea and economics were recorded.

RESULTS

Grassy weeds were pre-dominant followed by broad-leaved and sedges. *Eleusine indica* among the grassy weeds and *Acanthospermum hispidum* among the broad-leaved weeds were dominant. Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments the lowest weed density (4.5/m^2) was observed under post-emergence application of imazethapyr + imazamox 40 g/ha followed by pendimethalin 0.75 kg/ ha as pre-emergence (5.3/m^2) (Table 1). The minimum weed dry weight was also recorded in these treatments, which was significantly lower than all other treatments. These results are in conformity with the findings of Silva *et al*. (2014). Maximum weed control efficiency was recorded with the post-emergence application of imazethapyr +imazamox at 40 g/ha (66%) followed by one hand weeding at 3-4 leaf stage (63.7%) and pendimethalin at 0.75 kg/ha as pre-emergence (53%). This shows that weeds were controlled effectively under post-emergence application of imazethapyr + imazamox 40 g/ha.

The highest seed yield (1.68 t/ha) was recorded with the post emergence application of imazethapyr + imazamox 40 g/ ha and lowest (1.03 t/ha) was under unweeded check. However it was found on par with one hand weeding at 3-4 leaf stage. The cost of cultivation of the post emergence application of imazethapyr + imazamox 40 g/ha was comparable with one had weeding and B:C ratio was found maximum (2.54) as compared to rest of the herbicidal treatments under evaluation.

Table 1. Weed growth, yield and economics of cowpea as influenced by different weed control treatments

Treatment	Weed density (no./m^2)	Weed dry matter (kg/ha)	Weed control efficiency (%)	Seed yield (kg/ha)	Cost of cultivation (x10^3` ./ha)	B:C ratio
Imazethapyr 40 g/ha at 3-4 leaf stage	6.1(22.39)*	22.9 (523.4)*	39.4	1,384	22.91	2.11
Quizalofop ethyl 37.5 g/ha at 3-4 leaf stage	5.7(23.05)	20.7(439.5)	49.1	1,434	23.56	2.13
Fenoxaprop-p-ethyl 50 g/ ha at 3-4 leaf stage	6.2(22.77)	25.5(650.3)	24.7	1,436	23.28	2.16
Imazethapyr + imazamox 40 g/ha at 3-4 leaf stage	4.5(23.24)	16.9(293.5)	66.0	1,685	23.24	2.54
Pendimethalin 0.75 kg/ha as pre-emergence	5.3(23.85	20.1(405.9)	53.0	1,380	23.49	2.06
One hand weeding at 3-4 leaf stage	5.6(23.26)	17.5(313.6)	63.7	1,515	22.74	2.33
Unweeded check	7.4(23.12)	29.4(863.8)	0.0	1,039	21.69	1.68
LSD (P=0.05)	0.8	5.0	--	204.0	--	--

*Values in parentheses are original. Data transformed to square root transformation

CONCLUSION

It was concluded that post-emergence application of imazethapyr + imazamox 40 g/ha was found effective for controlling weeds, improving seed yield and profitability of the rainfed cowpea under labour scarce situations.

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Efficacy of sequential application of new generation herbicides on weed growth and yield of greengram

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In India, green gram [*Vigna radiata* (L.)] is the third important pulse crop after chickpea and pigeon pea. One of the major constraints in green gram production is weed competition. The loss of green gram yield due to weeds ranges from 65.4-79.0% (Dungarwal *et al*. 2003). The conventional methods of weed control are labour intensive and expensive. Keeping this in view, the present research work was carried out with the objective to evaluate efficacy of different pre- and post-emergence new generation herbicides for efficient weed control in green gram.

METHODOLOGY

The field experiment was conducted during *Kharif* 2013 in Hyderabad at Professor Jayshankar Telangana State Agricultural University.The experiment was laid out in a randomized block design with twelve treatments comprised of pendimethalin, imazethapyr alone and in sequence along with hand weeding using MGG-295 as test variety. Data on weed growth, yield performance and economics were recorded.

RESULTS

Weed density, weed dry matter and weed control efficiency differed significantly with the different weed management practices. At 30 DAS imazethapyr 75 g/ha as PE fb hand weeding at 20 DAS recorded significantly lowest density and dry matter of grasses, sedges and broadleaved weeds and it was on par with pendimethalin 580 g/ha as PE *fb* hand weeding at 20 DAS and hand weeding at 20 and 40 DAS. Application of post-emergence herbicides, *viz*. imazethapyr + imazamox 70 g/ha at 15-20 DAS as POE, imazethapyr 100 g/ ha + quizalofop 50 g/ha at 15-20 DAS as POE, imazethapyr 75 g/ ha at 15 DAS as POE and pendimethalin 580 g/ha as PE + quizalofop 50 g/ha at 15-20 DAS as POE continued their effect on weeds resulting in the lower weed density and weed dry matter compared to weedy check. The highest weed control efficiency was observed with imazethapyr 75 g/ha as PE *fb* hand weeding at 20 DAS (88.62%) followed by pendimethalin 580 g/ha as PE *fb* hand weeding at 20 DAS (86.53%), hand weeding at 20 and 40 DAS (86.20%) treatments since first weeding was done on 20th day after sowing.

The significantly highest seed yield was recorded in weed free treatment and was on par with hand weeding at 20 and 40 DAS and imazethapyr 75 g/ha as PE *fb* hand weeding at 20 DAS. The increase in yield attributes and yield under these treatments may be attributed to concomitant reduction in weed dry matter, which accounted for reduction in crop weed competition and provided congenial environment to the crop for better reproductive potential. The highest B:C ratio was recorded in imazethapyr + imazamox 70 g/ha at 15-20 DAS as POE. The yield reduction of 58.43 was observed in weedy check treatment.

Table 1. Effect of sequential application of herbicides on weed density, weed dry matter, weed control efficiency (WCE), weed index, grain yield and economics of greengram

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	Weed control efficiency (%)	Seed yield (kg/ha)	B:C ratio
Pendimethalin 580 g/ ha as PE	7.99 (63.33)	5.38 (28.43)	38.72	422	1.06
Imazethapyr 75g/ ha as PE	8.07 (64.67)	5.45 (29.23)	36.99	685	1.68
Pendimethalin 1.0 kg/ ha + imazethapyr 50 g/ha as PE	7.65 (58.0)	5.15 (26.04)	43.87	689	1.57
Pendimethalin 580 g/ ha as PE + hand weeding at 20 DAS	3.71 (13.33)	2.59 (6.25)	86.53	465	0.96
Imazethapyr 75 g/ ha as PE + hand weeding at 20 DAS	3.44 (11.33)	2.40 (5.28)	88.62	1040	2.17
Imazethapyr 75 g/ ha at 15 DAS as POE	5.55 (30.33)	3.59 (12.43)	73.21	812	2.00
Imazethapyr + imazamox 70 g/ ha at 15-20DAS as POE	4.95 (24.00)	3.10 (9.15)	80.28	923	2.21
Pendimethalin 580 g/ha as PE+ quizalofop 50 g/ ha at 15-20 DAS as POE	6.17 (37.67)	4.16 (16.81)	63.76	432	1.06
Imazethapyr 100 g/ ha + quizalofop 50 g/ ha at 15-20 DAS as POE	5.76 (26.67)	3.85 (14.33)	69.11	851	2.04
Weed free	5.58 (30.67)	3.73 (13.46)	70.99	1149	1.97
Hand weeding at 20 and 40 DAS	3.76 (13.67)	2.62 (6.40)	86.20	1085	2.11
Weedy check	10.12 (102.33)	6.84 (46.39)	0.00	451	1.25
LSD (P=0.05)	0.53	0.35	38.72	110	-

*Values in parentheses are original. Data transformed to square root transformation.

CONCLUSION

Under labour scarce condition farmer can go for either application of imazethapyr 75 g/ha as PE + hand weeding at 20 DAS or imazethapyr 75 g/ha as PE + hand weeding at 20 DAS or imazethapyr + imazamox 70g/ha at 15-20 DAS as POE.

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Role of MSO adjuvant in enhancing bioefficacy of imazethapyr applied to greengram

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Green gram is the second most important pulse crop grown in Telangana state in an area of 4.40 lakh ha with a productivity of 493kg/ha. Weed management is an important factor for enhancing the productivity of green gram.Yield losses in green gram due to weeds have been estimated in the range of 30-50%. Imazethapyr usage is not very popular among green gram growers of the state due to phytotoxicity at 75 g/ha dose or growth reduction. Spray adjuvants are used with post-emergence herbicides to the spray tank to improve the herbicide activity and they will improve the herbicide absorption. MSO adjuvant is a kind of oil based adjuvant which enhances the efficacy of herbicides by increasing the absorption of the herbicides by weeds and helps in reducing the herbicide dosage while achieving desired weed control. Keeping this in view, the present investigation was undertaken in green gram.

METHODOLOGY

A field experiment was conducted during *Kharif* 2013 at student Farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad in Southern Telangana Agro-climate zone of Telangana State. Ten weed control treatments were evaluated (Table-1) in randomized block design and replicated thrice. Green gram (WGG-37) was sown on at 30 X10 cm. Pendimethalin 30% EC was applied as pre-emergence (PE) after sowing, imazethapyr and quizalofop-ethyl were sprayed at 2-3 leaf stage of weeds (15 days after sowing) and manual weeding was done at 15 and 30 DAS. Weed density (no./m^2), weed dry weight (g/m^2) were recorded at 20, 40 DAS and at harvest.

RESULTS

Predominant weed species found in experimental site were *Digitaria sanguinalis*, *Dinebra arabica* (grasses), *Cyperus rotundus* (sedge) and *Parthenium hysterophorus*, *Amaranthus viridis* (broad leaf weeds). Application of imazethapyr resulted in significantly lower weed population and higher weed control efficiency (WCE) at all the growth stages of green gram compared to control.

Application of imazethapyr alone 75g/ha resulted in significantly higher weed control at 20 DAS but was on par with 50 g/ha and 62.5 g/ha applied at 40 DAS. Addition of adjuvant 2ml/l resulted in significantly lower weed density, WDM and higher WCE at 20 and 40 DAS compared to the lone application of imazethapyr at the same dose. WCE recorded with 62.5 g/ha imazethapyr + adjuvant was superior to imazethapyr sole application at 75 g/ha, which indicated enhanced imazethapyr efficacy with addition of MSO adjuvant. This will help in reducing the herbicide dose and consequent phytotoxicity on the crop and lower herbicide load on the environment. Weed density, WDM and WCE recorded in 62.5 and 75 g/ha imazethpyr + adjuvant treatments were statistically at par with each other at 20 and 40 DAS. Using the pendimethalin alone could provide weed control only upto 25-30 DAS beyond which poor WCE was recorded. Quizalofop application resulted in only grass weed control and poor BLW weed control during subsequent crop growth stages. Similar observations in green gram due to weed competition were earlier reported by Parasuraman (2000).

Table 1. Effect of post-emergence application of imazethapyr 10 % SL on weeds and yield of green gram during *Kharif* 2013

Treatment	Weed density (no/m^2)		Weed dry matter (g/m^2)		Weed control efficiency (%)		Seed yield (kg/ha)	Net returns (`/ha)	B:C ratio
	20DAS	40DAS	20DAS	40DAS	20DAS	40DAS			
Imazethapyr 10%SL 50 g/ha	4.86 (22.70)	4.55 (19.70)	5.14 (25.42)	5.44 (28.57)	40.26	53.10	666	10,527	1.5
Imazethapyr 10% SL 62.5 g/ha	4.63 (20.50)	4.45 (18.80)	4.89 (22.96)	5.31(27.26)	46.05	55.24	714	11,638	1.6
Imazethapyr 10% SL 75 g/ha	4.16 (16.30)	4.29 (17.40)	4.39 (18.26)	5.12(25.23)	57.11	58.57	802	13,897	1.6
Imazethapyr 10% SL 50 g/ha + MSO adjuvant 2ml/l of water	4.58 (20.00)	4.43 (18.60)	4.84 (22.40)	5.29(26.97)	47.37	55.71	694	11,537	1.6
Imazethapyr 10%SL 62.5 + MSO adjuvant 2ml/l of water	3.83 (13.70)	3.62 (12.10)	4.02 (15.14)	4.31(17.55)	64.40	71.19	1073	27,593	2.3
Imazethapyr 10% SL 75 g/ha +MSO adjuvant 2ml/l of water	3.74 (13.00)	3.59 (11.90)	3.96 (14.66)	4.26(17.26)	65.55	71.67	1034	24,122	2.1
Quizalofop - ethyl 5% EC 50 g/ha	4.36 (18.00)	4.81 (22.20)	4.60 (20.16)	5.75(32.19)	52.63	47.14	608	6,868	1.3
Pendimethalin 30%EC 1000 g/ha as PE	3.27 (9.70)	5.21 (26.20)	3.44 (10.86)	6.24(37.99)	74.47	37.62	464	1,437	1.1
Weed free check (MW at 20 and 40 DAS)	2.23 (4.00)	2.77 (6.70)	2.34 (4.48)	3.27 (9.72)	89.47	84.05	934	1,8187	1.8
Control	6.24 (38.00)	6.56 (42.00)	6.60 (42.56)	7.85(60.90)	0.00		406	827	1.0
LSD (P=0.05)	0.30	0.30	0.26	0.46	-	-	41.56	-	-

Original values are given in parentheses, which were transformed to " x+1, DAS : Days after sowing,

Highest grain yield (1.07 t/ha) was recorded in imazethapyr 10% SL + MSO adjuvant 2ml/L of water applied at 62.5 g/ha followed by imazethapyr 10% SL + MSO adjuvant 2ml/l of water applied at 75 g/ha. Yield recorded in all the imazethpyr treatments (sole application), quizalofop and pendimethalin were significantly inferior to imazethapyr 10% SL + MSO adjuvant 2 ml/l of water applied at 62.5 g/ha. Highest net returns (Rs. 27593/ha) and B:C ratio (2 .3) were recorded in imazethapyr 10% SL + MSO adjuvant 2 ml/l of water applied at 62.5 g/ha.

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Effect of fertilizer levels and weed management practices on weed growth and yield of summer mungbean

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In India, pulses occupies over an area of 25.2 million ha with a production of 17.2 million tonnes and productivity of 665 kg/ha. Since past one decade, the area under pulses are steadily decreasing due to various reasons. Weeds compete with pulses for space, nutrients, water and light. It is also recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms (Bueren *et al.* 2002). Very few studies on soil and foliar nutrition in conjunction with pre-plant soil incorporation, pre- and post-emergence application are done so far. In this background, the present investigation was carried out to cull out the information on appropriate combination of nutrient and weed management practices for maximization of yield in mung bean during summer season in central Telangana zone.

METHODOLOGY

A field experiment was conducted during summer 2013 at Agricultural Research Station, Madhira. The treatments comprised of four fertility levels, *viz.* M_1 - recommended dose of fertilizers (RD) (10-15-17-20 kg NPKS/ ha); M_2 - ½ RD + 2% urea spray (35 DAS); M_3 - 2% urea spray (25 DAS + 45 DAS) and M_4-control (no fertilizers) and five weed management practice, *viz.* S_1 - pendimethalin 1.0 kg/ha (pre-emergence); S_2 - imazathapyr 50 g/ha (post emergence at 20 DAS); S_3- chlorimuron ethyl 4g/ha as pre-plant incorporation, S_4- hand weeding (25 DAS) and S_5- weedy check in split plot design replicated thrice. Data on weeds, yield attributes of summer mung bean were recorded.

RESULTS

The results indicated that the response of mung bean to different fertilizers, its method and time of application was not significant. The lowest weed dry matter and highest weed control efficiency was recorded with hand weeding at 20 DAS when compared to control and was followed by pre-plant soil incorporation of chlorimuron ethyl (S_3). But, due to the herbicide injury/ toxicity for prolonged time on crop, very low yields were recorded with this treatment.

The interaction effect of nutrient and weed management treatments on weed dry matter production indicated that basal application of all nutrients in conjunction with hand weeding (M_1 S_4) has recorded significantly the lowest weed dry matter which was at par with 100% foliar nutrition (M_3 S_4) than the rest of the treatment combination. The highest seed yield (733 kg/ha), number of pods/cluster (5.4) and number of seeds/pod(10) were recorded with hand weeding at 25 days after sowing(S_4) when compared to control (S_1) and other chemical methods except with the application of imazathapyr 50 g/ha as post-emergence at 20 DAS (S_2) which was found at par with hand weeding.

Table 1. Effect of fertilizers and weed management practices on yield of summer mung bean

Treatment	Weed dry matter at 20 DAS (g/m^2)	Weed dry matter at 40 DAS (g/m^2)	Weed control efficiency (%)	No. of clusters/plant	No. of pods/cluster	No. of seeds/pod	Seed yield (kg/ha)
Main plots							
M_1	6.35 (46.2)	2.27 (48.93)	30.30	4.8	5.1	9.6	536
M_2	6.26 (46.3)	2.50 (59.73)	15.00	5.1	4.8	9.2	542
M_3	6.53 (49.0)	2.55 (70.31)	0.00	5.5	5.0	9.8	608
M_4	6.26 (45.6)	2.56 (67.59)	3.80	3.5	4.8	9.4	445
LSD(P=0.05)	NS	NS		NS	NS	NS	NS
Sub plots							
S_1	3.43 (19.3)	3.25 (97.38)	31.4	5.0	5.0	9.8	553
S_2	8.30 (68.3)	(2.25) 42.12	70.3	5.1	5.5	9.5	661
S_3	2.07 (3.6)	1.75 (21.43)	85.0	4.1	4.2	9.0	269
S_4	8.29 (68.1)	1.22 (5.08)	96.4	4.8	5.4	10.0	733
S_5	8.63 (74.6)	3.88 (142.20)	----	4.7	4.4	9.2	458
LSD (P=0.05)	0.66	0.24		0.7	0.6	0.6	78

CONCLUSION

The effect of different nutrient management practice in summer mung bean had no significant influence on grain yield. However, application of imazathapyr 50 g/ha as post-emergence at 20 DAS (S_2) was found at par with hand weeding.

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Effect of weed management options on weed flora and yield of greengram

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Green gram (*Vigna radiata* L.) is one of the most important and extensively cultivated pulse crops. In view of severe infestation of annual and perennial weeds in green gram, the potential yield is generally not realized. Crop need a weed free period of first 30 days, as the crop is short statured which suffers badly if weeds are not controlled at early stages (Mirjha *et al*. 2013). The available herbicide, *viz*. pendimethalin, fenoxaprop-p-ethyl, quizalofop-ethyl and imazethapyr are able to check the emergence and growth of annual weeds (Chhodavadia *et al*. 2013) in greengram. The present investigation was undertaken to test the efficacy of new molecules like quizalofop-ethyl, fenoxaprop-p-ethyl and imazethapyr in green gram.

METHODOLOGY

Field experiments were carried out during *Kharif* 2011-2013 at Anand Agricultural University, Anand (Gujarat) to test different weed management options against weeds. Ten treatments consisting of different pre and post emergence herbicides in integration with intercultivation and hand weeding were arranged in a randomized block design with four replications. Green gram variety '*Meha*' was used in the experimental field with recommended package of practices.. Data on weed growth, yield performance and economics were recorded.

RESULTS

Grassy weeds were predominated (75%), followed by broad-leaved (25%). *Eragrostis major* was dominant among grasses, *Digera arvensis* among broad-leaved weeds. Weed management options significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest weed dry weight (59.3 g/m^2) was observed under pendimethalin 500 g/ha as PE fb IC + HW at 30 DAS, followed by pendimethalin 500 g/ha as PE (63.0 g/m^2) and imazethapyr 75 g/ha as POE *fb* IC + HW at 30 DAS (71.1 g/m^2) at harvest. The minimum weed dry weight was recorded in non chemical practices (53.1 g/m^2), which was significantly lower and at par with above mentioned herbicidal treatments.

The highest seed yield (1.20 t/ha) was recorded with inter culturing *fb* hand weeding carried out at 20 and 40 DAS and the lowest (0.58 t/ha) was under weedy check. The yield loss due to uncontrolled growth of weeds as compared to non chemical practices was 56.5%. Among the herbicidal treatments, pendimethalin 500 g/ha as PE *fb* IC + HW at 30 DAS recorded higher seed yield (1.15 t/ha) which was at par with pendimethalin 500 g/ha as PE (1.13 t/ha), imazethapyr 75 g/ha as POE *fb* IC at 30 DAS (1.11 t/ha) and imazethapyr 75 g/ha as POE *fb* IC at 30 DAS (1.09 t/ha). The B:C ratio was found maximum with IC+ HW carried out at 20 and 40 DAS, followed by pendimethalin 500 g/ha as PE, pendimethalin 500 g/ha as PE *fb* IC + HW at 30 DAS and imazethapyr 75 g/ha as POE *fb* IC at 30 DAS.

Table 1. Weed growth, yield and economics of green gram as influenced by weed management options (Pooled of three years: 2011-2013)

Treatment	WDW at harvest (g/m^2)	WCE at harvest (%)	Seed yield (t/ha)	Haulm yield (t/ha)	Cost of cultivation (x10^3 ` /ha)	B:C ratio
Pendimethalin 500 g/ha PE	8.0def (63.2)*	71	1.13^{abc}	1.70^{ab}	21.96	1.53
Pendi 500 g/ha PE *fb* IC+HW at 30 DAS	7.8ef (59.3)	73	1.15^{ab}	1.76^{a}	23.76	1.38
Quizalofop 50 g/ha POE *fb* IC at 30 DAS	14.0bc (195.1)	11	1.02^{def}	1.49^{c}	23.20	1.17
Quizalofop 50 g/ha POE *fb* IC+HW at 30 DAS	13.9c (192.5)	12	1.06^{cde}	1.60^{bc}	24.40	1.13
Imazethapyr 75 g/ha POE *fb* IC at 30 DAS	8.6d (74.5)	66	1.09^{abc}	1.71^{ab}	23.10	1.33
Imazethapyr 75 g/ha POE *fb* IC+HW at 30 DAS	8.5de (71.1)	68	1.11^{abc}	170^{ab}	24.30	1.25
Fenoxaprop 100 g/ha POE *fb* IC at 30 DAS	14.7ab (215.1)	2	0.99^{f}	1.54^{c}	23.30	1.08
Fenoxaprop 100 g/ha POE *fb* IC+HW at 30 DAS	14.3abc (203.5)	7	1.00^{ef}	1.46^{c}	24.50	1.0
IC+HW at 20 and 40 DAS	7.3f (53.1)	76	1.20^{a}	1.81^{a}	24.10	1.45
Weedy check	14.8a (219.7)	-	0.58^{g}	0.93^{d}	20.50	0.40
LSD (P=0.05	Sig.	-	Sig.	Sig.	-	-
Y x T LSD (P=0.05)	NS	-	NS	NS	-	-

* Values in parentheses are original. Data transformed to square root transformation. Treatment means with the letter/ letters in common are not significant by Duncan's New Multiple Rang Test at 5 % level of significance.

CONCLUSION

Inter culturing and hand weeding carried out at 20 and 40 days after sowing (DAS) is better in timely availability of labours. In paucity of labours, per-emergence application of pendimethalin 500 g/ha alone or integration with IC+HW at 30 DAS or post emergence application of imazethapyr 75 g/ha *fb* IC+HW at 30 DAS are most effective for controlling weeds to improve seed yield and net return of *Kharif* greengram.

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Efficacy of herbicidal weed control in clusterbean at varying levels of phosphorus

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Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] popularly known by its vernacular name '*guar*' is an important leguminous crop of *Kharif* season in arid and semi arid regions of tropical India. It is considered as one of the most drought tolerant deep rooted annual grain legume in India getting significant foreign exchange in recent years by exporting guar gum. Lack of improved cultural practices, cultivation on marginal and sub marginal lands of poor fertility under rainfed conditions, inadequate use of fertilizers, heavy weed infestation, high sensitivity to pests and diseases are the major factors responsible for poor yield of this crop. As guar is a rainy season crop, it is heavily invaded by large number of fast growing weeds which compete for nutrients, moisture, light, space and other resources with main crop causing considerable reduction in yield. Imazethapyr is known to be effective against many annual and perennial grasses and broad leaf weeds. Phosphorus supply to legumes is more important than N because latter is being fixed symbiotically due to *Rhizobium*. The P status of Rajasthan soils particularly the light textured ones where most of the clusterbean cultivation is confined is low and crop responses to its application are encouraging (Patel *et al*. 2004). Phosphorus has beneficial effect on nodulation, growth and yield. Since, a very little information is available on these aspects of crop particularly for loamy sand soils under semi arid conditions, the present investigation was carried out.

METHODOLOGY

A field experiment was conducted under loamy sand soil during *Kharif*, 2013 at Agronomy farm, S.K.N. College of Agriculture, Jobner to test the efficacy of different herbicides with P application to control weeds in cluster bean. The six treatments of weed control comprised weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS, pendimethalin 0.75 kg/ha, imazethapyr 100 g/ha and fenoxoprop-p-ethyl 70 g/ha and four levels of phosphorus (0, 20, 40 and 60 kg/ha) were arranged in spilt plot design keeping weed control treatments in main and P levels in sub plots and were replicated thrice. Cluster bean variety '*RGC-1003*' was used as a test crop. Imazethapyr and pendimethalin were applied through 'fervent 10 SL' and stomp 30 EC, respectively and fenoxoprop-p-ethyl through puma super 9.3% EC. Imazethapyr and pendimethalin were applied as pre emergence treatment to the respective plots one day after sowing of cluster bean. Whereas, fenoxoprop-p-ethyl was applied as early post emergence treatment to the respective plots at 20 DAS. Phosphorus was applied through DAP as per treatments.

RESULTS

Results showed that HW twice at 20 and 40 DAS resulted in maximum reduction in weed density, weed dry matter and nutrient depletion by weeds and higher weed control efficiency (74.7%) in comparison to rest of the treatments. Two HW treatment also proved its superiority in improving growth and yield attributes *viz*. plant height, branches/plant, crop dry matter, number and weight of nodules/plant, pods/plant, grains/pod and test weight of cluster bean over most of the treatments. The highest grain, stover and biological yields (1.64, 3.79 and 5.44 t/ha) were obtained with two hand weeding treatment. Under herbicidal treatments pre emergence application of imazethapyr 100 g/ha was the best herbicidal treatment in reducing density and bio mass of weeds and nutrient depletion by weeds and enhancing growth and yield attributes. It also provided grain and stover yields of 1.47 and 3.34 t/ha, respectively, with the minimum weed competition index (10.39%).

Fetching the maximum net returns of 53080/ha and with a B:C ratio of 2.34, two HW at 20 and 40 DAS was found the most remunerative treatment. Application of imazethapyr at 100 g/ha was found as the best herbicidal treatment which provided additional net returns of 26271/ha over control with the highest B:C ratio of 2.56. Kalpana and Veleyuthan (2004) also reported superiority of imazethapyr in soybean. Results also showed that application of 60 kg P/ha in clusterbean recorded the highest dry weight of weeds at all the stages, N, P and K concentration in weeds and their depletion by weeds at harvest stage. Every increase in level of phosphorus upto 40 kg/ha significantly improved the growth and yield attributing characters over preceeding levels. Being at par with 60 kg/ha, it also provided 94.0, 85.4 and 87.9% higher grain, stover and biological yields of cluster bean than control. Providing additional net returns of 31633/ha over control and the highest B:C ratio (2.50), 40 kg/ha was found the most remunerative level of phosphorus fertilization in cluster bean.

CONCLUSION

Application of imazethapyr 100 g/ha (PE) along with 40 kg P/ha was the observed as the best herbicidal combination for getting higher yield and returns.

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Bioefficacy of herbicides for weed management in irrigated chickpea

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Chickpea is used in salad and to cook various dishes. The yield of chickpea has fallen due to various biotic and abiotic factors. Weeds cause loss in yield by competing for space, nutrients, water and light. The crop is a poor competitor of weeds because of slow growth rate and limited leaf development at early stage of crop growth, resulting in yield loss of 40-87%. This research aimed to quantify the competitive effects of weeds on chickpea.

METHODOLOGY

The experiment consisted of eleven treatments comprising of herbicidal application and a control with weed free check and were replicated thrice. The experiment was laid out in Randomized Complete Block Design. The soil was low in available N (150 kg/ha), medium in available P (49 kg/ha) and high in available K (500 kg/ha).

RESULTS

Pendimethalin 1 kg/ha followed by 1 hand weeding at 25-30 DAS recorded lower total weed population. This was due to complete elimination of weeds at initial stages by spraying of pendimethalin immediately after sowing. This was coupled with complete elimination of weeds both at intra and inter row space by hand weeding at 25-30 DAS and spraying of tank mix of imazethapyr 25 g/ha + quizalofop-p-ethyl 25 g/ha at 20-25 DAS. The higher weed control efficiency (100%) was with weed free check. Among herbicidal treatments pendimethalin 1 kg/ha followed by 1 hand weeding at 25-30 DAS recorded higher weed control efficiency (79.26%). This may be due to total elimination of weeds at critical stages of crop growth and could be attributed to lower weed count as well as dry weight of weeds in these treatments (Poonia *et al*. 2013) and (Khope *et al*. 2011).

Weed index indicating yield reduction due to weed competition, was higher in weedy check. Weed free check (two interculture + one hand weeding) and pendimethalin 1 kg/ha followed by 1 hand weeding at 25-30 DAS recorded significantly higher seed yield, net returns and benefit cost ratio (Goud *et al*. 2013). This was mainly due to higher gross returns along with lesser cost of cultivation, particularly less weed management cost. Significantly lower net returns were recorded with weedy check and application of imazethapyr 50 g/ha at 20-25 DAS .

Table1. Yield and economics of chickpea as influenced by weed control treatments

Treatment	Total weed count (no /m^2)	WCE (%)	WI (%)	Seed yield (kg/ha)	Net returns (?/ha)	B:C ratio
Unweeded check	8.55(72.67)	0.0	51.7	1007	9,236	1.49
Weed free check (two interculture + one hand weeding)	0.71(0.00)	100	0.0	2087	34,467	2.44
Pendimethalin 1 kg/ ha (PRE) followed by 1 hand Weeding at 25-30 DAS	3.54(12.00)	79.2	10.0	1878	32,015	2.56
Oxyfluorfen 0.12 kg/ ha (POE)	6.57(42.67)	35.5	43.3	1292	16,114	1.80
Imazethapyr 50 g/ ha (POE) at 20-25 DAS	6.20(38.00)	50.8	58.2	1063	9,895	1.50
Fenoxaprop-p-ethyl 60 g/ ha (POE) at 20-25 DAS	5.34(28.00)	69.9	35.2	1350	17,219	1.84
Quizalofop-p-ethyl 50 g/ ha (POE) at 20-25 DAS	5.21(26.67)	71.5	30.3	1453	19,541	1.92
Tank mix of imazethapyr 25 g/ ha + fenoxaprop-p-ethyl 30 g/ ha (POE) at 20-25 DAS	4.97(24.67)	73.8	22.5	1617	24,801	2.21
Tank mix of imazethapyr 50 g/ ha + fenoxaprop-p-ethyl 60 g/ ha (POE) at 20-25 DAS	6.20(38.00)	58.4	44.1	1167	11,177	1.52
Tank mix of Imazethapyr @ 25 g ha^{-1} + quizalofop-p-ethyl@ 25 g ha^{-1}(POE) at 20-25 DAS	4.81(22.67)	72.2	15.7	1757	28,431	2.37
Tank mix of Imazethapyr @ 50 g ha^{-1} + quizalofop-p-ethyl@ 50 g ha^{-1}(POE) at 20-25 DAS	5.56(30.67)	61.7	39.3	1264	13,340	1.60
LSD (P=0.05)	0.60	8.2	11.1	212	5,930	0.28

CONCLUSION

Weed free check (two interculture + one hand weeding) and pendimethalin 1 kg/ha followed by 1 hand weeding at 25-30 DAS recorded significantly higher seed yield, net returns and benefit cost ratio in irrigated chickpea.

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Integrated weed management in chickpea under irrigated condition

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In chickpea a field experiment was carried out to study the suitable and effective weed management practices to control weeds during critical period of crop-weed competition and to study the economics of weed control practices.

METHODOLOGY

A field experiment was conducted during *Rab*i, 2011-12 at Post Graduate Institute Instructional Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra). The experiment was laid out in Randomized Block Design with three replications and 11 treatments, *viz*.T_1 pendimethalin 30 EC PE 0.750 kg/ha, T_2 pendimethalin 30 EC PE 0.750 kg/ha *fb* one hand weeding at 30 DAS, T_3 oxyfluorfen 23.5 EC PE 0.100 kg/ha, T_4 oxyfluorfen 23.5 EC PE 0.100 kg/ha, T_6 metribuzin 70 % WP PE 0.250 kg/ha *fb* one hand weeding at 30 DAS, T_7 imazethapyr 10% SL EPoE 0.030 kg/ha at 20 DAS, T_8 imazethapyr 10% SL EPoE 0.060 kg/ha at 20 DAS, T_9 one hoeing at 15 DAS + one hand weeding at 30 DAS, T_{10} weedy check and T_{11} weed free up to 60 days.

RESULTS

The predominant weed flora observed in the experimental plot were: *Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Celosia argentea,* and *Chenopodium album.* The results revealed that, at all the days of observation, weed free up to 60 days recorded minimum and significantly lowest total weed count as compared to rest of the treatments but it was at par with the treatments PE application of pendimethalin 0.750 kg/ha *fb* one HW at 30 DAS, oxyfluorfen 0.100 kg/ha *fb* one HW at 30 DAS and one hoeing at 15 DAS and one HW at 30 DAS at all stages of observations The highest weed control efficiency was observed with weed free up to 60 days at all the stages of observations which was followed by treatments T_2,T_4 and T_9 at all the stages of observations. The grain yield was significantly higher in the weed free up to 60 days and it was at par with PE application of pendimethalin 30 EC 0.750 kg/ha *fb* one HW at 30 DAS, PE application of oxyfluorfen 23.5 EC 0.100 kg/ha *fb* one HW at 30 DAS and one hoeing at 15 DAS and one HW at 30 DAS.

The maximum net monetary returns were obtained with the treatment PE application of oxyfluorfen 23.5 EC 0.100 kg/ ha *fb* one HW at 30 DAS (47012/ha) but it was at par with treatments PE application of pendimethalin 0.750 kg/ha *fb* one HW at 30 DAS, (46813/ha), one hoeing at 15 DAS and one HW at 30 DAS (46877/ ha) and weed free up to 60 days (46629/ha). Whereas, B:C ratio (2.20) was maximum with treatment PE application of oxyfluorfen 23.5 EC 0.100 kg/ha *fb* one HW at 30 DAS.

Table 1. Seed yield, straw yield and harvest index as influencedby different treatments

Treatment	Total weed count at 60 DAS(No./m^2)	WCE(%) at 60 DAS	Seed yield (t/ha)	Net returns (`./ha)	B: C ratio
T_1 - Pendimethalin PE 0.750 kg/ ha	6.20 (38.0)	71.9	2.53	35,579	1.95
T_2 - Pendimethalin PE 0.750 kg/ ha *fb* one HW at 30 DAS	3.61 (12.6)	90.6	2.98	46,813	2.15
T_3 - Oxyfluorfen PE 0.100 kg/ha	6.64 (43.6)	67.5	2.51	34,700	1.96
T_4 - Oxyfluorfen PE 0.100 kg/ha *fb* one HW at 30 DAS	4.00 (15.6)	88.4	2.96	47,012	2.20
T_5 - Metribuzin PE 0.250 kg/ha	7.06 (49.3)	63.4	2.40	34,686	1.96
T_6 - Metribuzin PE 0.250 kg/ha *fb* one HW at 30 DAS	5.91 (34.6)	74.5	2.66	35,215	1.90
T_7 - Imazethapyr EPoE 0.030 kg/ha at 20 DAS	8.59 (73.3)	45.8	2.27	30,639	1.86
T_8 - Imazethapyr EPoE @ 0.060 kg ha^{-1} at 20 DAS	7.60 (57.3)	57.6	2.14	26,360	1.73
T_9 - One hoeing at 15 DAS + one HW at 30DAS	3.70 (13.3)	90.0	2.96	46,877	2.18
T_{10} - Weedy check	11.65 (135.3)	0.0	1.69	15,084	1.44
T_{11} - Weed free up to 60 days	0.71 (0.0)	100.	3.17	46,628	2.00
SEm±	0.20	NA	0.09	2,325	
CD (P=0.05)	0.58		0.28	6,859	

"x+0.5 transformed values. Original values are in parentheses, WCE : Weed control efficiency

CONCLUSION

Thus, for effective weed control and higher monetary benefits, integrated weed management with PE application of oxyfluorfen 0.100 kg/ha *fb* one HW at 30 DAS is a better option where labour availability is a severe problem.

Efficacy of different herbicides for controlling weeds in blackgram

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In India blackgram is grown in almost all the states. It is grown in about 3.1 million hectare area with a production of 1.49 million tonnes (Pyare *et al.* 2013). Associated weeds with crop not only compete for nutrients, moisture and light but space too. Timely control of nature and intensity of weeds can significantly improve the yield of blackgram. Different types of weeds *i.e.* grasses, broad leaves and sedges compete jointly or individually with different growth factors. Under these circumstances, use of herbicides may be desirable for the control of weeds particularly at early stages which will control the emerged and emerging weeds for a substantial period of time. During the recent years the chemical weed control in black gram has attracted the attention of research workers. Therefore, the present investigation was undertaken to develop an effective and economical weed control schedule in *Kharif* blackgram.

METHODOLOGY

A field experiment was conducted at the Norman E. Borlaug Institute, during *Kharif* 2009 and 2010 to evaluate the efficacy of different herbicides against weeds of black gram crop. The experiment was laid out in Randomized Block Design comprising ten treatments (Table 1) and replicated thrice. The black gram variety '*Pant Urd-19*' was sown on September 5, 2012 and August 20, 2013 with row spacing of 30 cm. Among the herbicidal treatment, pendimethalin and imazethapyr + pendimethalin were applied as pre emergence on 1 DAS while the remaining herbicides were applied as post emergence at 2- 3 leaf stage of weeds.

RESULTS

The major weed flora in the experimental field consisted of *Echinochloa colona*, *Eleusine indica*, *Dactyloctenium aegyptium*, *Digitaria sangunalis*, *Panicum maximum* among the grasses and *Digeria arvensis*, *Cleome viscosa*, *Celosia argentia*, *Malugo stricta*, *Trianthema monogyna* were the major broad leaved weeds (BLWs). *Cyperus rotundus* was one of the most dominating species among the sedges during both the years. All the weed control treatments were able to reduce the total dry weight of weeds at 40 DAS over the weedy plot. The application of higher dose of imazethapyr + pendimethalin at 1000 g/ha and imazethapyr + imazamos at 70 g/ha was found more effective in reducing the dry weight of weeds as compared to its lower dose. Significantly lower dry matter of weeds was recorded with application of imazethapyr + pendimethalin at 1000 g/ha might be due to elimination of grassy and non grassy weeds resulting in highest weed control efficiency of 78.8 and 62.6%, respectively as compared to its lower doses and sole application of herbicides. Among the sole application of herbicides, pendimethalin at 1000 g/ha was found more effective towards the dry weight of weeds as compared to other herbicides. Among the herbicidal treatments, pre mix application of imazethapyr + pendimethalin at 1000 g/ha recorded significantly higher grain yield which was at par with its lower dose applied at 900 g/ha.

Table 1. Effect of different herbicidal treatment on total weed dry weight and weed control efficiency at 40 DAS and grain yield of balckgram

Treatment	Dose (g/ha)	Total weed dry wt. (g/m^2)		WCE (%)		Grain yield (kg/ha)	
		2012	2013	2012	2013	2012	2013
Pendimethalin	1000	26.9	39.3	60.7	55.0	1482	820
Imazethapyr	50	30.5	52.3	55.4	40.1	1242	675
Imezathapyr	70	25.2	43.3	63.2	50.4	1275	730
Imezathapyr+pendimethalin	800	23.5	40.5	65.6	53.6	1425	828
Imezathapyr+pendimethalin	900	20.7	36.5	69.7	58.2	1543	1084
Imezathapyr+pendimethalin	1000	14.5	32.4	78.8	62.5	1663	1095
Imazethapyr+imazamos	60	36.7	46.6	46.3	46.6	1231	800
Imazethapyr+imazamos	70	32.9	36.3	51.9	58.4	1317	903
Hand weeding	20 and 40 DAS	24.7	20.9	63.9	76.0	1624	1240
Weedy	-	68.4	87.4	00.0	00.0	569	440
LSD (P=0.05)	-	7.8	6.4	-	-	166	135

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Bioefficacy of herbicides against weeds in blackgram

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Blackgram [*Vigna mungo* (L.) Hepper] is an important pulse crop in India. Monsoon rains during *Kharif* season results in heavy weed infestation in this crop. Unchecked weeds have been reported to cause 43.2-64.1% reduction in the grain yield of *Kharif* blackgram (Chand *et al.* 2004). The weed growth particularly *Echinochloa* spp. is severe and effectively competitive with crop for residual moisture, nutrients and reduces the blackgram yield to the extent of 75% (Rao 2008). Broad leaved weeds pose serious problem in blackgram cultivation in West Bengal condition. Post-emergence application of imazethapyr at 50 g/ha controlled mixed weed flora but resulted in slight injury to blackgram (Rao *et al.* 2010). Hence the present investigation was carried out to find out suitable herbicide/herbicide mixture for broad-spectrum weed control in blackgram.

METHODOLOGY

The field trial was laid out in a randomized block design with 12 treatments and replicated thrice at Agricultural Farm of Visva-Bharati during *Kharif,* 2014. The herbicidal treatments were pendimethalin, imazethapyr with two doses, pre-mix of imazethapyr + pendimethalin and pre-mix of imazethapyr + imazamox with two doses, two hoeings and weedy check. Pendimethalin and three different doses of imazethapyr + pendimethalin were applied as pre-emergence and different doses of imazethapyr and imazethapyr + imazamox with different two doses were applied both as pre and post emergence (3-4 leaf stage). The blackgram (var. '*Kalindi*') was sown on 12 September, 2014 and harvested on 25 November 2014. The weed population, dry matter of weed, seed yield of blackgram and economics were recorded.

RESULTS

Pre-emergence application of imazethapyr + pendimethalin effectively controlled the mixed weed flora. All the herbicidal treatments were effective to control grassy weeds as compared weedy check. Pre-emergence application of imazethapyr + pendimethalin (pre-mix) and imazethapyr+ imazamox were found effective in controlling broadleaved weeds. Regarding suppression of total weeds population, pre-emergence application of ready mix of imazethapyr + pendimethalin and imazethapyr + imazamox were very effective. Similar trend was also observed in case of dry matter of total weed population.

Pre-emergence application of imazethapyr + pendimethalin (pre-mix) 1000 g/ha recorded the highest yield (923 kg/ha) and was on par with two hoeing operation (921 kg/ha). Post-emergence application of imazethapyr and ready mix of imazethapyr + pendimethalin showed phytotoxic effect on black gram as a result of which the seed yield was hampered greatly. Pre-emergence application of imazethapyr + pendimethalin (pre-mix) 1000 g/ha gave the highest net return (23835/ha) and wider B:C ratio (2.35) and it was followed by pre-emergence application of pendimethalin which gave net return of Rs. 21385/ha and B:C ratio was 2.17. The two hoeing operation gave comparatively low economic return (20245/ha) and B:C ratio (1.95) because of high cost of cultivation. The post-emergence application of imazethapyr and imazethapyr + pendimethalin recorded low net return as compared to pre-emergence application of the same herbicide.

Table 1. Effect of treatments on yield and economics of blackgram

Treatment	Seed yield (kg/ha)	Weed dry weight (g/m^2)	Gross return (` /ha)	Net return (` /ha)	B:C ratio
Imazethapyr 70 g/ha PRE	677	4.5 (19.6)	30,465	12,165	1.67
Imazethapyr 80 g/ha PRE	673	4.5 (19.4)	30,285	11,635	1.62
Imazethapyr 70 g POE	635	5.7 (31.9)	28,560	10,260	1.56
Imazethapyr 80 g POE	606	5.6 (30.5)	27,255	8,605	1.46
Imazethapyr + imazamox (RM) 70 g/ha PRE	682	3.4 (11.4)	30,705	13,505	1.78
Imazethapyr + imazamox (RM) 80 g/ha PRE	678	3.1 (9.1)	30,525	13,125	1.76
Imazethapyr + imazamox (RM) 70 g POE	614	4.3 (17.9)	27,630	10,430	1.61
Imazethapyr + imazamox (RM) 80 g POE	645	3.4 (11.1)	29,025	11,625	1.67
Pendimethalin 1000 PRE	880	4.5 (20.0)	39,585	21,385	2.17
Imazethapyr + pendimethalin (RM) 1000 PRE	923	3.0 (8.7)	41,535	23,835	2.35
Hoeing (2) 20 & 40 DAS	921	4.4 (18.5)	41,445	20,245	1.95
Weedy check	486	10.0 (98.9)	21,885	5,385	1.33
LSD (0.05 P)	52	029	2,341	2,341	0.13

Figures in the parentheses indicate the actual values, Transformed value = "(x + 0.5)

CONCLUSION

Pre-emergence application of imazethapyr + pendimethalin (pre-mix) 1000 g/ha was found most effective for controlling weeds, improving seed yield and profitability of blackgram.

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Standardizing the dose and time of imazethapyr application in mash under mid-hill conditions of Himachal Pradesh

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Urdbean, the major pulse crop in India is a rich source of protein (24%), carbohydrates (60'%), fat (1-5%), amino acids, vitamins and minerals. In Himachal Pradesh, blackgram is an important crop among *Kharif* pulses and is usually grown on marginal and sub-marginal lands, which faces severe weed competition due to its slow initial growth and lack of effective weed control measures. An initial period of 20-40 days is very critical and season long weed competition has been found to reduce black gram yield to the extent of 87% depending on the type and intensity of weed flora (Singh *et al. 2002).* Selective herbicide can be one of the best alternatives for economical and timely weed control in urd bean. Imazethapyr, a effective post emergence herbicide acts by reducing the level of three branched chains aliphatic amino acids *viz.* isoleucine, leucine and valine, through the inhibition of acetohydroxy acid synthase an enzyme common to the biosynthetic pathway for these amino acid (Sondhia 2008). There is need to standardize the dose and time of this effective herbicide in this crop under mid hill conditions of Himachal Pradesh, therefore, the present investigation was undertaken.

METHODOLOGY

A field study was conducted at Research farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *Kharif* 2008 to ascertain the dose and time of imazethapyr in mash. Experiment with 14 treatments, three replications was laid out in randomized block design. The treatments consisted of four doses of imazethapyr *i.e.* 50, 75, 100 and 125 g/ha each sprayed at three times *i.e.* 10, 15 and 20 DAS, pendimethalin 1.5 kg/ha (pre.) as herbicide check and an unweeded check (Table I). Mash variety '*T-9*' was sown following recommended agronomic practices except treatments. The herbicides were applied with a manually operated knapsack sprayer with flat fan nozzle using a spray volume of 750 l/ha.

RESULTS

The predominant weeds of the experimental field were: *Echinochloa colona, Panicum dichotomiflorum, Cyperus iria, Ageratum conyzoides and Polygonum alatum.* Application of imazethapyr 100 and 125 g/ha either at 10 or 15 DAS being at par with imazethapyr 125 g/ha applied at 20 DAS have recorded significantly lower dry matter of total weeds at 60 DAS as evident by their higher weed control efficiencies which ranged from 93.6-84.6%. Due to significant less weed crop competition in these treatments have resulted in getting significantly higher seed yield of mash. However, imazethapyr 75 g/ha applied either at 15 or 10 DAS were also at par to these, because of effective weed control which was reflected by higher WCE of 81.4 and 77.0%, respectively (Table 1). The per cent increase in the yield by these said treatments ranged from 50.8-45.8 over unweeded check. Uncontrolled weeds, caused 33.7% reduction in the seed yield of blackgram. Nadan *et al.* (2011) also reported the best results with imazethapyr applied at 15-20 DAS, which was also at par with two hand weeding. Highest values of gross and net returns due to weed control *i.e.* Rs. 14,900 and 13,167/ha, respectively were obtained with imazethapyr 100 g/ha applied at 15 DAS which was followed by its application at 75 g/ha after same duration with corresponding values of Rs. 14,200 and 12,900/ha. Imazethapyr 75 g/ha at 15 DAS proved to be best with value of 9.93 B:C ratio followed by its application with similar dose at 10 DAS (9.54).

Table 1. Weed dry weight, yield, WCE and economics of mash as influenced by different weed control treatments

Treatment	Dose (g/ha)	Time of application (DAS)	Weed dry weight (g/m^2)	Seed yield (t/ha)	WCE (%)	WI (%)	GR (x10^3? /ha)	GR$_{WC}$ (x10^3? /ha)	NR$_{WC}$ (x10^3? /ha)	B:C wc
Imazethapyr	50	10	62.8	0.70	60.85	21.37	34.95	5.40	4.53	5.23
Imazethapyr	75	10	36.9	0.87	77.00	2.70	43.25	13.70	12.40	9.54
Imazethapyr	100	10	24.6	0.85	84.66	3.37	42.95	13.40	11.67	6.73
Imazethapyr	125	10	16.4	0.86	89.78	2.81	43.20	13.65	11.48	5.30
Imazethapyr	50	15	55.9	0.71	65.15	19.91	35.60	6.05	5.18	5.98
Imazethapyr	75	15	29.7	0.88	81.48	1.57	43.75	14.20	12.90	9.93
Imazethapyr	100	15	19.8	0.89	87.66	0.00	44.45	14.90	13.17	7.60
Imazethapyr	125	15	10.2	0.87	93.64	1.91	43.60	14.05	11.88	5.49
Imazethapyr	50	20	96.5	0.68	39.84	24.07	33.75	4.20	3.33	3.85
Imazethapyr	75	20	55.2	0.74	65.59	17.32	36.75	7.20	5.90	4.54
Imazethapyr	100	20	37.8	0.79	76.43	11.25	39.45	9.90	8.17	4.71
Imazethapyr	125	20	20.6	0.87	87.16	2.59	43.30	13.75	11.58	5.35
Pendimethalin	1500	Pre.	66.5	0.75	58.54	15.86	37.40	7.85	5.35	2.14
Unweeded check			160.4	0.59	0.00	33.52	29.55	-	-	-
CD (P=0.05)			14.5	0.03	NA		-	-	-	-

GR=Gross returns, GR$_{WC}$= Gross returns due to weed control, NR$_{WC}$= Net returns due to weed control, B:C$_{WC}$=Benefit cost ratio due to weed control

CONCLUSION

Application of imazethapyr 75 g/ha at 15 DAS in mash proved to be best for getting higher seed yield with better economics.

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Efficacy of weed management practices on weed dynamics and yield of long-duration pigeonpea

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Pigeonpea (*Cajanus cajan*(L) Millsp) being a widely spaced and slow growing crop during early stage, provides ample opportunity for weed growth, resulting in yield losses to the tune of 68% (Rana and Pal 1997). A single factor weed, if left uncontrolled, mitigates the benefits obtainable from different agricultural inputs. The effective and economical weed control may not be possible through manual means due to unavailability of human labour at critical period of competition and its high cost coupled with heavy and continuous rainfall in *Kharif* make the use of herbicides an alternative method to manage weed in this situation. Herbicide and its integration with manual and mechanical methods can prove more effective and economical. Therefore an experiment was planned with an objective to find out suitable and economical weed control method for enhancing productivity and profitability of pigeon pea.

METHODOLOGY

A field experiment was carried out during 2013-14(*Kharif*) at Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar) to test the efficacy of weed management practices against weed. The treatment comprised pendimethalin 0.75 kg/ha (3DAS) +1 HW at 50 DAS, imazathapyr 100 g/ha (15DAS) +1 H.W at 50 DAS, quizalofop ethyl 100g/ha (15DAS) + 1 H.W at 50 DAS, pendimethalin 0.75 kg/ha (3DAS) + imazathapyr 100 g/ha (15DAS), pendimethalin 0.75 kg/ha (3DAS) + imazathapyr 100 g/ha (15DAS) + 1HW at 50 DAS, pendimethalin 0.75 kg/ha (3DAS) + quizalofop ethyl 100 g/ha (15DAS), pendimethalin 0.75 kg/ha (3DAS)+quizalofop ethyl 100g/ha(15DAS)+one interculture operation at 50 DAS, weed free (HW at 25, 50 and 75 DAS) and weedy check were tested in randomized block design with three replications. Pigeonpea variety '*Pusa 9*' was sown in experimental field in July.

RESULTS

Weed control treatments recorded significantly lower weed count and weed dry biomass than weedy check. Among the weed control treatments, weed free plot recorded lowest weed population and weed dry biomass which was found at par with pre-emergence application of pendimethalin 0.75 kg/ha + post-emergence application of imazathapyr (15 DAS) followed by one hand weeding at 50 DAS. These weed control treatments also recoded higher weed control efficiency and lower weed index. Maximum weed index and lowest weed control efficiency were recorded in un-weeded check.

The highest grain yield (2.30 t/ha) was recorded under weed free treatment and the lowest (1319 kg/ha) was under weedy check. The yield loss due to uncontrolled growth of weeds as compared to weed free was 42.9%. The treatment Pendimethalin 0.75 kg/ha (3DAS)+ imazathapyr 100g/ha (15DAS) + 1HW at 50 DAS, Pendimethalin 0.75kg/ha (3DAS)+ quizalofop-ethyl 100g/ha(15DAS)+one intercultural operation at 50 DAS, imazathapyr 100g/ha(15DAS)+1 HW at 50 DAS and quizalofop-ethyl 100g/ha (15DAS) + 1 HW at 50 DAS 0.75 kg/ha (3DAS) + imazathapyr 100g/ha (15 DAS) + one HW at 50DAS recorded highest net returns (Rs. 80.10x10^3/ha) but was found par with pendimethalin0.75Kg/ha(3DAS)+ quizalofop ethyl (15 DAS)+ one intercultural operation at 50 DAS(Rs78.47x10^3/ha) and significantly higher over other weed control treatments while highest B:C ratio was recorded under pendimethalin 0.75kg/ ha(3DAS)+ quizalofop-ethyl 100g/ha (15DAS)+ one intercultural operation. The B:C ratio recorded under these two treatments did not varied significantly.

Table 1. Effect of weed control treatments on weeds, grain yield and economics of pigeon pea.

Treatment	Weeds/m^2	WCE (%)	WI (%)	Grain yield (t/ha)	Net return (x10^3` ./ha)	B:C ratio
Pendimethalin 0.75 kg/ha(3DAS)+1 HW at 50 DAS	11.67(136.2)	75.3	18.0	1.89	66.64	2.66
Imazathapyr 100g/ha(15DAS)+1 HW at 50 DAS	7.89(62.9)	83.4	9.0	2.10	75.44	2.92
Quizalofop ethyl 100g/ha (15DAS)+1 HW at 50 DAS	8.69(75.6)	80.3	11.3	2.04	71.13	2.55
Pendimethalin 0.75 kg/ha(3DAS)+ imazathapyr 100g/ha(15DAS)	9.16(92.6)	74.1	21.8	1.80	65.28	2.90
Pendimethalin 0.75kg/ha(3DAS)+imazathapyr100g/ha (15 DAS)+ 1 HW at 50 DAS	7.43(54.8)	86.6	2.3	2.25	80.10	2.88
Pendimethalin 0.75kg/ha(3DAS)+quizalofop ethyl 100g/ha(15DAS)	10.93(116.5)	70.5	24.8	1.73	59.90	2.43
Pendimethalin 0.75kg/ha(3DAS)+quizalofop ethyl 100g/ha(15DAS)+one interculture operation at50 DAS	8.50(72.4)	83.8	5.3	2.18	78.47	2.94
Weed free(HW at 25,50 and 75 DAS)	6.21(38.2)	90.6	0.00	2.30	76.51	2.27
Weedy check	24.77(613.4)	0.00	42.9	1.31	46.52	2.60
CD (P=0.05)	1.65	-	-	0.31	3.16	0.28

DAS= Days after sowing, original values are given in parentheses, WCE =Weed control efficiency, WI= Weed index

CONCLUSION

It was concluded that pre- emergence application of pendimethalin 0.75 kg/ha (3DAS) + imazathapyr 100g/ha(15DAS) + one hand weeding at 50DAS or pre- emergence application of pendimethalin+ quizalofop ethyl 100g/ha(15DAS) + one intercultural operation at 50 DAS was most effective for controlling weeds, improving grain yield and profitability of pigeonpea.

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Effect of pre- and post-emergence herbicides in transplanted rice and their residual effect on succeeding greengram

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India is the second largest producer of rice next to China. Weeds can cause a reduction of 28-45% of grain yield of transplanted rice (Singh *et al.* 2003). Pre-emergence application of high volume herbicides like butachlor, pretilachlor, anilophos etc were not effective in controlling the weeds in transplanted rice throughout the crop growing season and these herbicides also posing residual effect on succeeding crops. Hence, the sequential application of pre- and post-emergence herbicides may be useful to control the weeds throughout the crop growth without residual activity on succeeding crops.

METHODOLOGY

A field investigation was carried out during *rabi* 2009-10 at S.V. Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh to study the effect of various pre-and post-emergence herbicides on weed growth in transplanted rice and its residual effect on succeeding green gram on sandy loam soils. The experiment consisted of twelve weed management practices with pre-emergence herbicides, *viz*. pretilachlor, oxadiargyl, pyrazosulfuron-ethyl alone and in combination with post emergence herbicides, *viz*. penoxsulam and bispyribac-sodium (Table 1) arranged in randomized block design . The test variety NLR-34449 was transplanted on 18th December, 2009 and harvested on 7th April, 2010. To know the residual effect of these pre- and post-emergence herbicides, green gram variety '*LGG-460*' was sown on 11th April, 2010 in an undisturbed layout. The data on germination%, root length and shoot length were recorded at 10 DAS of green gram

RESULTS

Pre-emergence application of oxadiargyl 75 g/ha + bispyribac-sodium 30 g/ha at 20 DAT produced lower weed dry weight and higher grain yield in transplanted rice, however it was comparable with two hand weedings at 20 and 40 DAT. Germination percentage, root, shoot length and seedling vigour index were found non-significant in residual crop of green gram. However, lower germination % of greengram was noticed with pre-emergence application of pyrazosulfuron-ethyl 35 g/ha to transplanted rice. Root and shoot length of green gram was lower with the pre-emergence application of oxadiargyl 75 g/ha to transplanted rice. Seedling vigour index of green gram was also lower with pre-emergence application of oxadiargyl. Similar results were also reported in spinach by Mahmoudi *et al.* (2011). This clearly indicates that pre-emergence application of oxadiargyl showed inhibitory effect on growth of succeeding green gram. The higher seed yield of green gram was obtained with pre-emergence application of pretilachlor *fb* bispyribac-sodium to transplanted rice which was at par with hand weeding twice.

Table 1. Residual effect of pre-and post-emergence herbicides applied to transplanted rice on succeeding greengram

Weed management	Time of application (DAT)	Rice		Green gram				
		Weed dry weight (g/m^2)	Grain yield (t/ha)	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling vigour index	Seed yield (t/ha)
Pretilachlor1000 g/ha	4	78.54 (8.89)	5.32	77.1	3.2	7.4	822.09	0.56
Oxadiargyl 75 g/ha	4	60.87 (7.83)	5.55	77.2	2.5	7.2	753.30	0.53
Pyrazosulfuron-ethyl 35 g/ha	4	71.30 (8.47)	5.49	70.5	3.3	8.2	810.85	0.46
Pretilachlor 1000 *fb* penoxsulam 25 g/ha	4+20	37.20 (6.14)	5.82	74.8	2.9	8.6	857.97	0.54
Oxadiargyl 75 fb penoxsulam 25 g/ha	4+20	23.42 (4.89)	6.54	73.7	1.9	7.6	700.05	0.58
Pyrazosulfuron-ethyl 35 *fb* penoxsulam 25 g/ha	4+20	51.28 (7.20)	5.69	69.1	2.6	7.5	735.22	0.44
Pretilachlor 1000 *fb* bispyribac-sodium 30 g/ha	4+20	27.49 (5.29)	6.26	73.0	3.3	8.3	850.01	0.61
Oxadiargyl 75 *fb* bispyribac-sodium 30 g/ha	4+20	20.13 (4.54)	6.75	71.0	2.3	7.2	680.85	0.60
Pyrazosulfuron-ethyl 35 *fb* bispyribac-sodium 30 g/ha	4+20	25.42 (5.09)	5.94	67.8	2.7	7.8	727.09	0.44
Cyhalofop-butyl 125 g/ha	20	84.48 (9.22)	5.12	78.4	3.1	7.6	851.22	0.45
Two hand weeding	20+40	18.75 (4.39)	6.81	78.2	3.2	7.8	856.40	0.60
Unweeded check (control)	-	171.55 (13.12)	4.55	80.2	3.3	8.6	970.23	0.59
CD (P = 0.05)	-	0.38	0.4	NS	NS	NS	NS	0.13

CONCLUSION

Pre-emergence application of oxadiargyl 75 g/ha + bispyribac-sodium 30 g/ha recorded significantly reduced weed dry weight and increased grain yield in transplanted rice. However, pre-emergence application of oxadiargyl to transplanted rice showed residual effect on succeeding greengram interms of reducing root and shoot length including seedling vigour index.

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Influence of weed management practices on productivity of chickpea + mustard intercropping under sub-tropical conditions of Jammu and Kashmir

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Pulses play an important and diverse role in the cropping systems as well as in the protein in diets of poor people around the world. Globally, the area under pulse crops is about one-tenth of the total harvested area under all cereal crops and, that too, a high proportion of it is under rainfed low-input systems compared to cereal crops. Weed infestation pose a serious threat to the stability of crop yields. Therefore, intercropping of mustard in chickpea coupled with effective weed control measures may help the farming community to realize the potential yield of chickpea to its maximum with an additional yield of mustard which is raised as an intercrop.

METHODOLOGY

A field experiment was conducted at the research Farm, Main Campus, Chatha of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during *rabi* 2009-10 and 2010-11. The experiment was laid out in split-plot design with three replications. The intercropping treatments were assigned to main plots and sub-plot treatments comprised of weed management practices. The determination of weed density and weeds dry matter was done by the standard quadrate method. The yield of mustard crop was converted into chickpea equivalent yield based on price of the produce.

RESULTS

The chickpea and mustard in sole stand recorded significantly higher grain yield and was followed by additive and replacement series which in turn also differed significantly from one another in chickpea + mustard intercropping system. Among intercropping systems, significantly lowest weed count and weed dry weight were observed in additive treatment followed by replacement and sole crop treatments during both the years. Among the herbicidal treatments, significantly highest grain yield was recorded in pendimethalin 1kg/ha followed by fluchloralin 1 kg/ha, quizalofop-ethyl 50 ml/ha and isoproturon 0.75 kg/ha during 2009-10 and 2010-11, respectively. Highest net returns were recorded with chickpea + Indian mustard (additive series) intercropping system Among weed-management treatments, pendimethalin 1 kg/ha showed the maximum net profit which was higher than the net return values of fluchloralin 1 kg/ha, quizalofop-ethyl 50ml/ha and isoproturon 0.75 kg/ha.

CONCLUSION

It can be concluded that, chickpea + Indian mustard in additive treatment along with application of pendimethalin applied as pre-emergence 1 kg/ha followed by fluchloralin as pre-plant incorporation 1 kg/ha proved to be the most efficient weed management practices in chickpea + Indian mustard intercropping system under the sub tropical agro ecosystem of Jammu.

Weed management in summer mothbean

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An experiment was carried out in 2010 at Regional Research Station of Bidhan Chandra Krsihi Viswavidyalaya under New Alluvial Zone of West Bengal. The treatment details were: T_1- butachlor 1250 g/ha at 1 DAS, T_2-butachlor 1250 g/ha at 1 DAS + HW at 14 DAS, T_3- quizalofop-p-ethyl 30 g/ha at 7 DAS + HW at 14 DAS, T_4-quizalofop-p-ethyle 40 g/ha at 14 DAS + HW at 21 DAS, T_5- quizalofop-p-ethyl 50 g/ha at 14 DAS + HW at 21 DAS, T_6 - HW twice at 21 DAS + 35 DAS, T_7- weedy check replicated thrice and data were analyzed in Randomized Block Design. The variety used in this experiment was *'RMO-40'*.

Results revealed that quizalofop-p-ethyl 50 g/ha at 14 DAS + hand weeding at 21 DAS showed the highest reduction of weed population, weed dry weight and was statistically at par with hand weeding twice at 21 DAS and 35 DAS. This integrated treatment recorded highest weed control efficiency (75.6%) closely followed by hand weeding twice at 21 DAS and 35 DAS (73.5%). As regards to economic yield, quizalofop-p-ethyl 50 g/ha at 14 DAS + hand weeding at 21 DAS recorded the highest yield (1.07 t/ha) which was statistically at par with hand weeding twice at 21 DAS and 35 DAS (1.03 t/ha). It also recorded the highest net return and maximum benefit: cost ratio making it economically most sound treatment in the experiment. Un-weeded control produced the lowest yield (0.34 t/ha)

Effect of irrigation and weed management on weed dynamics and yield of chickpea

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Protein starvation is causing a most serious malnutrition problem of the mankind and particularly in developing countries. Chickpea is nutritionally rich crop and contains 20 per cent protein, 61.5 per cent carbohydrates and 4.5% fat. In India, its area, production and productivity are 8.56 m ha, 7.35 mt and 859 kg/ha, respectively (AICRP 2010). Yield losses to the tune of 40-80% have been reported, if weeds are not controlled within critical growth period of crop. Oxyfluorfen 100 g/ha is known to be effective against major weeds in chickpea (Ratnam *et al.* 2011). The present investigation was carried to find out the best herbicide for weed control of chickpea.

METHODOLOGY

A field experiment was carried out during *rabi* 2013-14 and 2014-15 at Indira Gandhi Krishi Viswavidyalaya, Raipur (C.G.) to study the effect of irrigation time and weed management practices on weed dynamics and yield of chickpea variety '*JG 226*' with recommended package of practices. Experiment was conducted in split plot design, replicated thrice with two irrigation treatments (irrigation before and after sowing) in main plots and seven weed management practices (pendimethalin 1.0 kg/ha, imazethapyr 0.04 kg/ha, oxyfluorfen 0.3 kg/ha, metribuzin 0.4 kg/ha and sulfentrazone 0.3 kg/ha as pre emergence herbicides, hand weeding twice at 20 and 40 DAS and untreated control) in sub plots. Data on weed growth and yield performance were recorded following the standard procedures.

RESULTS

In weedy check, *Medicago denticulate*, *Chenopodium album* and *Melilotus alba* constituted the 77.0%, 11.5% and 11.4% ; and 81.0%, 10.6% and 8.3% during 2013-14 and 2014-15, respectively. Dry matter of weeds, weed control efficiency, seed yield and weed index remained unaltered due to irrigation time. In variance, these observations were significantly influenced due to weed management practices. Hand weeding at 20 and 40 DAS proved to be the best in minimizing the dry matter of weeds and maximizing the weed control efficiency and chickpea seed yield as well as stover yield. Among herbicidal treatments, lowest dry matter of weeds at 45 DAS was observed under oxyfluorfen 0.3 kg/ha applied as pre emergence. There was seed yield reduction to the tune of 48.3% and 47.3% during 2013-14 and 2014-15, respectively due to weed competition in unweeded check. The seed yield reduction was minimized to the extent of 12.5% and 20.7% during 2013-14 and 2014-15, respectively oxyfluorfen 0.3 kg/ha. This clearly indicated that weeds were controlled effectively under oxyfluorfen 0.3 kg/ha. The highest seed yield was recorded with hand weeding (20 and 40 DAS). Among the herbicidal treatments, oxyfluorfen 0.3 kg/ha produced maximum seed yield. The higher seed yield under hand weeding as well as pre emergence application of oxyfluorfen 0.3 kg/ha was due to the lower weed competition in terms of dry matter of weeds which in turn provided congenial environment for maximum availability of water and nutrients to the chickpea.

Table 1. Effect of irrigation time and weed management practices on weed dynamics and yield of chickpea

Treatment	Weed dry matter (g/m^2) at 45 DAS		Weed control efficiency (%)		Seed yield (t/ha)	
Irrigation	2013-14	2014-15	2013-14	2014-15	2014-15	2014-15
Irrigation before sowing	7.3(69.4)	7.2 (67.1)	51.4	52.0	2.67	1.27
Irrigation after sowing	7.2(65.3)	7.1(61.9)	50.5	50.2	3.37	1.29
Weed management practices						
Pendimethalin 1.0 kg/ha	10.45 (108.6)	10.17 (102.8)	19.6	19.7	3.86	1.15
Imazethapyr 0.04 kg/ha	11.62 (134.5)	11.35 (128.3)	3.6	4.7	4.55	0.91
Oxyfluorfen 0.3 kg/ha	3.46 (10.9)	3.29 (9.9)	91.7	92.4	2.07	1.52
Metribuzin 0.4 kg/ha	6.28 (38.6)	6.28 (38.6)	70.8	69.9	2.68	1.43
Sulfentrazone 0.3 kg/ha	6.32 (39.1)	6.12 (36.5)	70.8	71.4	3.25	1.31
Hand weeding twice	1.00 (0.0)	1.00 (0)	100.0	100.0	0.0	1.76
Untreated control	11.78 (139.6)	11.59 (135.2)	0	0.0	4.73	0.90
CD (P=0.05)	0.82	0.54	9.8	4.5	0.64	0.13

CONCLUSION

Conventional hand weeding at 20 and 40 DAS was the best method of weed management in chickpea. However, the paucity of labour availability, pre emergence application of 0.3 kg/ha was found to be the best option for alleviating the weed competition and enhancing seed yield of chickpea.

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Effect of post-emergence application of propaquizafop and imazethapyr mixture on growth, yield and economics of blackgram

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Grassy as well as broad leaved weeds compete with the black gram for residual moisture, nutrients and reduces the black gram yield to extent of 49% (Rao and Rao 2003). Imazethapyr is reported to be very effective post emergence herbicide for controlling grassy and some broad leaf weeds in *Kharif* pulses including black gram. But its efficacy has not been judged in combination with propaquizafop for wide spectrum weed control in black gram. Therefore, a comprehensive field study was undertaken to find out the suitable dose of propaquizafop and imazethapyr mixture for effective control of weeds in blackgram.

METHODOLOGY

A field experiment was undertaken during *Kharif* 2013 at live stock farm JNKVV, Jabalpur, to evaluate the efficacy of propaquizafop and imazethapyr mixture against weeds in black gram. Nine treatments comprising of five doses of propaquizafop and imazethapyr mixture (47 + 66, 50 + 70, 53 +74, 56 +78 and 100 +140 g/ha), alone application of propaquizafop 100 g/ha and imazethapyr 100 g/ha, hand weeding twice (20 and 40 DAS) including weedy check, were laidout in randomized block design with three replications. Blackgram variety 'LBG-20' was grown in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at the rate of 20, 60 and 20 kg N, P, and K/ha, respectively**.**

RESULTS

Pods/plant and seed yield differed significantly due to weed control treatments. Pods/plant and seed yield were significantly higher under weed free treatments. The application of propaquizafop + imazethapyr mixture at the lowest rate (47 + 66 g/ha) had minimum number of pods/plant, seed and stover yield which increased correspondingly with increase in application rates being the higher when propaquizafop + imazethapyr mixture was applied at highest dose (100 + 140 g/ha) closely followed by T_3 and T_4 which were statistically at par with hand weeding. The minimum gross monetary returns (64227/ha), net monetary returns (45103/ha) and B:C ratio (3.35) was recorded under weedy check treatments than the other treatments. The maximum gross monetary returns (87924/ha) were under weed free condition closely followed by propaquizafop + imazethapyr mixture at 100 +140 g/ha (87212/ha). However, net monetary returns was maximum under plot receiving combined application of propaquizafop + imazethapyr mixture at 56+78 g/ha (67,568/ha) closely followed by T_3 (67261/ha) but B:C ratio was equal (4.48) in both the treatment (T_4 and T_3 respectively).

CONCLUSION

Based on the data presented in Table1 we can conclude that post emergence application of propaquizafop + imazethapyr mixture from 53 +74 to 56+78 g/ha found more remunerative as both received higher values of NMR (Rs 67261 and 67568 /ha) and B:C ratio (4.48 and 4.48) compared to hand weeding twice and other herbicidal treatments.

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Efficacy of different herbicides on weed dry weight and yield of greengram

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Gap between actual and potential production can be minimized with the use of adequate level of inputs in proportionate manner along with other improved cultural practices. Among several factors, proper weed control management plays an important role in improving the production of arid lands by saving moisture only for crop utilization. Weeds compete with crop for space, nutrients, water and light and reduce the grain yield of mungbean by 23.5-45.8% (Punia *et al.* 2004). Imazethapyr is an imidazolinone applied as post-emergence herbicide and it has soil and foliar activity, thus allowing flexibility in application timing. Further, many times weeds emerge at a later stage, which need to be controlled with post-emergence herbicide. Therefore, there was a need to find out effective post-emergence herbicidal weed management in mungbean (Singh *et al.* 2014) and integrated it with hand weeding for obtaining better yield of green gram under arid condition of Western Rajasthan.

METHODOLOGY

A field experiment was conducted at ARS, Mandor, Jodhpur during *Kharif* 2014 to study the efficacy of post-emergence herbicides on weeds dry weight and yield of green gram. Twelve treatment combinations *viz.* pendimethalin 1000 g/ha (pre-em), pendimethalin 1000 g/ha (pre-em.) + HW (35 DAS), imazethapyr 50 g/ha (20DAS), imazethapyr 50 g/ha (20DAS) + HW (35 DAS), imazethapyr 70 g/ha (20DAS), imazethapyr 70 g/ha (20DAS) + HW (35 DAS), imazethapyr+ imazamox (pre-mix) 60 g/ha (20DAS), imazethapyr + imazamox (pre-mix) 60 g/ha (20DAS) + HW (35 DAS), imazethapyr + imazamox (pre-mix) 70 g/ha (20DAS), imazethapyr + imazamox (pre-mix) 70 g/ha (20DAS) + HW (35 DAS), T_{11}-weed free (hand weeding at 20 and 40 DAS) and weedy check were taken under Randomized Block Design and replicated thrice. The cultivar of green gram was '*GM-4*' and 15 kg N (urea) with 30 kg phosphorus (DAP) were applied at the time of sowing.

RESULTS

The outcome of the investigation revealed that when pendimethalin or imazethapyr were integrated with hand weeding minimized the weed dry weight and increased yield over sole application of pendimethalin and imazethapyr, whereas, treatment imazethapyr 50g/ha at 20DAS + HW (35 DAS) obtained highest yield (700 kg/ha) next to the weed free plot among different weed management treatments, but showed at par with rest of the treatments except pendimethalin 1000 g/ha (pre-em.) and pendimethalin 1000 g/ha (pre-em.) + HW (35 DAS). However, if the pre-mixed combination of imazethapyr + imazamox 60 g/ha (20DAS) and integrated with one hand weeding at 35 DAS resulted in higher yield (656 kg/ha) increments due to lesser weed dry weight (25 g/m^2) that might be favour to utilize resources in better way but result was at par with higher doses of imazethapyr + imazamox 70g/ha (20 DAS) + HW (35 DAS) and other weed management treatments except pendimethalin alone or combined it with one hand weeding at 35 DAS. These findings were also in conformity with the results of (Singh *et al.* 2014 and Punia *et al.* (2004).

CONCLUSION

Based on yield observation under present investigation confirmed that imazethapyr integrated with one hand weeding at 35 DAS gave highest yield of green gram.

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Efficacy of propaquizafop and imazethapyr mixture against weeds in blackgram

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Weeds compete with the black gram for growth resources (moisture, nutrients, light, space etc.) and reduces the yield to extent of 49% (Rao and Rao 2003). Imazethapyr is reportedly very effective post emergence herbicide for controlling grassy and some broad leaf weeds in *Kharif* pulses including black gram. But its efficacy has not been adjudged in combination with propaquizafop for wide spectrum weed control in black gram. Therefore, a comprehensive field study was undertaken to find out the suitable dose of propaquizafop and imazethapyr mixture for effective control of weeds in black gram.

METHODOLOGY

A field experiment was undertaken during *Kharif* 2014 at Product Testing unit, Department of Agronomy, JNKVV, Jabalpur to evaluate the efficacy of propaquizafop and imazethapyr mixture against weeds in black gram. Nine treatments comprising of four doses of propaquizafop and imazethapyr mixture (47 +70, 50 + 75, 53 + 80 and 56 + 85 g/ha), alone application of propaquizafop 100 g/ha, imazethapyr 100g/ha, pendimethalin 1500 g/ha and hand weeding twice (20 and 40 DAS) including weedy check, were laid out in randomized block design with three replications. Black gram varietyT-9 was grown in the experimental field with recommended package of practices.

RESULTS

It is obvious from the data given in the Table 1 that grassy weeds were predominant (53.02%) in black gram compared to broad-leaved (28.7%) weeds and sedges (18.2%). Among the grassy weeds, *Echinochloa colona* (29.2%) was predominant in black gram. Herbicidal treatments significantly influenced the density and dry matter production of weeds. Among the herbicidal treatments, the reduction in weed density and weed biomass was less when propaquizafop was applied with imazethapyr at low dose(47 +70 g/ha) but the values of both the parameters were increased identically with the corresponding increase in dose of both the herbicides in mixture being the higher when propaquizafop+ imazethapyr mixture was applied at 53 + 80 g/ha or at higher dose (56 + 85 g/ ha) and proved significantly superior over weedy check, other mixtures including the check herbicides propaquizafop 100 g/ ha, imazethapyr 100 g/ha and pendimethalin 1500g/ha. However, none of the herbicidal treatments whether applied alone and in combination, surpassed the manual hand weeding twice which curbed the weed growth to the extent of 99.0%. The unchecked weed growth throughout the season, caused 60.7% reduction in yield of black gram but reduction in weed growth was checked when mechanical or chemical measures were adopted. The seed yield of black gram was less when imazethapyr (100 g/ha) was applied alone or in mixture with propaquizafop at lower doses (47+70 and 50 +75 g/ha) and pendimethalin (1500 g/ha). But yield reduction was arrested appreciably (6.28-3.39%) when propaquizafop was applied along with imazethapyr at 53 + 80 g/ha or at higher dose(56 + 85 g/ha) and proved significantly superior over other treatments being at par to hand weeding twice. Seed yield including benefit-cost ratio of black gram were minimum in weedy plots where weeds were not controlled throughout the crop season. However, these parameters were improved when propaquizafop.

Table 1. Effect of different treatments on density, dry weight of weeds, yield and benefit-cost ratio of blackgram

Treatment	Dose (g/ha)	Weed density (no./m^2)	Weed control efficiency (%)	Weed index (%)	Seed yield (t/ha)	B:C ratio
Propaquizafop+ imazethapyr	47+70	12.4 (153.6)*	61.2	24.5	1.23	3.36
Propaquizafop+ imazethapyr	50+75	11.8 (139.3)	73.0	16.5	1.36	3.68
Propaquizafop+ imazethapyr	53+80	11.0 (121.6)	80.1	6.7	1.52	4.06
Propaquizafop+ imazethapyr	56+85	10.3 (106.0)	83.1	3.6	1.57	4.15
Propaquizafop	100	12.5 (156.3)	63.1	31.2	1.12	3.18
Imazethapyr	100	11.3 (128.6)	71.1	24.5	1.23	3.40
Pendimethalin	1500	12.8 (163.6)	61.2	34.3	1.07	2.78
Hand weeding	At (20&40 DAS)	4.7 (22.3)	99.0	0.0	1.63	2.98
Weedy check	-	15.9 (254.0)	-	60.7	0.64	1.98
SEm±	-	0.10	-	-	0.38	-
CD at 5%	-	0.30	-	-	1.14	-

*Values in parentheses are original.

imazethapyr and pendimethalin were applied alone (at 100, 100 and 1500 g/ha, respectively) but these were higher under propaquizafop + imazethapyr mixture applied at the rate of 53 + 80 g/ha and proved significantly super over weedy check, sole application of propaquizafop (100 g/ha), imazethapyr (100 g/ha) and pendimethalin (1500 g/ha) and lower doses of propaquizafop + imazethapyr mixture (47+70 and 50+75 g/ha), but found at par to higher dose of propaquizafop+ imazethapyr mixture (56+85 g/ha) including hand weeding twice except B:C ratio.

CONCLUSION

Post-emergence application of propaquizafop along with imazethapyr at 53 + 80 g/ha was found more economical for controlling weeds in black gram.

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Evaluation of imidazolinone herbicides in greengram and their residual effect on succeeding mustard

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Weeds in greengram cause yield reduction to the extent of 20-45 per cent. Weed emergence in greengram begins almost with the crop emergence leading to crop-weed competition from initial stages. Pre-emergence use of pendimethalin at 1.0 kg /ha has been found effective to control weeds in greengram but a residual herbicide is needed to control second flush of weeds emerging after rains. Keeping it in view, herbicides imazethapyr alone or in combination with imazamox and pendimethalin as pre-mixture with imazethapyr were tested under PPI, Pre and post emergence conditions and compared with pendimethalin alone.

METHODOLOGY

The present studies were conducted during *Kharif* and rabi 2014 at Department of Agronomy, CCS Haryana Agricultural University, Hisar under irrigated conditions. Fifteen treatments (Table.1) were tried in randomized block design replicated thrice. Post emergence herbicides were applied at 20 DAS (2-3 leaf stage of weeds) by knapsack sprayer fitted with flat fan nozzle using 300 l/ha water. Mustard crop cultivar RH 749 was planted after harvest of greengram and observations on phytotoxic effects on mustard were recorded at recorded at 30 and 45 DAS.

RESULTS

Post emergence use of imazethapyr and its combination with imazamox at 70 & 80 g/ha caused slight toxicity to greengram. Pre emergence use of pendimethalin 30% EC+ imazethapyr 2% (RM) at 1000 g/ha was very effective with 80% control of weeds even up to 45 DAS without any crop suppression (Table.1). Seed yield was maximum (1161 kg/ha) in weed free treatment which was significantly at par with all PPI and PRE treatments but higher than all post emergence treatments. Visual toxicity on mustard was more in PPI treatments (90-95%) of imazethapyr but less in PRE and POST applications of various herbicides. Hollaway *et al.* (2006) reported persistence of imazethapyr for more than 3 years.

Table 1. Effect of different herbicides on weed control in green gram and their residual carryover effect on succeeding mustard crop.

Treatment	Dose g/ha	Application time	WCE %		Crop phytotoxicity (%)		Green gram Seed yield kg/ha	B:C	Residual effect on mustard: No. of Plants/ m^2	Residual effect on mustard: Crop phytotoxicity (%)		Mustard seed yield (kg/ha)
			30 DAS	60 DAS	30 DAS	45 DAS				30 DAS	60 DAS	
Imazethapyr	70	PPI	93.1	74.6	90	0	980	2.29	1.73	90	90	1298
Imazethapyr	80	PPI	93.8	84.8	95	0	967	2.27	1.26	95	95	1168
Imazethapyr	70	PRE	73.9	50.2	15	0	919	2.15	5.7	15	7.3	2569
Imazethapyr	80	PRE	85.7	44.9	25	0	922	2.15	5.46	25	0	2340
Imazethapyr	70	3-4 leaf	21.8	30.4	70	8	603	1.41	3	70	8	2551
Imazethapyr	80	3-4 leaf	34.7	27.2	85	10	657	1.53	2.78	85	10	2180
Imazethapyr + imazamox (RM)	70	PRE	94.2	77.4	15	0	798	1.85	5	15	0	2687
Imazethapyr + imazamox (RM)	80	PRE	95.1	81.5	25	0	800	1.85	4.66	25	0	2366
Imazethapyr + imazamox (RM)	70	3-4 leaf	18.0	9.2	10	0	492	1.14	5.16	10	0	2573
Imazethapyr + imazamox (RM)	80	3-4 leaf	49.1	35.5	25	0	500	1.16	4.83	25	0	2488
Pendimethalin	1000	PRE	86.1	54.4	0	0	946	2.22	7.13	0	0	2636
Imazethapyr + pendimethalin (RM)	1000	PRE	93.5	76.9	0	0	983	2.23	6.3	0	0	2499
Weedy check	-	-	0	0	0	0	519	1.29	7.8	0	0	2575
Two hoeings	-	20 & 40 DAS	84.0	45.16	0	0	971	1.51	8.93	0	0	2589
Weed free	-	-	100	100	0	0	1161	1.45	7.01	0	0	2664
SEm±			-	-			97	-	0.64			141
LSD (P= 0.05)			-	-			285		1.88			411

Original figures in parenthesis were subjected to square root transformation ("X+1) before statistical analysis DAS= Days after sowing

CONCLUSION

Pre emergence use of pendimethalin 30% EC+ imazethapyr 2% (RM) at 1000 g/ha was very effective with 80% control of weeds even up to 45 DAS without any crop suppression and no residual effect on succeeding mustard crop.

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Studies on time of application of imazethapyr and its ready-mix combination with imazamox against weeds in blackgram

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Blackgram is one of the most important pulse crops grown in India. It suits well in the cropping system being a short duration crop and vacate the field well in time giving the opportunity to many winter crops like mustard, lentil etc. Heavy weed infestation is the dominant reason for a low yield of blackgram. Yield loss due to uncontrolled weed growth in blackgram ranges from 27-100 %.

METHODOLOGY

A field experiment was conducted at research farm of Birsa Agricultural University, Ranchi during *kharif* 2014. The treatments comprised of imazethapyr 50 g/PE (T1), imazethapyr 70 g/PE (T2), imazethapyr 80 g/PE (T3), imazethapyr 50 g/ 3-4 leaf stage (T4), imazethapyr 70 g/ 3-4 leaf stage (T5), imazethapyr 80 g/3-4 leaf stage (T6) imazethapyr + imazamox (RM Odyssy) 50g/ha PE (T7), imazethapyr + imazamox (RM Odyssy) 70g/ha PE (T8) imazethapyr + imazamox (RM Odyssy)) 80g/ha PE (T9), imazethapyr + imazamox (RM Odyssy) 50g/ha 3-4 leaf stage (T10) imazethapyr + imazamox (RM) 70g/ha 3-4 leaf stage (T11), imazethapyr + imazamox (RM) 80g/ha 3-4 leaf stage (T12) pendimethalin 1.0 kg/ha PE (T13), imazethapyr + pendimethalin (RM Vallore) 1.0 kg/ha (T14), hoeing (20 & 40 DAS) (T15) and weedy check. (T16). The experiment was laid out in randomized block design.

RESULT

Imazathapyr and its combination with other herbicides applied at different times behaved differently in suppressing different categories of weeds. Application of imazethapyr + pendimethalin (RM Vallore) 1.0 kg/ha (T14) being similar to imazethapyr + imazamox (RM) 80g/ha 3-4 leaf stage (T12) and pendimehethalin 1.0 kg/ha PE (T13) recorded reduced density of broad leaved weeds (40/m^2) as well as total weed density (77/m^2) compared to weedy check (376 and 808/m^2 respectively) at 30 DAS. Imazethapyr + pendimethalin (RM Vallore) 1.0 kg/ha (T14) similar to pendimethalin 1.0 kg/ha PE (T13), hoeing (20 & 40 DAS) (T15) at 30 DAS and also imazethapyr + imazamox (RM) 70g/ha 3-4 leaf stage (T11) at 60 DAS recorded reduced density of grassy weeds to the extent of 90% and 84% compared to respective weedy checks at 30 (344/m^2) and 60 (174/m^2) DAS. Application of imazethapyr + imazamox (RM Odyssy) 70g/ha PE (T8) was similar to imazathapyre (T2 and T3) in suppressing sedges weeds at 30 DAS while at 60 DAS pre emergence application of imazathapyre 50, 70 or 80 g/ha as well as imazethapyr 80 g/ha 3-4 leaf stage (T6) were equally effective in suppressing sedges density. Minimum weed dry matter of broad leaf weed at 30 DAS was recorded with application of Valore 1000g/ha (T14) being similar to hoeing twice at 20 & 40 DAS (T15). Grassy weed dry matter was minimum with hoeing twice at 20 & 40 DAS (T15) being similar to application of Odyssey 80g/ ha pre emergence (T9) and imazethapyr + pendimethalin (RM Vallore) 1.0 kg/ha (T14). Minimum weed dry matter of sedges was recorded with application of imazethapyr + imazamox (RM Odyssy)) 70g/ha PE (T8) and imazethapyr + imazamox (RM Odyssy)) 80g/ha PE (T9) which were similar to imazethapyre 70g/ha pre emergence (T2), imazethapyre 80g/ha pre emergence (T3), imaze. 80g/ha POE (T6), imazethapyr + pendimethalin (RM Vallore) 1.0 kg/ha (T14) and hoeing twice at 20 & 40 DAS (T15). Similar results were reported by Kundu *et al.* (2012) in soybean. At 60 DAS minimum weed dry matter of broad leaf and grassy weeds was recorded with hoeing twice at 20 & 40 DAS (T15).

CONCLUSION

Application of imazethapyr + imazamox (RM Odyssy)) 80g/ha PE (T9) was superior in reducing weed dry matter of sedges. Application of imazethapyr + imazamox (RMOdyssy) 80g/ha PE (T9) recorded maximum seed yield (1091 kg/ha), net returns (Rs.23, 364/-ha) and B:C ratio (3.23).

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Integrated weed management in field pea

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Fieldpea (*Pisum sativum* L.) is a seed legume commonly used throughout the world in human cereal grain diets. Weeds are big constraints in crop production and responsible for heavy yield losses. The available herbicides, *viz*. pendimethalin, oxyfluorfen, imazethapyr and quizalofop-ethyl are able to check the emergence and growth of annual grasses and broadleaved weeds. This study was carried out to evaluate the relative efficacy of different pre- and post-emergence herbicides when applied alone or in combination with cultural operation in field pea.

MATERIALS AND METHODS

The field experiment was conducted at Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) in *rabi* season of 2012-13 to evaluate weed management in field pea (variety 'Gujarat Dantiwada). The experiment comprised 12 treatments (Table.1). All the herbicide were applied with manually operate knapsack sprayer fitted with flood jet nozzle at a spray volume of 500 l/ha. Weed count were recorded at 30 DAS, 60 DAS and at harvest.

RESULTS

The results revealed that different weed management practices exerted significant influence on growth and yield of field pea (Table 1). The treatment T_{11} (Weed free) recorded significantly enhanced growth and yield attributes viz., plant height, plant spread, branches/plant, root nodules/plant, pods/plant, seeds/pod, seed weight/plant and 100-seed weight, and ultimately increased seed and stover yield, however it was found statistically at par with the treatments T_{10} (HW & IC at 20 & 40 DAS), T_2 (Pendimethalin 0.75 kg/ha as pre-emergence fb HW & IC at 30 DAS), T_4 (Oxyfluorfen 0.18 kg/ha as pre-emergence fb HW & IC at 30 DAS) and T_8 (Pendimethalin 0.75 kg/ha as pre-emergence fb Quizalofop 40 g/ha as post-emergence at 25 DAS). Whereas, treatment T_{12} (Unweeded check) registered significantly the lowest growth and yield of the crop. These findings are in agreement with those of Ram *et al.* (2011) and Rana *et al.* (2013).

Table 1. Growth, yield and quality of field pea under different weed management practices

Treatment	Dose (g/ha)	Plant height (cm)	Plant spread (cm)	Branches/ plant	Root nodules/ plant	Pods/ plant	Seeds /pod	Seed weight /plant (g)	100-seed weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Seed protein (%)
Pendimethalin	750	103.3	12.0	2.9	3.7	26.7	4.9	8.8	15.6	13.0	19.0	20.4
Pendimethalin *fb* HW & IC	750	111.2	13.1	3.4	4.3	30.7	5.5	10.6	16.1	14.8	21.4	20.9
Oxyfluorfen	180	103.1	11.9	2.9	3.9	24.2	4.8	7.9	15.3	12.1	18.6	20.2
Oxyfluorfen *fb* HW & IC	180	109.4	12.9	3.1	4.7	30.3	5.3	10.4	16.4	14.6	20.8	20.8
Imazethapyr	75	102.8	11.8	2.9	3.7	22.3	4.7	7.7	15.0	12.0	18.2	20.0
Quizalofop	40	102.8	11.5	2.8	3.9	21.5	4.7	7.6	14.8	11.3	17.4	19.8
Pendimethalin *fb* Imazethapyr	750 & 75	105.4	12.2	3.0	3.3	29.1	5.1	9.1	16.1	13.2	19.8	20.5
Pendimethalin *fb* Quizalofop	750 & 40	105.7	12.6	3.0	3.0	29.7	5.1	10.2	16.3	13.5	20.4	20.6
HW & IC		104.7	12.1	3.0	3.2	27.0	5.1	8.9	15.7	13.1	19.7	20.5
2 HW & IC		111.6	13.2	3.3	5.3	32.7	6.1	11.1	16.7	15.1	22.2	21.0
Weed free		118.0	15.3	3.6	6.0	34.3	6.2	12.3	17.0	16.3	22.9	21.2
Unweeded check		96.7	10.4	2.5	2.7	21.4	4.3	7.1	14.4	10.9	16.0	19.2
S.Em.±		3.1	0.7	0.2	0.2	1.4	0.2	1.0	0.5	1.0	0.7	0.6
CD (P=0.05)		8.9	2.0	0.5	0.5	4.0	0.7	3.0	1.5	2.9	2.0	NS

CONCLUSION

Application of pendimethalin 0.75 kg/ha as pre-emergence *fb* HW & IC at 30 DAS or oxyfluorfen 0.18 kg/ha as pre-emergence *fb* HW & IC at 30 DAS effectively manages weeds in fieldpea.

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Integrated weed management in greengram

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Competition with the weeds leads to 30 to 80 % reduction in grain yield of greengram during summer and *kharif* seasons while 70-80% during *Rabi* season respectively. Initial 45 days period is considered to be critical period with respect to crop weed competition in green gram (Singh *et al*. 1996), and hence, inhibition of weed growth is essential for better crop yield. Chemical weed control is not common and the use of herbicides may prove uneconomical due to low yield potential of greengram. Keeping this in view an experiment conducted to study the 'Effect of integrated weed management in *rabi* greengram'.

METHODOLOGY

A field experiment was conducted during *rabi* season of 2010-2011 at the College Farm, Navsari Agricultural University, Navsari (Gujarath). Eighteen treatment combinations consisting of three varieties viz., Meha (V_1), CO-4 (V_2) and RTM-1 (V_3) and six weed management treatments, *viz*. Unweeded control (W_{1-}), Weed free up to harvest (2 H.W. & hoeing) (W_2), Pendimethalin 1.00 kg/ha + 1 H.H. at 45 DAS (W_3), Imazythapyr 0.1 kg/ha at 15 DAS (W_4), Alachlor 1.00 kg/ha + 1 H.H. at 45 DAS (W_5) and Quizalofop-p-ethyl 0.05 kg/ha at 15 DAS (W_6) were tested by employing factorial randomized block design (FRBD) with three replications. The observations on weed flora, dry weight of weeds at different growth stages as well as yield were taken from the net plot.

RESULTS

Significantly the highest seed yield and haulm yield were recorded under treatment of weed free up to harvest (2 H.W. & H.H.) being at par with treatment having application of pendimethalin 1.00 kg/ha + 1 H.H at 45 DAS (W_3) and alachlor 1.00 kg/ha + 1 H.H at 45 DAS (W_5). The remarkable increase in seed and haulm yield under the treatments weed free up to harvest (2 H.W. and H.H.) (W_2), pendimethalin 1.00 kg/ha + 1 H.H at 45 DAS (W_3) and alachlor 1.00 kg/ha + 1 H.H at 45 DAS (W_5) might be due to effective control of weeds in terms of reduced weed population and dry weight of weeds. These findings are in close agreement with those reported by Raj *et al.* (2010).

Table 1. Weed population/m^2 at 30, 45, 60 DAS and at harvest as influenced by various weed management treatments in *rabi* greengram

Treatment	Weed popl. at 30 DAS			Weed popl. at harvest			Dry weight of weeds		Seed yield (kg/ha)	Haulm yield (kg/ha)	HI (%)
	Monocot	Dicot	Sedge	Monocot	Dicot	Sedge	60 DAS (g/m^2)	At harvest (kg/ha^1)			
Varieties (V)											
V_1	3.96	4.13	4.22	5.45	5.53	5.55	8.95	33.18 (1101.16)	950.00	1760.22	35.01
V_2	3.93	4.08	4.11	5.24	5.73	5.47	8.61	33.03 (1091.38)	964.61	1843.33	34.92
V_3	4.03	3.97	4.29	5.46	5.77	5.50	8.70	32.87 (1080.49)	893.33	1740.22	34.34
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management (W)											
W_1	5.38	5.54	5.38	10.41	11.28	10.97	20.33	66.33 (4374.39)	504.33	876.44	36.98
W_2	2.91	3.03	3.04	3.22	3.77	3.79	5.17	16.67 (277.90)	1125.44	2115.00	34.77
W_3	3.17	3.28	3.19	3.91	4.15	4.30	5.97	19.37 (375.56)	1094.11	2032.44	35.00
W_4	4.31	4.46	4.46	4.94	5.08	4.62	7.25	23.12 (535.02)	919.22	1876.11	32.90
W_5	3.58	3.38	4.21	4.57	4.62	4.67	6.50	20.79 (443.60)	1065.44	1953.11	35.54
	4.49	4.66	4.77	5.24	5.14	4.68	7.32	23.46 (550.58)	917.33	1843.48	33.34
LSD (P=0.05)	0.39	0.41	0.44	0.41	0.46	0.48	0.61	96.25	92.54	174.18	NS

Data of weed population are after $\sqrt{x}$ transformed value

CONCLUSION

Based on the results of the field experimentation, it seems quite logical to conclude that higher yield of *rabi* greengram on vertisols of South Gujarat can be obtained by using either Meha, CO-4 or RTM-1 variety of *rabi* greengram and by keeping them weed free by two hand weedings and hoeings or by pre-emergence application of pendimethalin 1 kg/ha coupled with one hand hoeing at 45 days after sowing.

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Weed management in kabuli chickpea

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Weeds pose severe competition to chickpea crop under rainfed as well as irrigated conditions. Losses in seed yield due to weeds have been estimated to 40-70% (Vaishya *et al.* 1999). Weeding is not affordable due to scarcity of labours during peak period and also higher rates of wages. In view of this present study was undertaken to study the effect of herbicides alone and in combination with mechanical weed control measures in kabuli chickpea.

METHODOLOGY

A field experiment was conducted during *Rabi* 2011-2012 at Agronomy Farm, College of Agriculture, Nagpur, Maharashtra to study the effect of different weed control methods on growth and yield of chickpea. The experiment was laid out in Randomized block design with ten treatments (Table.1) replicated thrice. Chickpea variety '*PKV Kabuli-2*' was sown with recommended package of practices. Grain yield was recorded after harvest of crop and various economic parameters were worked out.

RESULTS

Oxyfluorfen 100 g/ha +one hoeing at 30 DAS (T_8) recorded significantly lowest dry matter accumulation (1.84 g) which was found superior over other treatments, but was at par with Pendimethalin at 1.0 kg/ha + hoeing at 30 DAS (T_9), Quizalofop ethyle at 50 g/ha at 10 DAS+ hoeing at 30 DAS (T_{10}) and Oxyflurofen at 100 g/ha (T_3). Highest weed control efficiency was recorded with the treatment of one hoeing and one hand weeding at 30 DAS (T_2) followed by treatment of Oxyfluorfen at 100 g/ha + hoeing at 30 DAS (T_8). These results were in agreement with the findings of Kachhadiya *et al.* (2009). One hoeing and one hand weeding at 30 DAS (T_2) produced significantly higher grain yield (1.28 kg/ha) and straw yield (1.56 kg/ha) over all the other treatments and was at par with Oxyflurofen at 100 g/ha +one hoeing at 30 DAS (T_8). Beneficial effect of pre emergence application of Oxyfluorfen at 100 g/ha in combination with hoeing might be due to broad spectrum control of monocot and dicot weeds that helped in increasing the availability of soil moisture and nutrients to the chickpea.

Table 1. Mean weed dry matter, weed control efficiency, grain and straw yield and economics of chickpea as influenced by various treatments

Treatment	Weed control efficiency (%) 20 DAS	40 DAS	60 DAS	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	GMR (`. ha^{-1})	NMR (`. ha^{-1})	B:C ratio
T_1-Control (weedy)	-	-	-	742	1067	41942	21819	2.08
T_2-Weed free check (one hoeing at 30 DAS and one hand weeding at 30 DAS)	1.86	97.24	96.12	1280	1565	70120	47847	3.15
T_3-Oxyflurofen @ 100 g.ha-1 (Pre)	92.65	89.40	84.26	1159	1416	63466	42381	3.01
T_4-Pendimethalin @ 1.0 kg ha-1 (Pre)	89.70	86.65	80.31	1134	1376	62051	39976	2.81
T_5-Quizalofop ethyle @ 50 g ha-1 at 10DAS	80.19	75.99	66.38	1121	1310	60922	39109	2.79
T_6-Hoeing at 30 DAS	3.73	55.63	37.24	1015	1250	55677	35234	2.72
T_7-Hand weeding at 30 DAS	5.59	97.23	96.16	1050	1307	57721	35798	2.63
T_8-Oxyfluorfen @ 100 g.ha-1 + hoeing at 30 DAS	94.63	94.03	92.12	1253	1487	68294	46889	3.19
T_9-Pendimethalin @ 1.0 kg.ha-1+ hoeing at 30 DAS	94.22	92.50	89.05	1203	1434	65593	43198	2.93
T_{10}-Quizalofop ethyle @ 50 g.ha-1 at 10DAS+ hoeing at 30 DAS	92.54	90.31	86.75	1172	1417	64078	41945	2.89
SE(m)±	-	-	-	23.86	35.53	3970.75	2575.46	-
CD at 5%	-	-	-	70.79	105.42	11798.14	7652.38	-

Note- Figures in parenthesis are original values whereas above figures are "x+0.5 transformed values

CONCLUSION

Integrated weed management through pre emergence application of Oxyfluorfen at 100 g/ha in combination with one hoeing at 30 DAS found suitable for better control of weeds in kabuli chickpea.

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Evaluation of post-emergence herbicides in greengram

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Green gram (*Vigna radiata*) is an important pulse crop of India which is cultivated in nearly 3.35 million hectare area with the production of 1.82 million tones and average productivity of 512 kg/ha. Among the various factors responsible for low yields of green gram, severe infestation of weeds during the early crop growth period is one of the constraints. Hand weeding is a traditional and effective method of weed control, but untimely rains, unavailability of labour at peak time and increasing labour cost are the main limitations of manual weeding. Under such situations, the only alternative that needs to be explored is the use of suitable herbicides which may be effective and economically viable (Guptha *et al.* 1990).

METHODOLOGY

A field experiment was conducted during two consecutive *Kharif* seasons of 2013 and 2014 at SK Rajasthan Agricultural University Farm, Bikaner to test the efficacy of different weed control measures against weeds. There were ten treatments (Table.1) arranged in randomized block design (RBD) with three replications. Above ground weed biomass was sampled at 60 DAS using a quadrant of 0.5 x 0.5 m. Plant material was dried at 65C for 48 hrs before determining dry weight. Standard methods were followed for weed, crop and economics analysis.

Table 1. Effect of weed control measures on weeds and green gram crop yield and its economics

Treatment	Weed /m^2	WDW (gm^2)	Grain yield (kg/ha)			Net return	B:C
	Total	Total	2013	2014	Mean	(`)	ratio
Pendimethalin 1000g/ha (PE)	5.63(31.33)	34.00	741	757	749	20433	2.23
Imazethapyr 50g/ha. (3-4 leaf stage)	3.66(13.00)	5.00	757	762	760	21128	2.30
Imazethapyr 70g/ha. (3-4 leaf stage)	3.12(9.33)	2.67	747	749	748	20243	2.22
Imazethapyr + pendamethaline (2+30 pre mix) 800g/ha. (PE)	1.90(3.33)	1.00	857	882	870	25852	2.51
Imazethapyr + pendamethaline (2+30 pre mix) 900g/ha. (PE)	1.46(1.67)	0.67	827	885	856	25690	2.48
Imazethapyr + pendamethaline (2+30 pre mix) 1000g/ha (PE)	0.88(0.33)	0.33	816	880	848	25223	2.43
Imazethapyr + imazemox (35+35 pre mix) 60g/ha (20DAS) (PoE)	2.47(5.67)	4.00	753	763	758	21763	2.39
Imazethapyr + imazemox(35+35 pre mix) 70 g/ha (20DAS) (PoE)	1.56(2.00)	0.67	730	768	749	21977	2.40
Weed free (hand weeding at 20& 40 DAS)	0.71(0.00)	0.00	865	940	903	27680	2.56
Weedy check	8.34(69.33)	56.67	623	608	616	14842	2.00
SEm	0.23	1.53	12	31	-	1395	0.08
CD at 5%	0.67	4.54	35	92	-	4144	0.24

RESULTS

Imazethapyr + pendimethalin (pre-mix) at 800 g/ha as pre-emergence provided effective control of both grassy and broad leaved weeds and created weed free conditions throughout the growing season and recorded significantly higher yield attributes and yield of greengram which were statistically at par with its higher doses. In post emergence herbicides imazethapyr alone at 50 g/ha applied at 3-4 leaf stage significantly reduced the density and dry weight of broad leaf weeds as compared to weedy check and Pendimethalin at 1000 g/ha as pre-emergence while imazethapyr+imazamox a 60 g/ha significantly controlled both grassy and broad leaved weeds. The results further revealed that application of imazethapyr + imazamox at 60 g/ha and Imazethapyr alone at 50 g/ha significantly increased the yield attributes and seed yield of greengram compared to weedy check but statistically at par with pendimethalin at 1000 g/ha.

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Integrated weed management in clusterbean in arid region

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Clusterbean commonly known as 'Guar' is an important drought hardy leguminous crop which is basically cultivated mostly in the arid and semiarid regions of tropical India during *kharif* season. Being a rainy season crop, it suffers badly due to severe competition by mixed weed flora. Yield reduction due to weed infestation is to the tune of 53.7% has been observed (Saxena *et al.* 2004). Therefore, weed control needs to be restored to exploit the yield potential of this crop.

METHODOLOGY

A field experiment was conducted during *kharif*, 2013 at the Instructional Farm, Agricultural Research Station, S.K. Rajasthan Agricultural University, Bikaner. The 16 treatment combinations (Table.1) were laid out in randomized block design and replicated three times. Weed free treatment was achieved by hand weedings whenever weeds appear. Weed control efficiency and weed index was calculated by standard formulae. For economic study prevailing market price was used for different outputs and inputs.

RESULTS

In experimental field clusterbean was heavily infested with mixed flora of broad leaved and grassy weeds chiefly consisted of *Amaranthus spinosus* L., *Euphorbia hirta* L., *Aristida depressa* L., *Portulaca oleracea* L., *Digera arvensis* Forsk., *Gisekia poiedious*, *Cenchrus biflorus* L., *Tribulus terrestris* L., *Aerva tomentosa* Forsk., *Corchorus tridense* L., *Eleusine verticillata* L., *Eragrostis tennela* and *Trianthema portulacastrum* L. All the weed control treatments significantly reduced weed density and dry weight total weeds at harvest over weedy check. Weed management practices adopted during the experimentation resulted in significant increase in growth and yield. The maximum net returns of Rs 54, 608 /ha was obtained with weed free treatment followed by Rs 53, 277/ha with pendimethalin 0.75 kg/ha alone. Maximum B:C ratio was also obtained with pendimethalin 0.75 kg/ha alone (3.88) followed by weed free treatment (3.81) over weedy check.

Table 1. Effect of weed control measures on Weeds, Weed control efficiency, Weed index, Grain yield, net returns and B: C ratio in clusterbean.

Treatment	Weed density (m^{-2})	WDW (g m^{-2})	WCE (%)	Weed index (%)	Grain yield (kg ha^{-1})	Net returns (` ha^{-1})	B: C ratio
Weedy check(W_1)	10.46(108.96)	91.94	0.00	48.35	767.0	21527	2.28
Weed free(W_2)	0.71(0.00)	0.00	100.00	0.00	1485.1	54608	3.81
Pendimethalin 0.75 kg ha^{-1} PE(W_3)	2.49(5.69)	3.95	99.62	3.03	1439.9	53277	3.88
W_3 + HW 30 DAS(W_4)	2.29(4.67)	4.90	95.38	2.69	1445.0	52347	3.64
Imazethapyr 40 g ha^{-1} 25 DAS(W_5)	4.72(21.75)	17.51	75.38	11.12	1319.8	47226	3.56
Imazethapyr 50 g ha^{-1} 25 DAS(W_6)	4.54(20.12)	16.72	76.87	10.54	1328.5	47890	3.59
Imazethapyr 60 g ha^{-1} 25 DAS(W_7)	4.43(19.16)	16.62	77.93	10.24	1333.0	48049	3.60
W_5 + HW 40 DAS(W_8)	1.88(3.05)	2.71	97.35	7.87	1368.2	48407	3.44
W_6 + HW 40 DAS(W_9)	1.66(2.26)	2.18	98.20	7.13	1379.1	48818	3.47
W_7 + HW 40 DAS(W_{10})	1.47(1.67)	1.78	98.85	6.59	1387.2	49287	3.49
Imazethapyr+Imazamox40 g ha^{-1} 25 DAS(W_{11})	2.49(5.68)	6.80	87.73	8.96	1352.0	48997	3.65
Imazethapyr+Imazamox60 g ha^{-1} 25 DAS(W_{12})	2.46(5.55)	6.84	88.42	8.73	1355.3	48995	3.65
Imazethapyr+Imazamox80 g ha^{-1} 25 DAS(W_{13})	2.44(5.39)	7.22	88.67	8.54	1358.1	49235	3.67
W_{11} + HW 40 DAS(W_{14})	2.17(4.22)	5.97	98.20	5.58	1402.2	49964	3.52
W_{12} + HW 40 DAS(W_{15})	1.99(3.44)	5.39	98.85	5.16	1408.3	50444	3.55
W_{13} + HW 40 DAS(W_{16})	1.78(2.65)	4.85	99.49	4.64	1416.1	50761	3.56
SEm±	0.42	1.77			96.93	4399.44	0.23
CD (P=0.05)	1.22	5.13			279.97	12707	0.66

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Efficacy of imazethapyr on weed growth and yield of blackgram in latericsoil of West Bengal

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Blackgram is an important pulse crop of West Bengal. Heavy weed infestation is the main reason for low productivity of blackgram (Aggarwal *et al.* 2014). At present, pre-emergence herbicides are available and recommended to manage weeds in blackgram. Recently the post emergence herbicide imazethapyr is being marketed with the assurance of selective broad spectrum control of weeds in blackgram. Since the information on the effect of the herbicide under lateric soil of West Bengal is meager, the present investigation was carried to findout the efficacy of post-emergence application of imazethapyr at different doses against weeds and yield of blackgram.

METHODOLOGY

A field experiment was carried out during post *kharif* season of 2014 at Agricultural Farm of Rathindra Krishi Vigyan Kendra, Institute of Agriculture, Visva-Bharati University, Sriniketan, West Bengal to study the efficacy of early post emergence herbicide imazethapyr against broad spectrum weeds in blackgram. Eight treatments (Table.1) were replicated thrice in a randomised block design. Blackgram variety '*WBU-108'* (Sarada) was used in the experiment. The data on weed density and dry weight of weeds/m were recorded at different growth stages crop. Weed control efficiency (%) was computed using the dry weight of weeds. Seed yield of blackgram along with yield components were recorded at harvest.

RESULTS

The lowest count and dry weight of weeds was registered under hand weeding twice at 20 and 40 DAS. Among the herbicidal treatments higher doses of imazethapyr (100 and 125 g/ha) registered the lowest density and dry weight of weeds which were statistically at par with lower dose *i.e.* imazethapyr 75 g/ha. Post emergence application of imazethapyr at 75 g/ha at 20 DAS registered the higher weed control efficiency at 45 DAS. Similar findings were also reported by Aggarwal *et al.*(2014) and Nirala *et al*. (2012). Imazethapyr at 75 g/ha at 20 DAS registered the lowest weed index (1.59%) among the herbicidal treatments. This clearly indicated that weeds were controlled effectively under imazethapyr at 75 g/ha. The highest seed yield (1036 Kg/ha) was recorded with hand weeding (20 and 40 DAS) which was statistically at par with imazethapyrat 75 g/ha at 20 DAS (1007 kg/ha) followed by higher doses of imazethapyr. Effective and timely management of broadspectrum weeds by these treatments facilitated better crop growth and increased seed yield in blackgram.

Table 1. Effect of treatments on density and dry weight of weeds, weed control efficiency, weed index, yield components and yield of blackgram

Treatment	Weed density (no. /m^2) at 45 DAS	Weed dry weight (g /m^2) at 45 DAS	Weed control efficiency (%)	Weed index (%)	No of pods per plant	No of seeds per pod	Test weight (g)	Seed yield (kg/ha)
Imazethapyrat 50 g ha^{-1}	4.26 (17.67)	2.79 (7.30)	76.49	15.16	14.7	7	32.07	879
Imazethapyrat 75 g ha^{-1}	2.48 (5.67)	1.34 (1.29)	95.84	2.84	17.0	7	33.98	1007
Imazethapyr at 100 g ha^{-1}	2.35 (5.00)	1.25 (1.07)	96.54	8.59	16.0	6	32.49	947
Imazethapyrat 125 g ha^{-1}	2.12 (4.00)	1.18 (0.88)	97.16	10.30	16.0	6	32.55	930
Pendimethalin at.750 g ha^{-1}	4.95 (24.00)	3.39 (11.01)	64.53	17.37	15.0	6	32.13	856
Butachlorat 1000 g ha^{-1}	4.02 (15.67)	2.35 (5.01)	83.88	11.49	16.3	6	32.43	917
Hand weeding twice	0.71 (0)	0.71 (0)	100	0	18.3	6	33.49	1036
Unweeded control	7.29 (52.67)	5.62 (31.05)	0	31.35	12.0	7	31.97	712
LSD (P=0.5)	0.41	0.24	-	-	1.6	NS	NS	78

Figures in parentheses are the original values. The data was transformed to SQRT (x + 0.5) before analysis.

CONCLUSION

Early post-emergence application of imazethapyr at 75 g/ha at 20 DAS appeared to be a promising and effective weed management practice for managing broad spectrum weeds and obtaining higher seed yield of post *kharif* blackgram.

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New post-emergence herbicidal effects on weed parameters and seed yield of blackgram

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Regardless of the composition, weeds compete with black gram for resources, especially during establishment and early growth stages, affecting its growth and yield. The scope for application of either pre-sowing or pre emergence herbicides under rice fallow conditions is also very little. The potentiality of new generation herbicides as a mean of weed management in zero till rice fallow blackgram has not been fully explored. Hence the present study was designed to examine the influence of new generation herbicides at variable doses on weeds and seed yield of rice fallow blackgram.

METHODOLOGY

A field experiment was conducted for efficient weed management in zero till sown rice fallow black gram at Agricultural College & Research Institute, Madurai during *rabi* season, 2005. Black gram variety ADT 3 released by Tamil Nadu Agricultural University was selected for this study. The experiment consists of 11 treatments (Table.1) laid out in randomized block design and replicated thrice. All post emergence herbicides were sprayed at 15 days after sowing (DAS). Data on parameters like weed density, weed dry matter production, weed control efficiency and seed yield were recorded.

RESULTS

Application of fenoxaprop-p-ethyl 75 and 100 g/ha and cyhalofop butyl 100 and 125 g/ha recorded higher weed control rating of 9.0 (Table 1). Application of fenoxaprop-p-ethyl 100 g/ha recorded lower weed density, dry matter production and higher weed control efficiency and it was comparable with cyhalofop butyl 100 g/ha, 125 g/ha and fenoxaprop-p-ethyl 75 g/ha. This was in accordance with the findings of Kurchania *et al.* (1999). Imazethapyr 100 g/ha was found to be the next best treatment to reduce weed density and dry matter production. Post emergence application of fenoxaprop-p-ethyl 75 g/ha resulted in higher seed yield of 920 kg/ha. However, it was comparable with fenoxaprop-p-ethyl 100 g/ha, cyhalofop butyl 100 and 125 g/ha. This might be due to timely control of weeds during critical period of crop weed competition in rice fallow blackgram. The highest B:C ratio of 2.73 was recorded with the application of fenoxaprop-p-ethyl at 75 g/ha.

Table 1. Weed growth, yield and economics of rice fallow black gram as influenced by weed control treatments

Treatment	Weed control rating (WCR)	Weed density (no./m^2)	Weed dry matter (kg/ha)	Weed control efficiency (%)	Seed yield (kg/ha)	Cost of cultivation (`)	B:C ratio
Fenoxaprop-p-ethyl 50 g/ha	8.00	3.97 (0.776)	3.18	92.29	826	6333	2.60
Fenoxaprop-p-ethyl 75 g/ha	9.00	2.34 (0.637)	1.87	95.45	920	6718	2.73
Fenoxaprop-p-ethyl 100 g/ha	9.00	2.29 (0.632)	1.83	95.55	882	7101	2.48
Imazethapyr 50 g/ha	7.33	24.06 (1.416)	19.27	53.28	710	6245	2.27
Imazethapyr 75 g/ha	8.33	22.47 (1.388)	17.99	56.36	765	6607	2.31
Imazethapyr 100 g/ha	8.67	20.95 (1.360)	16.78	59.32	773	6970	2.22
Cyhalofop butyl 75 g/ha	7.67	4.02 (0.779)	3.22	92.19	823	6825	2.41
Cyhalofop butyl 100 g/ha	9.00	2.35 (0.638)	1.88	95.43	889	7250	2.45
Cyhalofop butyl 125 g/ha	9.00	2.31 (0.634)	1.85	95.51	875	7675	2.28
Hand weeding	-	24.28 (1.419)	19.44	52.85	695	7036	1.97
Unweeded check	-	51.50 (1.728)	41.25	-	375	5460	1.37
LSD (P=0.05)		0.008	1.08		46		

Data in parenthesis are log(x+2) transformed values

CONCLUSION

The investigation conclusively proved that post emergence application of either fenoxaprop-p-ethyl 75 and 100 g/ha or cyhalofop butyl 100 and 125 g/ha at 15 days after sowing effectively controlled the weeds and increased the seed yield of rice fallow black gram. However, high monetary return was obtained with application of fenoxaprop-p-ethyl 75 g/ha.

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Effect of weed control measures on weed control efficiency and weed index in clusterbean

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Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] commonly known as guar, is an important drought hardy leguminous crop. Clusterbean is mostly cultivated in arid and semiarid regions of tropical India during *kharif* season. In Rajasthan, total area under clusterbean was 30.94 lakh hectares, production was 18.46 lakh tones contributing 83.83 per cent of total clusterbean production and the productivity is 597 kg/ha (www.krishi.rajasthan.in, 2011). Being a rainy season crop, it suffers badly due to severe competition by mixed weed flora. Yield reduction due to weed infestation is to the tune of 53.7% has been observed (Saxena *et al.* 2004). Therefore, weed control needs to be restored to exploit the yield potential of this crop.

METHODOLOGY

An experiment was conducted during *Kharif*-2013 to find out suitable herbicides for weed management in clusterbean at Instructional Farm of Agriculture Research Station, S.K. Rajasthan Agricultural University, Bikaner. The experiment comprises of 16 treatment combinations (Table. 1) replicated thrice in randomized block design. Herbicides pendimethalin as pre-emergence, imazethapyr and imazethapyr+imazamox as post-emergence were applied as per treatment. Weed control efficiency and weed index was calculated by standard formulae.

RESULTS

Weed control efficiency at 60 DAS based on weed density fluctuated to a great extent under the influence of various weed control treatments. Highest weed control efficiency was recorded under weed free treatment (100%) followed by pendimethalin 0.75 kg/ha alone, pendimethalin 0.75 kg/ha + hand weeding at 30 DAS, Among the herbicides the lowest total weed control efficiency of 75.38% was recorded with application of imazethapyr 40 g/ha.

Highest weed index was recorded under weedy check (48.35%). Among the herbicides the highest weed index of (11.12%) was recorded with application of imazethapyr 40 g/ha. Data further indicate that the lowest weed index was recorded under pendimethalin 0.75 kg/ha + hand weeding at 30 DAS (2.69%) followed by pendimethalin 0.75 kg/ha alone, imazethapyr 40 g/ha.

Table1. Effect of weed control measures on weed control efficiency and weed index in clusterbean

Treatment	Weed control efficiency (%)	Weed index (%)
Weedy check(W_1)	0.00	48.35
Weed free(W_2)	100.00	0.00
Pendimethalin 0.75 kg/ha PE(W_3)	99.62	3.03
W_3 + HW 30 DAS(W_4)	95.38	2.69
Imazethapyr 40 g/ha 25 DAS(W_5)	75.38	11.12
Imazethapyr 50 g/ha 25 DAS(W_6)	76.87	10.54
Imazethapyr 60 g/ha 25 DAS(W_7)	77.93	10.24
W_5 + HW 40 DAS(W_8)	97.35	7.87
W_6 + HW 40 DAS(W_9)	98.20	7.13
W_7 + HW 40 DAS(W_{10})	98.85	6.59
Imazethapyr+Imazamox 40 g/ha 25 DAS(W_{11})	87.73	8.96
Imazethapyr+Imazamox 60 g/ha 25 DAS(W_{12})	88.42	8.73
Imazethapyr+Imazamox 80 g/ha 25 DAS(W_{13})	88.67	8.54
W_{11} + HW 40 DAS(W_{14})	98.20	5.58
W_{12} + HW 40 DAS(W_{15})	98.85	5.16
W_{13} + HW 40 DAS(W_{16})	99.49	4.64

HW= Hand weeding

DAS=Day after sowing

CONCLUSION

It was concluded that all weed control treatments are found equally effective in controlling weeds. Post-emergence application of herbicides alone and in combination with one hand weeding can be used to control weeds as an alternative of pre-emergence herbicide.

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Effect of weed management practices on yield and economics of blackgram

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Blackgram is an important pulse crop in India In Madhya Pradesh, blackgram is grown in 5.71 lakh hectares area, production is 1.48 lakh tones and productivity 269 kg/ha. Depending on the nature, density and period of occurrence, weeds can cause losses of seed yield of blackgram varying from 41.6-64.1% (Chand *et al*. 2004, Singh 2011). The control of weeds during critical period of crop weed competition is very important to avoid yield loss. With the reference to availability of new molecules and ready mixture of herbicide, the experiment was conducted to study the effect of imazethapyr and its combination with imazamox on weeds in blackgram.

METHODOLOGY

A field experiment was conducted at the Research Farm of the Department of Agronomy, College of Agriculture, Gwalior (M.P.) during the *Kharif* 2014. The field experiment was laid out in a randomized block design (RBD) with three replications having twelve weed management treatments (Table.1).

RESULTS

The significantly lowest weed dry weight was recorded with treatment T_{11} (two hand weeding at 20 and 40 DAS) at all the stages. Among herbicidal treatments, lower weed dry weight and higher crop yield were obtained under pre-mix application of imazethapyr + imazamox 80 g/ha as post – emergence, followed by pre-mix application of pendimethalin + imazethapyr 1000 g/ha as pre-emergence. Post emergence application of imazethapyr+ imazamox (pre-mix) 80 g/ha (PoE) gave highest net return of Rs. 33,262/ha closely followed by pendimethalin + imazethapyr (pre-mix) 1000 g/ha PE, imazethapyr 80 g/ha PoE and two hand weeding at 20 and 40 DAS recording Rs. 32,762, Rs. 30690 and Rs. 30682 /hectare, respectively.

Table 1. Effect of different weed control measures on weed dry weight, WCE, WI, seed, stover and biological yield (kg/ha), net income and benefit cost ratio of blackgram

Treatment	Dry weight of weeds (g/m^2) at 60 DAS	WCE (%) 60 DAS	Weed index (%)	Seed yield kg/ha	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net income (`/ha)	B:C ratio
T_1 Imazethapyr 70 g/ha PE	43.07	66.95	32.93	664	2005	2669	24.87	18738	2.18
T_2 Imazethapyr 80 g/ha PE	38.23	70.66	25.05	742	2188	2930	25.38	22604	2.41
T_3 Imazethapyr 70 g/ha PoE	19.47	85.06	18.48	807	2331	3138	25.73	26127	2.65
T_4 Imazethapyr 80g/ha PoE	12.07	90.74	9.29	898	2578	3477	25.83	30690	2.91
T_5 Imazethapyr + Imazamox (pre-mix) 70 g/ha PE	53.97	58.58	43.43	560	1784	2344	23.89	12712	1.77
T_6 Imazethapyr+ Imazamox (pre-mix) 80 g/ha PE	48.27	62.96	39.49	599	1849	2448	24.50	14449	1.86
T_7 Imazethapyr + Imazamox (pre-mix) 70 g/ha PoE	14.13	89.15	14.55	846	2422	3268	25.90	27482	2.66
T_8 Imazethapyr + Imazamox (pre-mix) 80 g/ha PoE	5.92	95.46	2.63	964	2682	3646	26.44	33262	2.98
T_9 Pendimethalin 1000 g/ha PE	59.86	54.06	46.06	534	1732	2266	23.48	11559	1.71
T_{10} Pendimethalin +Imazethapyr (pre-mix) 1000 g/ha PE	9.17	92.96	6.67	924	2630	3555	26.00	32762	3.14
T_{11} Two hand weeding 20 and 40 DAS	4.87	96.27	-	990	2708	3698	26.78	30682	2.48
T_{12} Weedy check	130.30	-	61.82	378	1484	1862	20.21	5626	1.39
LSD (P=0.05)	5.73			82	168	190	0.85		

PE – Pre-emergence; PoE – Post-emergence; DAS – Days after sowing; WCE—Weed control efficiency; WI—Weed index

CONCLUSION

Manual weed control gives higher seed yield, but in term of net return and B:C ratio it is not profitable because of higher cost. Therefore, pre-mix application of pendimethalin + imazethapyr 1000 g/ha as pre-emergence or pre-mix application of imazethapyr + imazamox 80 g/ha as post-emergence are most economical and effective weed management practices for controlling the narrow and broad leaf weeds in black gram under sandy clay loam soils of northern M.P.

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Efficacy of different pre- and post-emergence herbicides in pigeonpea

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Pigeonpea is recommended for cultivation mainly for *kharif* under Vidarbha condition. Among various constraints in crop production weeds are the major problems but weed control is generally neglected. Hence, weed management is an important factor to increase the crop productivity. With an aim to monitor the efficacy of different pre and post emergence herbicide molecules, the present investigation was undertaken at Akola (MS) in rainfed conditions.

METHODOLOGY

A field investigation entitled 'Efficacy of different pre emergence and post emergence herbicides in pigeonpea', was carried out at, Akola (MS) during the *Kharif* 2011. The experiment was laid out in randomized block design with nine treatments replicated thrice (Table. 1). Pigeonpea (PKV-TARA) was sown on 6th July 2011 at 90 x 20 cm spacing with 25:50:0 NPK kg ha^{-1}.

RESULTS

Highest weed control efficiency was recorded in Pendimethalin + HW treatment (72.53 %) followed by Imazethapyr + Quazalofop ethyl at 20 DAS *fb* HW treatment (72.32 %) and Imazethapyr + HW at 50 DAS treatment (71.98 %). Amongst herbicidal treatment higher weed control efficiency was observed in Pendimethalin as PE *fb* Paraquat at 56 DAS, Imazethapyr at 20 DAS *fb* Paraquat at 56 DAS. This might be due to better control of weeds by various herbicides integrated with hand weeding and combination of pre and post emergence herbicides. Chauhan (1992) and Singh (2007) reported similar observations that application of pendimethalin and other chemicals alone and integrated with hand weeding gives effective control of weeds.

Pendimethalin *fb* HW (T_2) showed minimum weed index (6.36%), followed by Imazethapyr + Quazalofop ethyl at 20 DAS *fb* HW treatment (8.08%), Imazethapyr *fb* HW at 50 DAS treatment (9.91%) and among different herbicidal treatment Pendimethalin as PE *fb* Paraquat at 56 DAS treatment (14.04 %), Imazethapyr at 20 DAS *fb* Paraquat at 56 DAS treatment (18.00 %). Arvind Kumar (1998) also observed that largest weed dry matter, greatest weed contain efficiency for pendimethalin + one hand weeding in pigeonpea + sorghum intercropping.

CONCLUSION

Maximum weed control efficiency and minimum weed index was recorded with pre emergence application of Pendimethalin at 0.75 kg/ha PE *fb* HW at 50 DAS followed by post emergence application of Imazethapyr at 0.050 kg/ha+ Quizalofop -p- ethyl 0.50 kg /ha at 20 DAS *fb* HW at 50 DAS and Imazethapyr at 0.075 kg/ha at 20 DAS *fb* HW at 50 DAS.

Table1: **Weed control efficiency (%) and weed index (%) as influenced by different treatments.**

Treatment	Weed Index (%)	Weed Control Efficiency (%)
Weedy check	46.27	0.00
Pendimethalin @ 0.75 kg/ha. as PE *fb* HW at 50 DAS	6.36	72.53
Imazethapyr @ 0.075 kg/ha at 20 DAS *fb* HW at 50 DAS	9.91	71.98
Imazethapyr @ 0.050 kg/ha + QE 0.50 kg/ha at 20 DAS *fb* HW at 50 DAS	8.08	72.32
Pendimethalin @ 1.0 kg/ha as PE *fb* PQ @ 0.40 kg/ha at 42 DAS	20.69	62.85
Imazethapyr @ 0.075 kg/ha at 20 DAS *fb* PQ @ 0.40 kg/ha at 42 DAS	29.12	62.49
Pendimethalin @ 1.0 kg/ha as PE *fb* PQ @ 0.40 kg/ha at 56 DAS	14.04	71.28
Imazethapyr @ 0.075 kg/ha at 20 DAS *fb* PQ @ 0.40 kg/ha at 56 DAS	18.00	70.83
Weed free.	0.00	100

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Efficacy of post-emergence herbicides on grain and straw yield of greengram

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Recently broad-spectrum herbicide like Pendimethalin is commonly used as pre-emergence herbicide in many crops including Greengram (*Vigna radiata* L.), as it has capacity to control the noxious weeds which are not controlled by cultural and mechanical means. As new herbicides like Imazethapyr, Quizalofop ethyl *etc*. are marketed with assurance of selective control of post emergence weeds, information on the suitability and efficacy of these herbicides in greengram are particularly effective, when their individual component is known to control a different class of weeds more effectively. Therefore, use of chemical and cultural methods of weed control seems necessary for effective control of weeds.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Kharif* 2011. The experiment was laid out in randomized block design with eight treatments replicated thrice. The treatment comprised of Weed control (T_1), Hand Weeding + 1H (T_2), Pendimethalin 1.0 kg/ha (T_3), Quizalofop ethyl at 0.050 kg/ha (T_4), Quizalofop ethyl at 0.075 kg/ha (T_5), Imazethapyr at 0.075kg /ha (T_6), Imazethapyr at 0.100 kg/ha (T_7), Quizalofop ethyl at 0.050 kg/ha + Imazethapyr at 0.100 kg/ha (T_8). Greengram (PKV 8802) was sown on 27th June 2011 at 45 x 10 cm spacing with 25:50:0 kg/ha NPK.

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RESULTS

Data related to grain yield of greengram are graphically represented in Fig.1. It is obvious from the data that grain yield of greengram was significantly influenced by various weed control treatments. The mean grain yield of greengram was 816.5 kg/ha. Significantly Highest grain yield (1035 kg/ha) was recorded in treatment comprising of Hand weeding + 1H, which was followed by treatment Quizalofop ethyl at 0.050 kg/ha + Imazethapyr at 0.100 kg/ha. Treatment control showed lowest grain yield (612.70 kg/ha). Yield increase over control with treatment of Hand weeding +1 H was found to the tune of 68.9%. Among the treatments of alone herbicide and herbicide combination, highest grain yield was observed with treatment Quizalofop ethyl at 0.050 kg/ha + Imazethapyr at 0.100kg/ha, which was increased by 56.63% over treatment control. Grain yield was increased by 35.00% over treatment control with treatment Imazethapyr at 0.100 kg/ha. Remaining treatments were found statistically similar with each other. These results are in accordance to findings of Mishra and Bhanu (2006) and Balyan *et al.* (1991).

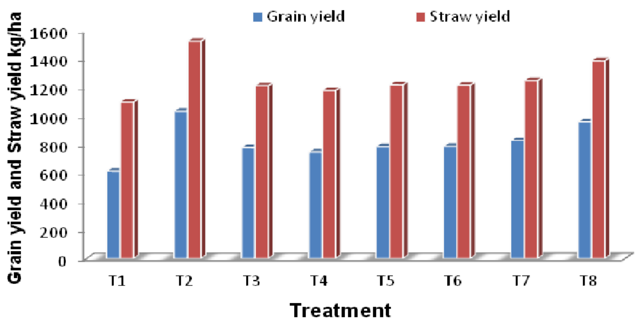

Fig.1 Grain yield and Straw yield as nfluenced by different treatments.

CONCLUSION

It is concluded that highest grain and straw yield of greengram was obtained with application of Quizalofop ethyl at 0.050 kg/ha + Imazethapyr at 0.100 kg/ha.

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Influence of weed management practices on weed dynamics, yield and economics of pigeonpea

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In pigeonpea, reduction in yield due to weeds to a tune of 80% has been reported (Talnikar *et al*. 2008) as the crop is cultivated at wider row spacing and also due to its slow initial growth. To achieve enhanced crop production and higher benefits from applied inputs safe and effective weed control measures are essential.

METHODOLOGY

A field experiment was conducted at Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *Kharif* 2014 to evaluate the effect of different weed management practices on weed dynamics, yield and economics of redgram. Eight weed control treatments (Table. 1) were tested to find out practically convenient and economically feasible weed management practice in redgram.

RESULTS

Imazethapyr was effective to certain extent against *Cyperus rotundus* and against grasses like *Echinochloa spp, Digitaria spp, Cynodon dactylon* at all doses of test while pendimethalin 30% EC as pre emergence was not effective on *Cyperus rotundus* and other grasses. Pendimethalin 30% EC, as pre emergence herbicide, though prevented the emergence of broad leaved weeds initially could not prevent the subsequent emergence of broad leaved weeds from the weed seed bank of soil. Among all the weed management options, hand weeding twice registered lowest weed density and dry matter of weeds with highest weed control efficiency both at 30 and 60 DAS. Among the herbicides, imazethapyr at 75, 90 and 150 g/ha recorded on par and significantly superior weed control efficiency both at 30 and 60 DAS over imazethapyr 10% SL at 60 g/ha and preemergence herbicide pendimethalin. However, imazethapyr 10% SL at 150g/ha recorded phytoxicity. Lower weed control efficiency of pendimethalin might be attributed to poor control of weeds that emerged at later stages of crop growth due to subsequent flushes.

Table 1. Weed dynamics, weed control efficiency, yield and economics of redgram under different weed management practices.

Treatment	Weed density (no./m2)		Dry weight of weeds (g/m2)		Weed control efficiency (%)		Grain yield (kg/ha)	Net returns (kg/ha)	B: C ratio
	30DAS	60DAS	30DAS	60DAS	30DAS	60DAS			
Weedy Check	6.80	12.13	88.0	237.3	0.0	0.0	634	13565	0.97
Hand weeding at 20 and 45DAS	3.95	6.63	6.5	78.7	92.6	67.0	1393	40131	2.11
Pendimethaline @ 0.75 kg/ha	5.29	10.73	33.9	131.3	61.6	43.7	843	21335	1.39
Imazythapyr 10% SL@ 60 g/ha	5.32	10.16	23.6	114.3	73.2	51.2	969	26692	1.73
Imazythapyr 10% SL@ 75 g/ha	4.49	9.11	17.4	79.3	80.2	65.8	1138	33789	2.15
Imazythapyr 10% SL@ 90 g/ha	4.43	8.46	19.3	77.0	78.0	67.1	1123	32736	2.03
Imazythapyr 10% SL@ 150 g/ha	4.28	8.24	19.9	76.0	77.3	67.6	1169	33952	2.01
LSD (P=0.05)	0.65	1.03	5.34	37.2	3.07	11.5	164.2		

Significantly higher grain yield and net monetary returns per hectare were observed in plots where hand weeding was done at 20 and 45 DAS over rest of the treatments. This was followed by imazythapyr at doses 75 and 90 g/ha. Both doses were found to be equally effective in controlling weeds and were superior over imazythapyr at 60 g/ha and pendimethalin at 0.75 kg/ha. Weedy check recorded 55% of yield reduction over hand weeding. The benefit: cost ratio was maximum for imazythapyr at 75 g/ha. Though hand weeding at 20 and 45 DAS fetched the higher monetary return (40131) over all the other treatments, it had benefit: cost ratio (2.11) lesser than post emergence application of imazythapyr l at 75 g/ha treatment.

CONCLUSION

Post emergence application of Imazythapyr 10% SL at 75 g/ha at 15-20 DAS is a practical and economically viable weed management option in redgram.

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Weed management in summer clusterbean

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Cluster bean (*Cyamposis tetragomoloba*) commonly known as guar, is a drought and high India is the largest producer of guar and contributes 80% of total guar production in the world. During last three years, guar gum had topped the list of India's top agricultural export commodity in terms of value (Anonymous 2014). Yield reduction due to weed infestation is to the tune of 53.7% has been observed (Saxena *et al.* 2004). Hence, the present investigation was undertaken to find out an effective and economical viable weed management practices for summer cluster bean.

METHODOLOGY

A field experiment was conducted at College of Agriculture, Junagadh Agricultural University, Junagadh during the summer 2013-14. Twelve treatments (Table. 1) were tested in randomized block design with three replications. Cluster bean variety '*Gujarat Guar-2*' was sown with recommended package of practices except weed management. Data on weed growth, yield performance and economics were recorded.

RESULTS

The lowest weed index and highest weed control efficiency was observed when two HW at 20 &40 DAS followed by pendimethalin at 0.750 kg/ha PE + HW at 40 DAS. The highest seed and stover yield was recorded with weed free and the lowest was under unweeded check. The yield loss due to uncontrolled growth of weeds as compared to weed free was 77.27%. Among the weed management treatments, two HW at 20 & 40 DAS recorded maximum seed yield, which was at par with pendimethalin at 0.750 kg/ha PE + HW at 40 DAS, oxyflurofen at 0.150 kg/ha PE + HW at 40 DAS and imazethapyr at 0.075 kg/ha at 20 DAS + HW at 40 DAS. While, maximum stover yield was also recorded in two HW at 20 and 40 DAS but, it was at par with all other treatments except one HW at 20 DAS. The net returns (Rs. 27162/ha) and B:C ratio (1.94) was found maximum with pendimethalin at 0.750 kg/ha PE + HW at 40 DAS which was at par with two HW at 20 and 40 DAS, oxyflurofen at 0.150 kg/ha PE + HW at 40 DAS and imazethapyr at 0.075 kg/ha at 20 DAS + HW at 40 DAS.

Table1. Weed growth, yield and economics of cluster bean as influenced by weed management treatments

Treatment	Dry weight of weeds (kg/ha)	Weed index	Weed control efficiency (%)	Seed yield (kg/ha)	Stover yield (kg/ha)	Net return (`/ha)	B:C ratio
Pendimethalin at 0.750 kg/ha PE + HW at 40 DAS	285	6.93	80.84	1494	3740	27162	1.94
Oxyflurofen at 0.150 kg/ha PE + HW at 40 DAS	386	12.03	74.23	1404	3616	23753	1.82
Quizalofop-ethyl at 0.045 kg/ha at 20 DAS + HW 40 DAS	437	19.08	70.79	1294	3457	19632	1.67
Imazethapyrat 0.075 kg/ha 20 DAS + HW at 40 DAS	401	13.09	73.15	1389	3547	22956	1.79
Pendimethalin at 0.750 kg/ha PE + Quizalofop –ethyl at 0.045 kg/ha at 40 DAS	653	21.88	56.40	1232	3189	17594	1.61
Pendimethalin at 0.750 kg/ha PE + Imazethapyr at 0.075 kg/ha at 40 DAS	568	19.73	62.01	1281	3202	19220	1.67
Oxyflurofen at 0.150 kg/ha PE + Quizalofop-ethyl at 0.045 kg/ha at 40 DAS	777	27.89	48.10	1139	3061	14090	1.49
Oxyflurofen at 0.150 kg/ha PE + Imazethapyr at 0.075 kg/ha at 40 DAS	671	24.15	55.00	1196	3089	16001	1.55
One HW at 20 DAS	913	33.54	39.07	1047	2855	11873	1.43
Two HW at 20 and 40 DAS	255	5.49	83.03	1515	3742	27045	1.91
Weed free	0	0.00	100.00	1605	3902	28405	1.90
Unweed Check	1497	42.68	0.00	905	2474	9092	1.36
LSD (P=0.05)	118	11.08	7.67	215	696	7732	0.26

CONCLUSION

Pre-emergence application of pendimethalin at 0.750 kg/ha + one hand weeding at 40 DAS was found most effective for controlling weeds & improving seed yield and economically viable for summer cluster bean.

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Studies on efficacy of different pre- and post-emergence herbicides on yield of greengram

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Weeds play an important role in deciding the success or failure of agricultural crops; and hence weed infestation in Greengram (*Vigna radiata* L) is considered to be one of the major obstacles in its successful cultivation. Improved weed control practices that include chemical weed control with newer formulations with latest new herbicide may control the weeds efficiently and may improve the yield level with lower rate of input practice through better use of management strategies. With this view, the present investigation was undertaken to test the weed control efficacy of various chemical herbicides which were just introduced in the local market.

METHODOLOGY

A field investigation was carried out at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season of 2012-2013. The treatments were comprised of three pre-emergence herbicide Pendimethalin 1.0 kg/ha, Pendimethalin 30 EC + Imazethapyr 2EC at 0.75 kg/ha and Pendimethalin 30 EC + Imazethapyr 2EC at 1.0 kg/ha and five post emergence herbicide Quizalofop ethyl at 0.075 kg/ha, Imazethapyr 35 EC+ Imazamox 35 at 0.075 kg/ha, Imazethapyr 35 EC+ Imazamox at 0.100 kg/ha, Imazethapyr at 0.075 kg/ha and Imazethapyr at 0.100 kg/ha at 20 DAS respectively were evaluated alone and In combination with cultural method compared with mechanical treatment and unweeded control in randomized block design. Greengram variety PKV- Green gold was sown during *kharif* season of the year 2012 at a 45 x 10 cm spacing with fertilizer dose of 20:40:0 NPK kg/ha.

RESULTS

Hand weeding, which was at par with treatment herbicide treatments of Imazethapyr at 0.100 kg/ha, Imazethapyr at 0.075 kg/ha, Pendimethalin 1.0 kg/ha, Pendimethalin 30 EC+ Imazethapyr 2 EC at 1.00 kg/ha and Quizalofop ethyl at 0.075 kg/ha, respectively. Herbicide treatment Pendimethalin 30 EC+ Imazethapyr 2 EC at 0.75 kg/ha, Imazethapyr 35 EC+ Imazamox at 0.100 kg/ha and Imazethapyr 35 EC+ Imazamox 35 at 0.075 kg/ha were found to be statistically similar with each other and significantly superior over weedy check. Improvements in yield contributing characters and thereby grain yield due to these treatment may be attributed to significantly lower weed density and dry matter, which created favourable condition for better plant growth and development in the crop. The results are in accordance to findings of Mishra and Bhanu (2006) and Balyan *et al.* (1991).

CONCLUSION

Table 1. Number of pods/plant, pod length, grain weight/plant, test weight and grain yield of greengram as influenced by various treatments

Treatment	No. of pods per plant	Pod length (cm)	Grain wt. per plant (g)	Test wt (g)	Grain yield (kg/ha)
Weedy check	14.17	7.10	4.50	31.18	501
Recommended Practice (2HW)	21.20	8.03	7.63	38.50	1128
Pendimethalin 30 EC 1.0 kg/ha	20.33	7.70	5.23	34.70	1082
Pendimethalin 30 EC+ Imazethapyr 2EC at 0.75 kg/ha	16.83	7.63	4.97	33.43	935
Pendimethalin 30 EC+ Imazethapyr 2EC at 1.0 kg/ha	20.23	7.70	6.83	33.27	1013
Quizalofop ethyl 5 EC at 0.075 kg/ha	17.00	7.80	4.95	33.17	1008
Imazethapyr 35 EC+ Imazamox 35 at 0.075 kg /ha	16.07	7.47	5.13	35.73	780
Imazethapyr 35 EC+ Imazamox at 0.100 kg/ha	18.53	7.30	5.00	34.17	819
Imazethapyr 10 EC at 0.075 kg/ha	19.80	7.93	6.70	36.50	1085
Imazethapyr 10 EC at 0.100 kg/ha	20.53	7.97	7.07	37.23	1119
Weed free check	22.07	8.05	7.83	38.80	1187
LSD (P=0.05)	3.72	0.33	1.86	2.61	231

Among various herbicide treatments, application of Imazethapyr at 0.100 kg/ha, Imazethapyr at 0.075 kg/ha, Pendimethalin 1.0 kg/ha, Pendimethalin 30 EC+ Imazethapyr 2 EC at 1.00 kg/ha and Quizalofop ethyl at 0.075 kg/ha were found significantly superior over other herbicides in obtaining greater values of yield contributing characters and grain yield of greengram.

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Influence of new herbicide molecules on weed growth and yield of maize

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Maize is one of the most important food crops in India and is increasingly gaining an important position in crop husbandry because of its higher yield potential and short growth duration. It contributes a lot to the economy of the country, as it is a rich source of food, fodder, feed and also provides raw materials for the industry. Weed infestation poses competition for natural and applied inputs, such as space and nutrients. Non-availability of manual labour due to competition from other crops and high wages of manual labour also comes in the way of timely weed control in maize. Herbicides play major role in managing weeds in such a situation. The maximum weed competition in maize occurs during the period of 2-6 weeks after sowing, so use of pre-emergence and post-emergence herbicide in combination is found to be better choice (Ishrat 2012).

METHODOLOGY

A field experiment was conducted during *Kharif* 2013 at Main Research Station, Hebbal, UAS, Bengaluru to study the influence of new herbicide molecules on weed growth and yield of maize. Ten treatments, *viz.* were replicated thrice in RCBD.

RESULTS

Major weeds observed in the experimental field were *Cyperus rotundus*, *Cynodon dactylon*, *Ageratum conyzoides* and *Borreria articularis*. Weed density and weed dry weight at harvest was significantly lower in pre-emergence herbicide followed by post-emergence herbicide application treatments (97.7-119.7 /m^2 and 80.0-90.7 g/0.25 m^2, respectively) compared to application of pre-emergence herbicide alone (150.3-184.3/m^2 and 122.4-137.5 g/0.25 m^2, respectively) (Table 1).

Table 1. Weed density, dry weight, kernel yield, 100-kernel weight, weed control efficiency and harvest index in maize as influenced by weed management practices

Treatment	Weed density at harvest (no./m^2)	Weed dry weight at harvest (g/0.25 m^2)	Kernel yield (t/ha)	100 kernel weight (g)	Weed control efficiency (%)	Harvest index
T_1: Acetochlor 2250 g/ha – 2 DAS	2.19 (153.0)	2.11 (127.1)	7.08	31.3	37.1	0.44
T_2: Atrazine 1250 g/ha – 2 DAS	2.21 (184.3)	2.14 (137.5)	6.91	31.7	31.2	0.44
T_3: Alachlor 1250 g/ha – 2 DAS	2.14 (150.3)	2.09 (122.4)	7.13	32.7	32.7	0.44
T_4: Topramezone 25.2 g/ha + atrazine 250 g/ha – 15 DAS	2.12 (128.7)	1.98 (104.3)	7.41	33.7	48.4	0.45
T_5: Tembotrione 105 g/ha + isoxadifen – ethyl 52 g/ha + Stefes mero adjuvant at 2.5 ml/lt – 15 DAS	2.10 (125.0)	2.01 (100.8)	7.69	35.7	50.1	0.45
T_6: Acetochlor 2250 g/ha – 2 DAS *fb* 2,4-D Na salt 500 g/ha – 40 DAS	2.01 (100.0)	1.92 (80.4)	8.12	36.3	60.2	0.44
T_7: Atrazine 1250 g/ha - 2 DAS *fb* 2,4-D Na salt 500 g/ha – 40 DAS	2.09 (119.7)	1.97 (90.7)	7.70	36.0	55.1	0.43
T_8: Alachlor 1250 g/ha – 2 DAS *fb* 2,4-D Na salt 500 g/ha – 40 DAS	1.96 (97.7)	1.91 (80.0)	8.29	37.3	60.4	0.45
T_9: Two hand weedings at 20 and 40 DAS	2.07 (116.7)	1.96 (89.8)	7.92	35.7	55.6	0.44
T_{10}: Unweeded control	2.40 (250.0)	2.31 (202.2)	2.54	24.7	0.0	0.37
LSD (P=0.05)	0.13	0.15	0.81	3.3	NA	0.025

Significantly higher weed density and dry weight was recorded in unweeded control (250.0/m^2 and 202.2 g/0.25 m^2, respectively). As a consequence of this significantly higher kernel yield, weed control efficiency, 100 kernel weight was recorded in alachlor 1250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS (8.29 t/ha, 60.4% and 37.3 g, respectively) compared to all other treatments except acetochlor 2250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS (8.12 t/ha, 60.2% and 36.3 g, respectively), two hand weedings at 20 and 40 DAS (7.92 t/ha, 55.6% and 35.7 g, respectively), atrazine 1250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS (7.70 t/ha, 55.1% and 36.0 g, respectively) and tembotrione 105 g/ha + isoxadifen- ethyl 21 52 g/ha + Stefes mero adjuvant at 2.5 ml/l at 15 DAS (7.69 t/ha, 50.1% and 35.7 g, respectively) with which it was on par. These findings are in accordance with (Veeresh 2013).

CONCLUSION

Pre-emergence application of alachlor 1250 g/ha, acetochlor 2250 g/ha followed by 2,4-D Na salt 500 g/ha was found to be the best weed management practice to get higher kernel yield, yield attributes and weed control efficiency in maize by effectively controlling broad spectrum of weeds.

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Growth, yield and economics of maize as influenced by weed management practices using new herbicide molecules

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Maize is the most important component of food security at global level. In India, maize is the third most important food crop after rice and wheat. Weeds emerge fast and grow rapidly competing with the maize crop severely for nutrients, moisture, sunlight and space during initial stages of crop growth. Further, wide space provided to the maize allows fast growth of variety of weed species, causing considerable reduction in yield by affecting the growth, yield and yield components. Generally 2-6 weeks after sowing is the most critical period for weed competition in maize (Sharma *et al.* 2000). Herbicides play major role in managing weeds in present labor scarce situation. Atrazine has been found to be the most effective pre-emergence herbicide and is widely used in maize, but its usage does not control some broad leaf weeds. To manage complex and dynamic weed flora in maize during later stages of crop growth, combination of pre- and post-emergence herbicides needs to be evaluated.

METHODOLOGY

A field experiment was conducted during *Kharif* 2013 at Main Research Station, Hebbal, UAS, Bengaluru to study the influence of new herbicide molecules on weed growth and yield of maize. Ten treatment ,*viz*. T_1- acetochlor 2250 g/ha at 2 DAS, T_2 - atrazine 1250 g/ha at 2 DAS, T_3 - alachlor 1250 g/ha at 2 DAS, T_4 - topramezone 33.6 g/l + isoxadifen- ethyl 25.2 g/ha + atrazine 250 g/ha at 15 DAS, T_5 - tembotrione 105 g/ha + isoxadifen- ethyl 52 g/ha + Stefes mero adjuvant at 2.5 ml/l at 15 DAS, T_6 - acetochlor 2250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS , T_7 - atrazine 1250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS, T_8 - alachlor 1250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS, T_9 - two hand weedings at 20 and 40 DAS and T_{10} - unweeded control were replicated thrice in RCBD.

Table 1. Leaf area, total dry weight of plant, kernel weight per cob, kernel yield, B:C ratio and weed index as influenced by weed management practices in maize

Treatment	Leaf area at harvest(cm^2/plant)	Total dry weight of plant at harvest (g/plant)	Kernel weight per cob at harvest (g/cob)	Kernel yield (t/ha)	B:C	Weed index
T_1: Acetochlor 2250 g/ha-2 DAS	4933	300.1	171.3	7.08	3.61	10.6
T_2:Atrazine 1250 g/ha – 2 DAS	4461	264.4	162.9	6.91	3.53	12.8
T_3:Alachlor 1250 g/ha – 2 DAS	5226	307.2	173.6	7.13	3.61	9.9
T_4:Topramezone 25.2 g/ha + atrazine 250 g/ha – 15 DAS	5461	309.7	175.0	7.41	3.77	6.5
T_5:Tembotrione 105 g/ha + isoxadifen – ethyl 52 g/ha + Stefes mero adjuvant at 2.5 ml/ l – 15 DAS	5921	331.6	188.1	7.69	3.69	2.9
T_6:Acetochlor 2250 g/ha – 2 DAS *fb* 2,4-D Na salt 500 g/ha – 40 DAS	6342	351.1	195.9	8.12	4.05	-2.4
T_7:Atrazine 1250 g/ha - 2 DAS *fb* 2,4-D Na salt 500 g/ha – 40 DAS	6048	332.7	189.9	7.70	3.87	2.8
T_8:Alachlor 1250 g/ha – 2 DAS *fb* 2,4-D Na salt 500 g/ ha – 40 DAS	7023	359.3	199.3	8.29	4.10	-4.6
T_9:Two hand weedings at 20 and 40 DAS	6556	335.8	192.4	7.92	3.56	0.0
T_{10} :Unweeded control	3142	145.0	61.6	2.54	1.39	68.0
LSD (P=0.05)	1417	41.07	15.54	0.81	NA	

NA: Not analyzed

RESULTS

Significantly higher kernel yield, B:C ratio and lower weed index of maize was noticed in treatment alachlor 1250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS as compared to all other treatments except acetochlor 2250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS, two hand weedings at 20 and 40 DAS, atrazine 1250 g/ha at 2 DAS *fb* 2,4-D Na salt 500 g/ha at 40 DAS and tembotrione 105 g/ha + isoxadifen- ethyl 52 g/ha + Stefes mero adjuvant at 2.5 ml/l at 15 DAS with which it was on par. This is attributed to higher leaf area, total dry weight of plant and kernel weight/cob in alachlor *fb* 2,4-D Na salt, acetochlor *fb* 2,4-D Na salt, two hand weedings, atrazine *fb* 2,4-D Na salt and tembotrione + isoxadifen- ethyl at 15 DAS due to effective weed control during critical period of weed crop competition. Whereas, the lower kernel yield was recorded in unweeded control (Table 1), as a result of severe weed infestation and competition throughout the crop growth period which suppressed the growth of crop, as spelt out by Shinde *et al.* (2001).

CONCLUSION

Application of pre emergence herbicides like alachlor, acetochlor, atrazine followed by post emergence herbicide 2, 4-D Na salt was found to be the best weed management practice for obtaining higher productivity and net returns in maize by controlling weeds effectively on time.

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Weed management with new generation herbicides in maize

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Maize (*Zea mays* L.) is the world's third most important cereal crop after wheat and rice. In India, it is cultivated in an area of 6.29 M ha with a productivity of 1.64 t/ha. Rainy-season maize suffers heavy yield losses ranging from 28-100% due to weed infestation owing to congenial environment for luxurious weed growth. Atrazine recommended as pre-emergence herbicide, is not effective against grasses and sedges and there are reports of persistence of atrazine in soil resulting in residual effects. Topramezone and tembotrione are the new selective, post-emergence herbicides introduced for use in maize that inhibit Hydroxy-phenyl pyruvate dioxygenase (4-HPPD) enzyme and the biosynthesis of plastoquinone (Grossmannand 2007, Singh *et al.* 2012). Tank mixing of these herbicides with lower dose of atrazine was reported to be more effective than application of individual chemical, hence the present investigation was undertaken to study the tankmix efficacy of these herbicides.

METHODOLOGY

Field experiment was carried out during *Kharif*, 2014 at Professor Jayashankar Telangana State Agricultural University, Hyderabad to evaluate the tank mix efficacy of new herbicides. The soil was sandy loam in texture. The experiment was conducted in randomized block design (RBD) with a plot size of 5.4 x 4m with three replications. Ten treatments consisting of atrazine *fb* intercultivation, tank mix of topramezone and tembotrione with atrazine with and without adjuvants as post-emergence (PoE), intercropping with cowpea and application of pendimethalin as pre-emergence (PE) and unweeded control. Maize hybrid, '*DHM-117*' was used with recommended package of practices. The recommended fertilizer dose was 180-60-60 kg of N, P_2O_5 and K_2O/ha, respectively.

Table 1. Weed control, yield and economics of maize as influenced by different weed control measures

Treatment	Weed dry matter (g/m^2)	WCE (%)	Grain yield (t/ha)	Net returns (x10^3 Rs./ha)	B:C ratio
Atrazine (1.0 kg/ha) as PE *fb* inter- cultivation at 30 DAS	(20.34) 4.61	74.3	5.72	55.33	3.11
Topramezone (25.2 g/ha) + MSO (adjuvant) as PoE	(27.13) 5.31	64.3	4.99	43.13	2.50
Tembotrione (105 g /ha) + adjuvant as PoE	(28.26) 5.41	65.6	4.83	40.97	2.43
Topramezone + atrazine (25.2+250 g/ha) + adjuvant as PoE	(16.73) 4.21	78.9	6.43	62.60	3.17
Tembotrione + atrazine (105+250 g /ha) + adjuvant as PoE.	(18.23) 4.38	77.0	6.28	60.18	3.10
Tembotrione (105 g/ha) as PoE	(30.56) 5.61	61.4	4.52	37.02	2.30
Intercropping of maize with cowpea and PE application of pendimethalin (1.0 kg/ha).	(18.93) 4.46	76.1	4.71 (MEY)	41.17	2.55
Hand weeding at 20 and 40 DAS.	(73.32) 8.62	7.5	6.58	59.36	2.72
Intercultivation at 20 and 40 DAS	(74.56) 8.69	6.0	5.48	52.35	3.01
Unweeded control	(79.32) 8.96	_	2.02	16.67	1.68
LSD (P=0.05)	0.4		0.36	4.77	

RESULTS

Predominent weed species observed were *Cynodon dactylon* L., *Dactyloctenium aegyptium* L., *Echinocloa spp* and *Rottboellia exaltata* L (among grasses), *Parthenium hysterophorus* L., *Commelina benghalensis* L., *Amaranthus viridis* L., *Euphorbia geniculate* L. and *Trianthema portulacastrum* L. (among the broad leaved weeds) and *Cyperus rotundus* L (sedge). Herbicidal treatments significantly influenced the density and dry matter production of weeds. Lowest weed dry matter was recorded with topramezone + atrazine at 25.2 + 250 g/ha + MSO adjuvant as PoE. Higher weed control efficiency was recorded with topramezone + atrazine at 25.2 + 250 g/ha + MSO and tembotrione + atrazine at 105 + 250 g/ha + stefesmero indicating that weeds are controlled efficiently with tank mix application of herbicides.

The highest grain and stover yield was recorded with hand weeding at 20 and 40 DAS which was at par with topramezone + atrazine at 25.2 + 250 g/ha + MSO and tembotrione + atrazine at 105 + 250 g/ha + stefesmero. The yield loss due to uncontrolled growth of weeds was 69.2%. Herbicidal treatments resulted in considerably lower cost of cultivation compared to hand weeding. The B:C ratio was found maximum (3.17) with topramezone + atrazine at 25.2 + 250 g/ha + MSO and atrazine at 1.0 kg/ha as PE *fb* intercultivation at 30 DAS (3.11) and tembotrione + atrazine at 105 + 250 g/ha + adjuvant (3.10).

CONCLUSION

Tank-mix application of post-emergence herbicides topramezone (22.5g/ha) or tembotrione (105 g/ha) with lower dose of atrazine at 250 g/ha can be recommended for efficient weed control and improved grain yield with high B:C ratio in *Kharif* maize.

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Impact of sustainable weed management practices on growth and yield of maize

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India ranks fourth in production with 22.50 million tonnes including 5.50 million tonnes in rabi in 2012-13 with productivity of 2552 kg/ha. Maize is very susceptible to weed competition, which lowers yield by 35% to complete crop failure (Sharma *et al*. 1998). The intensive use of a limited number of herbicides creates a situation where herbicide resistance is more likely to develop. Presently, 58 weed species in corn are resistant, which is the second highest after wheat. Maximum of 66 weed species are resistant to herbicide atrazine (Heap 2014). So, present study was conducted to identify the suitable sustainable weed management practices.

METHODOLOGY

An experiment was carried out during *Rabi* season of 2014-15 at PJTSAU, Hyderabad (T.S) to test the efficacy of hand weeding, herbicides, live mulch, brown manuring, polythene mulch and high density planting comprised of eight treatments, replicated thrice. '*Dekalb Super 900M*' (Hybrid) was sown on 28 October, 2014 with spacing of 60 x 20 cm. Recommended dose of P and K entirely applied as basal and N was applied in three equal splits at basal, knee height and tasseling stage (RDF : 200-60-40 kg N, P_2O_5 and K_2O). Data on weeds, yield performance of maize were recorded.

RESULTS

Among different weed species, broad-leaved weeds dominated (49%), followed by grassy weeds (44%) and sedge (7%). Dominant weed flora observed were *Parthenium hysterophorus* (among broad-leaved weeds), *Cynodon dactylon*, *Dactylactenium aegyptium* (among grasses) and *Cyperus rotundus* (among sedge). Among the various treatments tested, at harvest, the lowest weed density was recorded in cowpea live mulch followed by white polythene mulch. However the lowest weed dry matter and higher weed WCE were recorded in hand weeding twice, followed by black and white polythene mulches.

Table 1. Effect of the weed management practices on weed density, weed dry matter (WDM), weed control efficiency (WCE), grain yield and other parameters

Treatment	Weed Density (no/m²)	WDM (g/m²)	WCE (%)	Weed Index (%)	Stover yield t/ha	Kernel yield (t/ha)	Harvest index (%)
Farmers practice (HW at 20 & 40 DAS)	6.69 (44)	4.89 (23)	78.4	7.6	8.49	7.07	45.5
Atrazine at 1 kg/ha at 2 DAS *fb* 2, 4- D Sodium salt at 1.0 kg/ha at 25 to 30 DAS	6.46 (42)	9.71 (93)	13.6	9.7	8.37	6.92	44.7
Live mulch (Vegetable cowpea)	5.47 (29)	6.55 (42)	61.1	44.3	7.53	4.26	35.9
Brown manuring (Desiccation of cowpea live mulch at 50% flowering with 2, 4-D Sodium salt)	6.13 (37)	6.80 (46)	57.7	49.5	7.43	3.86	34.8
Black polythene mulch (25µm thickness UV resistant)	6.47 (41)	5.71 (32)	70.7	0.0	8.63	7.66	46.8
White polythene mulch (25µm thickness UV resistant)	5.51 (30)	6.11 (36)	66.4	1.3	8.68	7.56	46.3
High density planting (planting on either side of the ridge) and application of halosulfuron-methyl @ 67.5 g/ha at 15-20 DAS.	6.65 (44)	6.73 (45)	58.6	30.3	7.33	5.34	42.1
Weedy check (no weed control)	7.08 (49)	10.42 (108)	0.0	49.7	6.79	3.85	36.0
LSD (P=0.05)	0.52	1.12			1.11	0.77	6.8

*Values in parentheses are original. Data transformed to square root transformation; WDM – Weed dry matter, WCE – Weed Control efficiency

The significantly higher stover yield, grain yield and lower weed index were recorded in black polythene mulch, which was statistically at par with white polythene mulch, hand weeding twice (20 and 40 DAS) and pre-emergence application of atrazine at 1 kg/ha followed by 2, 4-D at 1 kg/ha sodium salt at 30 DAS as compared to weedy check. These treatments increased grain yield over weedy check by 99, 96, 84 and 80% respectively.

CONCLUSION

Polythene mulch of 25 mm thickness either black or white UV resistant was found more competitive to suppress the weeds and more productive among all sustainable practices of weed management.

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Effect of weed management practices in maize-based intercropping system

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Maize (*Zea mays* L.) is an important cereal crop and popularly known as 'queen of cereals'. It is the third most important crop in the world agricultural economy after wheat and rice with an area of 168.2 million hectares with a production of 854.5 million tones with average productivity of 5.12 t/ha. In maize based intercropping system manual weeding is though efficient, but costly too (Shah *et al*. 2011). Chemical weed control will go a long way to alleviate the weed problem in maize. Choice of safe herbicide for both sole and intercrop system determines the success of weed control.

METHODOLOGY

A field experiment was conducted during *Rabi* 2013-14 at TNAU, Madurai and it was carried out in split plot design with three replications. The main plots were assigned with cropping system, *viz*. maize, maize + blackgram, maize + cowpea and weed management practices such as pre emergence (PE) application of pendimethalin at 0.75 kg/ha, alachlor at 1 kg/ha and oxyfluorfen at 0.2 kg/ha and in combination with one rotary hoeing on 35 DAS. In addition to this, rotary hoeing twice at 15 and 35 DAS, hand weeding on 15, 35 DAS and unweeded check were assigned to sub plots. Test crops are maize hybrid, black gram and cowpea with varieties of '*COHM 6*', '*VBN (Bg) 4*' and '*VBN1*', respectively. Crops were grown in sandy clay loamy soil with pH and EC of 7.2 and 0.40 (dS/m), respectively. Fertilizers were applied at 250:75:75 kg NPK/ha. Data on weed density weed control efficiency and weed index on 60 DAS and yield of maize were studied.

RESULTS

Broad-leaved weeds were predominant, followed by grassy weeds and sedges. *Boerhaavia diffusa* (among the broad-leaved weeds) and *Echinochloa colona* (among the grassy weeds) were more dominant. In this study, reduction in density of weeds benefit was more pronounced in maize + cowpea. Lower weed population was recorded under pendimethalin at 0.75 kg/ha *fb* one rotary hoeing at all stages of observation. This was followed by alachlor at 1.0 kg/ha *fb* one rotary hoeing and oxyfluorfen at 0.2 kg/ha *fb* one rotary hoeing. Application of pendimethalin at 0.75 kg/ha *fb* one rotary hoeing under maize + cowpea intercropping system recorded higher weed control efficiency (85.8%) and reduced weed index (13.3). The maximum WCE obtained by the above promising weed management practices was due to greater reduction of grasses, sedges and broad leaved weeds in all the stages of crop growth itself which in turn increased the vigor and growth of maize and cowpea, blackgram resulted in good crop establishment. Among intercropping, maize + cowpea association recorded higher grain yield of maize as compared to other intercrops. Cowpea minimized the nutrients depletion by weeds and enhanced the nutrient uptake of maize and provided a congenial environment for increased yield. Among the weed management practice, application of pendimethalin at 0.75 kg/ha *fb* one rotary hoeing increased the grain yield. This was followed by pre-emergence application of alachlor at 1.0 kg/ha with one rotary hoeing.

Table 1. Effect of cropping system and weed control treatments on weed density, WCE, weed index and yield

Treatment	Weed density (no./m^2)	WCE (%)	Weed index	Maize grain yield (kg/ha)
Cropping system				
C_1- Maize alone	(89.09)9.44	65.41	52.56	3312
C_2- Maize + Blackgram	(70.29)8.38	68.12	43.82	3922
C_3- Maize + Cowpea	(58.16)7.63	68.36	29.28	4938
LSD (P=0.05)	3.30	-		370
Weed management treatments				
W_1-PE Pendimethalin + one Rotary hoeing	(42.41)6.51	85.88	13.34	6051
W_2-PE Alachlor + one Rotary hoeing	(56.89)7.54	84.19	25.17	5225
W_3-PE Oxyfluorfen + one Rotary hoeing	(70.89)8.42	81.56	37.57	4359
W_4-Rotary hoeing twice (15 & 35 DAS)	(78.34)8.85	77.25	50.91	3428
W_5- Hand weeding twice (15 & 35 DAS)	(78.83)8.88	74.92	55.74	3090
W_6- Unweeded check	(136.56)11.69	-	68.57	2194
LSD (P=0.05)	3.73	-	-	522

CONCLUSION

From the experimental study, it can be concluded that pre-emergence application of pendimethalin at 0.75 kg/ha followed by one rotary hoeing on 35 DAS under maize based cowpea intercropping system can be recommended for broad spectrum weed control and enhanced productivity.

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Effect of tank-mix application of tembotrione and atrazine on weed growth and productivity of maize

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Maize is the third most important cereal food crop of India after rice and wheat and is cultivated in an area of 8.11 million ha with a production of 19.77 million tones (Duriasamy *et al.* 2011).The crop is predominantly grown in *Kharif* (wet) season in India. Herbicides are the efficient tools for checking weed infestation in *Kharif* maize. But single application of one herbicide has seldom been found effective against complex weed flora throughout the critical period of competition. Mix application of herbicides is coming out as very essential tool to tackle the problem of complex weeds in many crops including maize. Tembotrione is a new selective post emergence herbicide recently introduced for use in maize mixing with herbicide atrazine. With this background the present experiment was conducted to study the effect of tank mix application of tembotrione and atrazine on weed growth and productivity of *Kharif* maize.

METHODOLOGY

A field experiment was conducted during *Kharif* season of 2014 at Agriculture farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal with maize variety '*Kaveri Super 2020'* to study the effect of tank mix application of tembotrione and atrazine on weed growth and productivity of *Kharif* maize. The experiment comprising of nine treatments laid out in a randomized block design with three replications. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. Data on density and dry weight of weeds, yield attributes and yield of maize were recorded during the growth period. Weed control efficiency (%) was computed using the dry weight of weeds.

RESULTS

The lowest density as well as dry weight of weeds at 60 DAS were recorded with tembotrione at 120 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha but it was at par with its application at 100 and 80 g/ha + stefesmero at 733 g/ha + atrazine 500 g/ha and hand weeding twice with respect to weed dry weight (Table 1). Tembotrione at 120 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha registered the highest WCE closely followed by its application at 100 and 80 g /ha combined with atrazine at 500 g/ha. Weed infestation resulted in 48% yield reduction in *Kharif* maize. Tembotrione at 100 g/ha + stefesmero at 733 g/ha + atrazine 500 g/ha registered the highest number of kernels/cob, 500 kernel weight and grain yield of maize and was statistically at par with its application at 120and 80 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha and hand weeding twice at 25 and 40 DAS. The treatment tembotrione at 100 g /ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha also recorded the highest gross andnet return closely followed by tembotrione at 120 g/ha + stefesmero at 733 g/ha + atrazine 500 g/ha and tembotrione at 80 g/ha + stefesmero at 733 g/ha + atrazine 500 g/ha (Table 1).

Table1. Effect of treatments on density and dry weight of weeds, weed control efficiency, yield components, yield and economic returns of *Kharif* maize

Treatment	Weed density (No. /m^2) at 60 DAS	Weed dry weight (g/m^2) at 60 DAS	Weed control efficiency (%) at 60 DAS	No. of kernels/cob	500 kernel wt. (g)	Grain yield (t/ha)	Net returns (x10^3 Rs./ha)
Tembotrione at 80 g/ha + stefesmero surfactant at 733 g/ha	258.0	102.8	49.4	290.9	70.83	3.45	20.29
Tembotrione at 80 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha	63.7	21.9	89.2	376.7	80.61	4.10	27.85
Tembotrione at 100 g/ha + stefes mero surfactant at 733 g/ha	210.3	88.2	56.6	303.1	72.50	3.77	23.64
Tembotrione at 100 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha	56.7	18.4	90.9	380.1	81.14	4.57	32.99
Tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha	178.7	70.3	65.4	314.7	77.88	3.80	23.59
Tembotrione at 120 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha	29.0	11.3	94.4	368.4	79.52	4.31	29.37
Atrazine 1000 g/ha	78.0	26.2	87.1	307.7	74.06	3.803	25.99
Hand weeding (25 and 40 DAS)	74.0	22.7	88.8	383.9	81.01	4.52	26.05
Unweeded control	392.7	202.9	0	257.3	65.21	2.37	9.50
LSD (P=0.5)	18.2	12.0	-	48.56	9.14	0.48	-

CONCLUSION

It may be concluded that application of tembotrione at 100 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha considerably reduced the weed infestation registering higher weed control efficiency, grain yield and net return of maize and was comparable with tembotrione at 80 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g /ha and tembotrione at 120 g/ha + stefesmero surfactant at 733 g/ha + atrazine 500 g/ha.

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Efficacy of pre- and post-emergence herbicides on weed flora and yield of sweet corn

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Weeds are not controlled during critical period of weed crop competition; there is reduction in the yield of sweet corn from 60-70% depending upon the weed flora and density (Walia *et al.* 2007). Hand weeding is a traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour during peak period of demand, are the main limitations of manual weeding. Keeping this fact in view, the present investigation is undertaken to study the efficacy of pre-emergence and post-emergence herbicide on yield attributes and yield of sweet corn crop.

METHODOLOGY

The present investigation was conducted during *Kharif* 2014 at P.G. Research Farm, Agronomy Section, College of Agriculture, Dhule. Experiment consisted of ten treatments laid out in randomized block design with three replications. The soil of the experimental field was clay in the texture, with low in available nitrogen and available phosphorus and rich in available potassium.

RESULTS

Some predominant weed species in sweet corn are *Cynodon dactylon*, *Digera arvensis*, *Digitaria marginata*, *Eleusine indica*, *Commelina benghalensis*, *Argemone Mexicana*, *Amaranthus viridis*, *Euphorbia indica*, *Phyllanthus niruri*, *Parthenium hysterophorus* which cause heavy losses in production. The green cob and fodder yield of sweet corn was found to be significantly higher (20.7 and 43.2 t/ha respectively) in treatment of weed free. This was followed by application of atrazine *fb* metasulfuron-methyl (0.75 kg/ha (PE) *fb* 0.75kg/ha (PoE) (18.4 and 39.7 t/ha) T_{10}. While treatment T_{10} was found at par with atrazine *fb* 2, 4-D (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE) (T_9), pendimethalin *fb* atrazine (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE) (T_8) and hand weeding (T_3). Among the herbicide treatments tried in the experiment, application of per-emergence herbicide *i.e.* atrazine at 0.75 kg/ha followed by post-emergence herbicide *i.e.* metasulfuron-methyl at 0.075 kg/ha at 15 DAS treatment was found significantly better than application of herbicide alone in respect of green cob and fodder yield of sweet corn may be probably due to better weed management resulting in improvement in all growth and sink parameters which contributed to higher yield owing to favourable condition in absorbing soil moisture, nutrient content and sunlight penetration during crop period. The green cob and fodder yield of sweet corn was significantly lowest under weedy check treatment (T_1). However, the net monetary returns and B:C ratio were maximum under weed free treatments, but lowest B:C ratio as compared to application of atrazine *fb* metasulfuron-methyl (0.75 kg/ha (PE) *fb* 0.75kg/ha (PoE) due to higher cost of manual labour for weeding. These results are in conformity with those of Suresh Kumar *et al.* (2012).

Table 1. Effect of different weed management treatments on weed growth, yield and economics of sweet corn

Treatment	Dry weight of weeds weeds (kg/ ha)	Weed index (%)	Cob yield (t/ ha)	Fodder yield (t/ha)	Net returns (x 10^3 Rs./ha)	B:C ratio
T_1 : Weedy check	1680	61.16	8.0	14.2	47.28	1.87
T_2: Weed free check	46.6	-	20.7	43.2	20.60	4.12
T_3: Hand weeding	148.2	15.53	17.5	37.8	17.03	3.77
T_4: Atrazine (PE)	441.5	28.64	14.7	30.7	13.35	3.21
T_5: Pendimethalin (PE)	593.2	33.00	13.8	28.8	12.36	3.11
T_6: Atrazine + pendimethalin (0.75+0.75 Kg/ha (PE)	380.3	24.75	15.6	32.2	14.48	3.43
T_7: Atrazine + 2,4-D (0.75 +0.75 Kg/ha (PE)	341.1	26.21	15.2	32.4	14.35	3.47
T_8: Pendimethalin *fb* atrazine (0.75 kg/ha(PE) *fb* 0.75 kg/ha (PoE)	339.5	14.56	17.7	38.2	17.46	3.92
T_9: Atrazine *fb* 2,4-D (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE)	197.1	13.59	17.9	38.8	17.90	4.07
T_{10}: Atrazine *fb* metasulfuron-methyl (0.75 kg/ha (PE) *fb* 0.75kg/ha (PoE)	125.7	11.16	18.4	39.7	18.54	4.18
LSD (P= 0.05)	58.287	-	1.7	3.5	-	-

CONCLUSION

Sequential use of per- emergence spray of, *i.e.* atrazine at 0.75 kg/ha followed by post-emergence herbicide, *i.e.* metasulfuron-methyl at 0.075 kg/ha at 15 DAS is found beneficial from economical point of view.

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Effect of weeder machine on occurrences of weed in grain sorghum grown with different planting methods

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Grain sorghum, *Sorghum bicolor* (L.) is one of the summer crops cultivated in single or two-cropping systems in Korea, and its cultivation acreage is increasing. Grain sorghum is planted at about the same time when many summer annual weed species normally emerge. Weeds compete with grain sorghum for light, nutrients, and soil water, resulting in reduced yields, lower grain quality, and increased production costs. Weeds are especially troublesome in the production of grain sorghum. Grain sorghum seeds are comparatively small and grow slowly for the first 20-25 days. Most of the weeds out compete grain sorghum during the early stages of crop growth. Yield loss of grain sorghum due to weed competition exceeds most other grain crops. Losses typically range from 30-50%. The yield components most reduced by weed competition are number of heads per plant, panicle size, and numbers of seeds per panicle or head. Fewer herbicides are registered against weeds in grain sorghum than for other major row crops. Thus, this study was carried out to determine the effect of weeder machine on the control of weeds and the number of treatment required for mechanical weed control in sorghum.

METHODOLOGY

This experiment was conducted at the National Institute of Crop Science in Miryang, Kyungnam province. The experiment was conducted to elucidate the growth characteristics of sorghum with different planting methods: direct sowing and transplanting (20 DAS). Sorghum sprouts were sown at 70 x 20cm by hand on 22 June. Fertilizers were applied at the standard rate of N: P_2O_5: K_2O 10:7:8 kg/ha. Weed weight was taken from three randomly chosen-2 plots at 60DAS (T). Application of weeder machine (FRT 80E) was one time (20, 30DAS, DAT) and two times (20/40DAS, DAT) for direct sowing and transplanting, respectively.

Table 1. Efficacy of weeder machine on weed control and yield of sorghum under two planting methods

Treatment		Cultivation time and frequency	Control value (%)	Culm length (cm)	Stem diameter (mm)	Ear length (cm)	Yield (t/ha)	Index
Transplanting	Weeder	DAT 20 (1)	67	119.3	19.9	27.0	1.62[a]	95
		DAT 30 (1)	57	111.6	20.1	26.7	1.56[ab]	91
		DAT 20/40 (2)	87	126.8	18.9	27.9	1.68[a]	98
	Vinyl mulching	Control	84	126.2	19.1	26.9	1.71[a]	100
	Untreated	-	-	139.3	17.8	25.4	1.27[b]	74
Direct sowing	Weeder	DAS 10/20(2)	86.5	168.4	16.1	23.3	2.63[c]	77
		DAS 10/30(2)	88.1	158.8	17.8	24.4	3.09[b]	91
		DAS 20/30(2)	82.4	162.9	15.8	24.1	2.52[c]	74
	Vinyl mulching	Control	91.3	128.3	20.8	25.8	3.40[a]	100
	Untreated	-	-	171.3	13.5	21.3	1.31[d]	38

RESULTS

Weed control efficacy of weeder machine at 60 DAS was about 82-90% in transplanting. However, in direct sowing it was 13-75% efficient. Therefore transplanting is more effective than direct sowing. The most effective application time was one time (30DAT) followed by two times (20/40DAT) and one time (20DAT). Plant height was the smallest with little effect on the weeds at 30DAT. Heading date of the plants from transplanting and direct sowing were 31 July to 3 August and 24-29 August, respectively. Results with mechanical weed control have been particularly good in transplanted row crop such as sorghum (Table 1). This study was carried out to determine the effect of weeder machine on the control of weeds and the number of treatment required for mechanical weed control in sorghum.

CONCLUSION

Transplanted crops also gain a competitive advantage over the weeds. However, current techniques for transplanting are only profitable in some highly valuable vegetable crops and need to be further developed to make it cost effective in other row crops.

Effect of weed control methods on maize

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The congenial climatic conditions encourage more weed growth in widely spaced crop like maize (Gill *et al*. 1985). Unchecked weed growth in crop may result in grain yield losses to the extent of 100% (Sharma 2005). Hence, the experiment was designed with the view to find out the efficacy of different herbicides and its combination on productivity of maize.

METHODOLOGY

The field experiment was conducted on sandy loam soil of Birsa Agricultural University, Ranchi during rainy season of 2014 to evaluate the performance of weed-control methods on weed dynamics and productivity of maize. The experiment was laid out in randomized block design having 12 methods of weed control including different herbicides and their combination, inclusion of *Sesbania* + 2,4-D, two hand-weeding and weedy check, replicated 3 times**.** Suwan variety of maize was sown on 26.06.14 and harvested on 06.10.14. The crop was fertilized with recommended 120:60:40 kg N, P_2O_5, K_2O /ha. Half amount of N and full of P and K were applied at the time of seeding and remaining N was applied in 2 equal splits at knee height and silking stage.

RESULTS

The result revealed that application of atrazine + pendimethalin 0.50 + 0.50 kg/ha pre emergence being similar to atrazine 1.0 kg/ha pre emergence, pretilachlor + metribuzin 0.75 + 0.175 kg/ha pre emergence and two hand weeding at 20 and 40 DAS recorded reduced weeds and their total dry matter accumulation to the extent of 59.54% (26.55/m^2) compared to weedy check (65.6/m^2) at 30 days after sowing. Whereas at 60 days after sowing application of atrazine + pendimethalin 0.5 + 0.5 kg/ha PE being similar to two hand weeding at 20 and 40 DAS recorded 67.20% reduced total weed dry matter (41.0 /m^2) compared to weedy check (125.00/m^2). Pre emergence application of atrazine + pendimethalin 0.5 + 0.5 kg/ha pre emergence recorded significantly 65.58% higher grain yield (3.80 t/ha) as compared to weedy check (1.30 t/ha) consequently recorded significantly maximum gross return (Rs. 74335/ha), net return (Rs. 59338/ha) and B:C ratio (4.96). These results confirm the findings of Sidhu *et al.* (2014).

CONCLUSION

It may be concluded that for higher productivity and profitability of maize weed control by application of atrazine + pendimethalin 0.50 + 0.50 kg/ha pre emergence can be applied.

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Efficacy of herbicides on quality, yield and economics of sweet corn

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Weeds are not controlled during critical period of weed crop competition; there is reduction in the yield of sweet corn from 60-70% depending upon the weed flora and density (Walia *et al.* 2007). Hand weeding is a traditional and effective method of weed control, but untimely and continues rains as well as unavailability of labour during peak period of demand, are the main limitations of manual weeding. Keeping this fact in view, the present investigation is undertaken to study the efficacy of pre-emergence and post-emergence herbicide in sweet corn crop and its yield attributes and yield.

METHODOLOGY

The present investigation was conducted during *Kharif* 2014 at P.G. Research Farm, Agronomy Section, College of Agriculture, Dhule. Experiment consisted of ten treatments laid out in randomized block design with three replications. The different weed control treatments comprised of weedy check, weed free check, hand weeding, atrazine (PE), pendimethalin (PE), atrazine + pendimethalin (0.75 + 0.75 Kg/ /ha (PE), atrazine + 2,4-D (0.75 + 0.75 Kg/ha (PE), pendimethalin *fb* atrzine (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE), atrazine *fb* 2,4-D (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE) and atrazine *fb* metsulfuron methyl (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE) were used in this experiment. The soil of the experimental field was clay in the texture, with low in available nitrogen and available phosphorus and rich in available potassium.

RESULTS

The quality character like protein and total sugar percentage, green cob and fodder yield of sweet corn was found to be significantly higher in treatment of weed free. This was followed by application of atrazine *fb* metsulfuron–methyl (0.75 kg/ha (PE) *fb* 0.75kg/ha (PoE) T_{10}. While, treatment T_{10} was found at par with Atrazine *fb* 2, 4-D (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE) (T_9), Pendimethalin *fb* Atrazine (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE) (T_8) and Hand weeding (T_3). Among the herbicide treatments, application of pre-emergence herbicide *i.e.* atrazine at 0.75 kg/ha followed by post-emergence herbicide *i.e.* metsulfuron-methyl at 0.075 kg/ha at 15 DAS was found significantly better than application of herbicide alone in respect of green cob and fodder yield of sweet corn. This may probably be due to better weed management resulting in improvement in all growth and sink parameters which contributed higher yield owing to favourable condition in absorbing soil moisture, nutrient content and sunlight penetration during crop period. The green cob and fodder yield of sweet corn was significantly lowest under weedy check treatment (T_1). However, the net monetary returns and B:C ratio were maximum under weed free treatments, but lowest B:C ratio as compared to application of atrazine *fb* metsulfuron- methyl (0.75 kg/ha (PE) *fb* 0.75kg/ha (PoE) due to higher cost of manual labour for weeding. These results are in conformity with those of Suresh Kumar *et al.* (2012).

Table 1. Effect of different weed management treatments on weed growth, yield and economics of Sweet corn

Treatment	Protein content (%)	Total sugar (%)	Cob yield (t/ha)	Fodder yield (t/ha)	Net returns ($x10^3$ Rs./ha)	B:C ratio
T_1 : Weedy check	12.7	11.0	8.05	14.29	47.28	1.87
T_2: Weed free check	15.5	12.9	20.73	43.27	206.09	4.12
T_3: Hand weeding	15.2	12.4	17.51	37.84	170.32	3.77
T_4: Atrazine (PE)	13.8	11.7	14.79	30.79	133.51	3.21
T_5: Pendimethalin (PE)	13.0	11.3	13.88	28.88	123.67	3.11
T_6: Atrazine + pendimethalin (0.75+ 0.75 kg/ha (PE)	13.9	11.8	15.60	32.20	144.80	3.43
T_7: Atrazine + 2,4-D (0.75 + 0.75 kg/ha (PE)	14.1	11.8	15.29	32.40	143.55	3.47
T_8: Pendimethalin *fb* atrazine (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE)	15.2	12.4	17.71	38.24	174.69	3.92
T_9: Atrazine *fb* 2,4-D (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE)	15.3	12.4	17.91	38.82	179.04	4.07
T_{10}: Atrazine *fb* metsulfuron-methyl (0.75 kg/ha (PE) *fb* 0.75 kg/ha (PoE)	15.5	12.4	18.41	39.75	185.46	4.18
LSD (P= 0.05)	0.8	0.5	1.71	3.51	-	-

PoE = Post-emergence, PE = Pre-emergence, *fb* = followed by

CONCLUSION

Sequential use of per-emergence spray of *i.e.* atrazine at 0.75 kg/ha followed by post-emergence herbicide *i.e.* metsulfuron-methyl at 0.075 kg/ha at 15 DAS is found beneficial quality and yield of sweet corn

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Effect of weeder machine on occurrence of weed in grain sorghum grown with different planting methods

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Sorghum is one of the summer crops cultivated in single or two-cropping systems in Korea, and its cultivation acreage is increasing. Sorghum has the ability to tolerate short-term drought, and a late summer sorghum crop may follow an early season potato crop. Weed control in Sorghum is essential if high yields and efficient harvest are to be achieved; however, good weed control in sorghum is often difficult to achieve. Grain sorghum is planted at about the same time when many summer annual weed species normally emerge. Sorghum is a small seeded grass and is relatively slow growing in the first few weeks after emergence. In addition, sorghum will not tolerate many of the herbicides that can be effectively used on corn. Most of the weeds out compete grain sorghum during the early stages of crop growth. Yield loss of grain sorghum due to weed competition exceeds most other grain crops. Losses typically range from 30-50%. The yield components most reduced by weed competition are number of heads per plant, panicle size, and numbers of seeds per panicle or head. Thus, this study was carried out to determine the effect of weeder machine on the control of weeds and the number of treatment required for mechanical weed control in sorghum.

METHODOLOGY

This experiment was conducted at the National Institute of Crop Science in Miryang, Kyungnam province, in Korea from 2012-2014. The experiment was conducted to elucidate the growth characteristics of sorghum with different planting methods: direct sowing and transplanting (20 Days after sowing, DAS). Sorghum sprouts were sown at 70 cm x 20 cm by hand on 22 June. Fertilizers were applied at the standard rate of $N-P_2O_5-K_2O$ 10-7-8 kg/ha. Weed weight was taken from three randomly chosenm-2 plots at 60DAS (T). Application of weeder machine (FRT 80E) was one time (20 and 30 DAT) and two times (10/20, 10/30, 20/30, 20/40 DAS) for direct sowing and transplanting, respectively.

RESULTS

This study was carried out to determine the effect of weeder machine on the control of weeds and the number of treatment required for mechanical weed control in sorghum. In transplanting, the weed control efficacy of weeder machine at 60 DAS was about 83, 80 at one time, 85% two times. The most effective application time was two times (20/40 DAT) followed by one time (20 DAT, 30 DAT). Plant height was the smallest with little effect on the weeds at 30DAT. But, When reviewing yield and economy, the times and frequency of weeder machine were preferably a one times and 20 DAT. Results with mechanical weed control have been particularly good in transplanted row crop such as sorghum. In direct sowing, the weed control efficacy of weeder machine at 60 DAS was about 87, 88 and 82% at two times, respectively. Among mechanical weeding methods in Korea, rotary weeders with or without an engine are still used by some organic or low-chemical farmers. This method is applicable only to small-scale farmers who can do a great deal of heavy work.

CONCLUSION

To Korean small-scale farmers, ecological or cultural, mechanical weedings usually present practical difficulties, because their minor crop takes place on land holdings which are generally less than 0.7 ha. This means high costs, intensive labor and low income for them under currently mentioned IWM technologies, although we should inform them repeatedly about these useful measures. Also, re-development of the economic benefits of introducing alternate crops should hopefully be included in applying IWM methods to the sorghum production for both small- and large-scale farmers in Korea in the future. For the IWM in sustainable sorghum production, weed scientists should certainly have a strategy to study target technologies and to develop them in the near future, which are practically effective in the management of weeds in fields, economically applicable to sorghum farmers in Korean and sustainable for the environment.

Effect of different weed management strategies on productivity of maize under mid-hill rainfed conditions

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Maize is the most important cereal food crop of the world, cultivated over an area of 159.2 million ha globally with production and productivity of 835 million tones and 5.24 t/ha, respectively. Maize is very significant crop of Jammu and Kashmir State as it is staple food of majority of the people living in the hilly regions of the state. Maize is grown on an area of 311 thousand ha with the production and productivity of 6232 thousand quintals and 2.0 t/ha, respectively. However, the productivity of the maize crop is limited by a number of biotic and abiotic factors out of which weed infestation is the most limiting factor causing the yield loss to the crop from 30%-50%. These losses to the crop productivity are more pronounced in rainfed ecologies as weeds offer severe competition for moisture and nutrients to the crop. Hence, present study is aimed to device effective and economical weed management strategies to enhance productivity of maize in the mid-hill rainfed conditions of Jammu and Kashmir.

METHODOLOGY

A field experiment was conducted under mid-hill rainfed conditions of Jammu and Kashmir at AICRP Maize Research Centre, Udhampur during *Kharif* 2012. The average rainfall of the region during cropping season was 1283.6 mm. The soil of the experimental site was sandy-loam and low in Nitrogen, medium in Phosphorus and Potassium content. A total number of eight weed control treatments including weedy check were replicated thrice in Randomised Block Design. The weed count and weed dry matter accumulation were recorded at 50 DAS by quadrate method. The relative economics of treatments were worked out by taking minimum support price of maize.

RESULTS

Results of the experiment revealed that all weed control treatments recorded significantly lower weed density and dry matter of weeds over weedy check. The lowest weed dry matter and highest weed control efficiency were recorded in two hand weedings (20 & 40 DAS). However, the weed dry matter of broad leaved weeds observed with application of Atrazine at 1.0 kg/ha as PE, atrazine at 1.0 kg/ha at 20 DAS were statistically at par with two hand weedings (Kumar *et al.* 2012). All the weed control treatments recorded significantly higher maize grain yields over weedy check.

Table 1. Effect of different herbicides on weed density, weed dry matter and yield and economics of maize

Treatment	Grain yield (t/ha)	Weed density/ m^2 (narrow leaved weeds)	Weed density/ m^2 (broad leaved weeds)	Weed dry weight (narrow leaved weeds) g/m^2	Weed dry weight (broad leaved weeds) g/m^2	Net returns ($x10^3$ Rs./ha)	B:C ratio	Weed control efficiency (%)
Weedy check	2.41	10.06 (100.3)	9.5(95.33)	6.50(41.40)	7.11 (49.63)	6.18	1.2	-
Atrazine at 1.0 kg/ha PE	5.48	7.91 (61.7)	6.16(37.00)	4.75(21.73)	4.50(19.33)	46.08	2.9	54.8
Atrazine at 1.0 kg/ha 20 DAS	5.06	7.54(56.0)	6.24(38.00)	4.53(19.53)	4.55(19.73)	40.16	2.6	56.8
Pendimethalinn at 1.0 kg/ha PE	5.32	8.54(72.0)	6.40(40.00)	5.10(25.17)	4.67(20.90)	43.26	2.7	49.3
Maize + cowpea	3.70	9.31(85.7)	7.23(51.33)	5.93(34.27)	5.26(26.70)	22.48	2.0	33.0
One hand weeding 20 DAS	5.15	8.98(79.7)	6.42(40.33)	5.53(29.70)	4.89(23.07)	40.50	2.6	42.0
Two hand weedings 20 & 40 DAS	5.98	6.80(45.3)	5.53(29.67)	3.72(12.97)	4.15(16.30)	41.23	2.2	67.8
Organic mulch at 6.0 t/ha	3.26	9.28(85.3)	7.31(52.67)	6.13(36.80)	5.18(25.90)	17.21	1.7	31.1
LSD (P=0.05)	0.45	0.55	0.41	0.63	0.42	-	-	-

*Figures in parenthesis are original values subject to "x+1 square root transformations

The maximum grain yield was realized in two hand weedings (20 & 40 DAS) which was significantly higher than all the weed control treatments. The application of pendimethalin at 1.0 kg/ha, One hand weeding 20 DAS and Atrazine at 1.0 kg/ha 20 DAS were statistically at par with each other with respect to grain yield of maize. Further, in terms of relative economics, the maximum net returns and B:C ratio were obtained with application of Atrazine at 1 kg/ha as PE followed by Pendimethalin at 1 kg/ha as PE.

CONCLUSION

The applications of atrazine at 1 kg/ha as PE or pendimethalin at 1kg/ha as PE were found to be best weed management strategy for economical and effective weed management.

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Bioefficacy of post-emergence tembotrione application on weed dynamics and productivity of maize in rainfed foothill and mid-hill conditions

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Maize (*Zea mays* L.) called 'Queen of cereals' is one of the most important crops in the world's agricultural economy. The crop is cultivated on an area of about 159.2 mha globally with production and productivity of 835 mt and 5.24 t/ha, respectively (*Anonymous 2012*). It is a versatile crop and has a great potential to grow in the foot-hill and mid-hill conditions in the state. In the state of Jammu and Kashmir, maize has special significance because it forms the staple diet of majority of the people. It is a popular rain fed crop of Jammu region, which constitutes about 70% area. Maize being wide spaced crop and its slow growth during initial period favours weed growth even before the crop emergence. Yield losses due to season long weed infestation range from 30% to complete crop failure Usage of pre-emergence herbicides assumes greater importance in the view of their effectiveness from initial stages. But there was no post emergence herbicides still available in market, unfortunately if in any case farmer miss the application of pre emergent herbicides and the scarcity of labour, then there was no alternative for him to control the weeds emerging in later stages. Tembotrione, a new post emergent broad spectrum systemic herbicide belongs to group Triketone, is a pigment synthesis inhibitor, inhibits 4-HPPD enzyme, controls broad leaves as well as grassy weeds. Thus, managing weeds through pre-emergence and post emergence herbicides will be an ideal means for controlling the weeds in view of their economics and effectiveness in maize. Hence, keeping the above facts in the fore front, a study was carried out to find out the efficacy of post emergent herbicides as an alternative to manage weeds in later stages.

METHODOLOGY

A field experiment was carried out during the *Kharif* season of 2014 at the Research Farms of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu to evaluate the effect of post emergent tembotrione application on weed dynamics and productivity of *Kharif* maize in rainfed foothill and mid hill conditions of Jammu and Kashmir State. The experiment was laid out in randomized block design comprising eleven treatments with three replications each. The treatments consisted of tembotrione at 110 g/ha at 15 DAS, tembotrione at 110 g/ha at 30 DAS, tembotrione at 120 g/ha at 15 DAS, tembotrione at 120 g/ha at 30 DAS, tembotrione at 31 g/ha + atrazine at 370 g/ha at 15 DAS, atrazine at 1 kg/ha pre emergence, pendimethalin at 1 kg/ha pre emergence, halosulfuron methyl at 135 g/ha at 15 DAS, 2 hand weedings at 15 DAS and 30 DAS, weedy check and weed free. Maize crop variety '*Double dekalb*' was sown with a seed rate of 20 kg/ha. The mean data on weeds were subjected to square root transformation ("x+1) to normalize their distribution.

RESULTS

The experimental field was infested with mixed weed flora. Grassy weeds were predominant, followed by sedges and broad-leaved weeds. E*chinochloa colonum* among the grassy weeds and *Cyperus rotundus* among the sedges were more dominant. All the weed management treatments significantly reduced the weed population over the weedy check. Significantly highest weed control efficiency and grain yield under both foothill and mid hill conditions were observed in 2 hand weedings at 15 and 30 DAS which was found to be statistically at par with application of tembotrione post emergence at 120 g/ha at 15 DAS under both the situations. Application of tembotrione at 120 g/ ha at 15 DAS registered highest B:C ratio of 1.24 and 1.58, respectively under foot hill and mid hill conditions (Table 1).

Table 1. Effect of post emergent tembotrione application on weed dynamics, grain yield and B:C ratio of *Kharif* maize in rainfed foothill and mid hill conditions of J & K

Treatment	Foot hill conditions				Mid hill conditions			
	Weed Population (no./m^2)	Weed control efficiency	Grain yield kg/ha	B:C ratio	Weed Population (no./m^2)	Weed control efficiency (%)	Grain yield (t/ha)	B:C ratio
Tembotrione at 120 g/ha at 15 DAS	37.00 (6.16)	84.63	2496	1.24	47.00 (6.91)	82.9	2.89	1.58
Atrazine at 1 kg/ha pre-emergence	68.00 (8.31)	71.75	2227	1.05	83.67 (9.15)	69.5	2.56	1.32
Pendimethalin at 1 kg/ha pre-emergence	115.3 (10.78)	52.08	2020	0.82	126.33 (11.28)	54.0	2.41	1.16
2 Hand weedings at 15 DAS and 30 DAS	31.67 (5.69)	86.84	2535	0.82	38.67 (6.29)	85.9	2.98	1.12
Weedy check	240.67 (15.54)	0.00	1450	0.46	275.00 (16.60)	0.0	1.71	0.71
Weed free	1.0 (0.00)	100.00	2765	0.76	1.0(0.00)	100.0	3.25	1.05
LSD(P=0.05)	0.69	-	226	-	0.90	-	0.19	-

*Figures in parentheses are original values subject to "x+1 square root transformations

CONCLUSION

Hence, it can be safely concluded that Post emergent application of tembotrione at 120 g/ha at 15 DAS has been found to be an efficient weed management tool in the hands of the maize growers who either misses pre-emergence herbicidal application, reduced weed control efficiency in case of rain immediately after application or could not afford the labour intensive hand weedings.

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Efficacy of tembotrione on mixed weed flora and yield of spring maize under irrigated sub-tropical shiwalik foothills

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Maize (*Zea mays* L.) occupies a pride place in India both as food and feed for animals and is a versatile crop has a great potential to grow not only in summer but during winter and spring seasons also in the foot-hill and mid-hill conditions in the state. Presence of weeds reduces the photosynthetic efficiency, dry matter production and distribution to economical parts and thereby reduces sink capacity of crop resulting in poor grain yield. Thus yield losses due to season long weed infestation range from 30-45% leading to crop failure (Pandey *et al.* 2001). As the weeds interfere during the harvesting of the crop, post emergence herbicide Tembotrione controls broad leaved as well as grassy weeds and help in avoiding the problem of weeds at later stages. Managing weeds through pre-emergence and post emergence herbicides will be an ideal means for controlling the weeds in view of their economics and effectiveness in maize. Keeping in view the above facts, the present investigation was undertaken.

METHODOLOGY

A field experiment was conducted during the spring season of 2013 at the Research Farm of Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The experiment was laid out in randomized block design with eleven treatments and three replications. The treatments consisted of tembotrione at 110 g/ha at 15 DAS, tembotrione at 110 g/ha at 30 DAS, tembotrione at 120 g/ha at 15 DAS, tembotrione at 120 g/ha at 30 DAS, tembotrione at 31 g/ha + atrazine at 370 g/ha at 15 DAS, atrazine at 1 kg/ha pre emergence, pendimethalin at 1.0 kg/ha pre emergence, halosulfuron methyl at 135 g/ha at 15 DAS, 2 hand weedings at 15 DAS and 30 DAS, weedy check and weed free. Spring maize crop variety '*JH-3459*' was sown with a seed rate of 20 kg/ha. The mean data on weeds were subjected to square root transformation ("x+1) to normalize their distribution. Observations for yield and yield attributing characters were recorded after the harvest of crop. Data on weed growth, yield performance and economics were recorded.

RESULTS

The experimental field was infested mainly with broad leaved weeds *Phyllanthus niruri* and *Solanum nigrum,* while the grassy weeds includes *Cynodon dactylon, Digitaria sanguinalis* and *Sorghum halepense*. *Cyperus rotundus* was found to be the only dominant sedge. The application of tembotrione post emergence at 120 g/ha at 15 DAS found very effective in reducing weed density and dry weight. The lowest value of weed index was recorded with post emergence application of tembotrione at 120 g/ha at 15 DAS followed by post emergence application of tembotrione at 120 g/ha at 30 DAS and two hand weedings at 15 and 30 DAS. Among the herbicidal treatments post emergence application of tembotrione at 120 g/ha at 15 DAS recorded significantly higher grain and stover yield of spring maize. Application of tembotrione at 120 g/ha at 15 DAS registered highest net returns and B:C ratio which was followed by tembotrione at 120 g/ha at 30 DAS.

Table 1. Effect of weed management practices on weed growth, yield and economics of spring maize

Treatment	Total weed count/m^2	Dry matter accumulation (g/m^2)	Weed Index (%)	Grain yield (t/ha)	Net Returns (x10^3 Rs. /ha)	B:C Ratio
Tembotrione at 120 g/ha at 15 DAS	5.68 (31.3)	3.49 (11.1)	4.53	3.24	43.97	1.88
Tembotrione at 120 g/ha at 30 DAS	5.89 (33.7)	3.59 (11.9)	6.17	3.19	43.02	1.84
Tembotrione at 31 g/ha + atrazine at 370 g/ha at 15DAS	9.91 (97.4)	7.34 (52.8)	17.30	2.81	36.19	1.58
Atrazine at 1 kg/ha PE	7.78 (59.6)	4.98 (23.8)	12.18	2.98	39.35	1.69
Pendimethalin at 1 kg/ha PE	10.4 (106.6)	8.67 (74.2)	22.41	2.63	32.58	1.36
2 Hand weedings at 15 DAS and 30 DAS	6.21 (37.6)	3.77 (13.2)	6.60	3.17	37.99	1.34
Weedy check	14.8 (218.6)	10.04 (99.8)	40.05	2.03	21.78	0.98
Weed free	1.00 (0.0)	1.00 (0.0)	0.00	3.39	38.99	1.25
LSD (P=0.05)	0.36	0.28	-	0.15	-	-

CONCLUSION

Post emergent application of tembotrione at 120 g/ha either at 15 DAS or 30 DAS has been found to be an innovative and new tool in the hands of the maize farmers of the region who either could not go for pre-emergence herbicidal application or could not afford the labour intensive hand weedings.

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Long-term effect of tillage and weed management on productivity of maize-wheat cropping system in sub-tropical foot hill plains

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Maize and wheat are the two important staple food crops of India which provide food security to the country's population. In India it is cultivated over an area of 8.71 million ha with the production and productivity of 21.57 million tones and 2.48 t/ha (Anonymous 2012). In India wheat is cultivated over an area of 29.25 million ha registering a total production of 92.30 million tones with productivity of 2.93 t/ha (Anonymous 2013). Intensive tillage can also have a negative impact on environment quality by accelerating soil carbon loss and green house gas emissions. Further, tillage operations account for more than 25% of agricultural production costs and with increasing in fuel prices, tillage now accounts for a higher proportion of production costs than harvesting does. Therefore, it is need to evaluated long term impact of tillage and weed management practices on productivity of maize-wheat cropping system.

METHODOLOGY

A field experiment was conducted to study the long term effect of tillage and weed management on productivity of maize-wheat cropping system in sub-tropical foot hills plain of Jammu at research farm, SKUAST-J during the *Kharif* and *Rabi* seasons of 2013-14. The soil of the experimental site was sandy clay loam in texture, low in organic carbon and nitrogen, medium in available phosphorous and potassium. The experiment was laid out in split-plot design with three replication. The treatments were comprised of zero, zero, conventional, conventional as in main plot in maize and zero, conventional, zero, conventional in wheat where as the sub plot treatments included hand weeding, recommended herbicide (Atrazine in maize and metribuzine in wheat) and weedy check. The varieties of *Kharif* maize were '*Kanchan-517*' and wheat is '*RSP-561*' respectively.

RESULTS

In maize, weed population was not influenced significantly due to different tillage treatments but zero tilled plots recording relatively higher weed dry matter and corresponding lower grain yield. The weed control treatments showed significant variations with respect to weed population, weed dry matter and grain yield of maize. Significant highest grain yield was recorded with two hand weedings which was followed by statistically similar maize grain yield attained with the application of atrazine at 1kg/ha.

Table 1. Weed count, Weed dry weight and grain yield of maize-wheat as influence by different tillage and weed control treatment

Treatment	Weed count at Pre-tasseling/m^2)	Weed count at 30 DAS/m^2	Weed Dry wt. at Pre tasseling (g/m^2)	Weed Dry wt 30 DAS (g/m^2)	Grain Yield (t/ha)	Grain Yield (t/ha)
Main Plot(M *fb* W)	Maize	Wheat	Maize	Wheat	Maize	Wheat
ZT *fb* ZT	4.01(16.10)	8.84(77.09)	31.30	20.94	3.14	3.147
ZT pb CT	3.86(14.90)	7.93(61.88)	30.10	15.96	3.26	3.325
CT pb ZT	3.64(13.30)	8.82(76.84)	28.50	19.52	3.64	3.157
CT pb CT	3.45(11.60)	7.85(60.66)	26.70	11.85	3.85	3.336
SEM±	0.29	0.07	0.78	1.36	0.97	7.15
LSD (P=0.05)	NS	0.21	2.20	4.09	0.29	NS
Sub Plot						
Hand weeding	2.79(7.79)	7.04(48. 10)	11.60	13.06	4.08	3.850
Recommended herbicide (Atrazine at 1 kg/ha)	2.84(8.10)	6.28(38.00)	11.90	9.68	3.92	3.958
Weedy Check	6.02(36.30)	11.01(119.90)	66.9 0	29.56	2.53	1.916
LSD (P=0.05)	0.43	0.33	1.71	3.37	0.24	3.0669

Significantly lowest maize-grain yield was observed in weedy check treatment. Almost a similar trend was noticed with respect to weed population and dry matter of weeds in maize. In wheat crop, it was observed that weed population and dry weight of weeds remained significantly higher where zero-tillage was practices to the wheat crop for its establishment. The weeds population and dry matter decreased in the wheat crop when conventional tillage was practiced in the wheat. However, grain yield did not differ significantly due to different tillage treatments. The weed population, weed dry matter and grain yield of wheat were significantly influence by weed control treatments. Significantly highest grain yield of wheat was recorded with application of metribuzine at 200 g/ha which was found to be at par with the yield value obtained with two hand weeded plots. Almost a similar trend was observed with respect to weed population and weed dry matter production at 60 DAS of wheat crop.

CONCLUSION

It was concluded that in maize, conventional tillage *fb* conventional tillage with two hand weeding resulted in excellent result followed by conventional *fb* conventional tillage with application of attrazine 1 kg/ha and in wheat conventional *fb* conventional tillage with application of metribuzine 200 g/ha was best followed by conventional *fb* zero with application of atrazine 1kg/ha.

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Weed flora and yield of winter maize + potato intercropping system as influenced by weed management

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Maize (*Zea mays* L.) is one of the oldest and most productive cereal food crop. The acreage of winter maize in India is increasing very fast due to its higher productivity and net profit compared to traditional *Kharif* crop. The average productivity of winter maize is 4.0 t/ha compared to 2.0 t/ha of *Kharif* maize. Maize being a widely spaced crop gets infested with variety of weeds and subjected to heavy weed competition. Planting potato as intercrop in between main rows not only helps in the maximum utilization of natural resources but also contributes higher yield of crops .Therefore, an investigation was carried out to study the effect of different weed management practices on weed control and yield of winter maize + potato intercropping system under agro climatic conditions of Jammu.

METHODOLOGY

A field experiment was conducted on sandy loam soil during the *Rabi* 2009-10 and 2010-11. The experiment consisted of four main plot treatments; winter maize (sole), potato (sole), winter maize + potato (additive series) and winter maize + potato (replacement series) and six sub-plot treatments comprising of weedy check, weed free, alachlor pre at 1.5 kg /ha, atrazine pre at 0.5 kg /ha, early post alachlor at 2.0 kg /ha and atrazine post at 0.75 kg /ha and laid out in split plot design with three replications. Winter maize '*Bulland'* of 175 days duration and potato '*Kufri Sinduri'* of 120 days duration were sown at row to row spacing of 60 cm. Application of fertilizer in sole maize was 175-60-30 kg N-P_2O_5-K_2O /ha, whereas in case of sole potato was 120-60-120 N-P_2O_5-K_2O / ha.

RESULTS

Broad leaved weeds were predominant (51.2%) followed by sedges (36.7%) and grassy weeds (12.1%). M*edicago sativa* among the broad leaved weeds, *Phalaris minor* among the grassy weeds and *Cyperus rotundus* among the sedge were more dominant. Herbicidal treatments significantly influenced the population and dry matter production of weeds. It was observed that sole winter maize resulted in higher weed density which was significantly higher than sole potato and winter maize + potato (additive series), whereas the lowest total weed density was recorded in winter maize + potato (additive series). This might be due to the fact that slow initial growth and wider row spacing of maize provided relatively conducive conditions for growth of weeds (Pandey *et al.* 2003). Among the weed management practices, lowest total weed density and weed biomass were recorded with application of atrazine pre emergence at 0.5 kg/ha which was followed by post emergence application of atrazine at 0.75 kg/ha. Winter maize + potato (additive series) appeared to be biologically most efficient system giving the highest production efficiency followed by winter maize + potato (replacement series). Intercropping of winter maize + potato (additive series) significantly enhanced grain yield of winter maize. Among the weed control practices, pre emergence application of atrazine at 0.5 kg/ha recorded significantly higher grain yield which was statistically at par with post emergence application of atrazine at 0.75 kg/ha and pre emergence application of alachlor at 1.5 kg/ha.

Table 1. Wed density, weed dry weight, production efficiency and yield of maize and potato as influenced by different weed control treatments in winter maize-potato intercropping system

Treatment	Weed density/m^2	Weed dry weight (g/m^2)	Production efficiency kg/ha/day	Maize (t /ha)	Potato (t/ha)
Sole maize	8.4(90.6)	8.0 (73.6)	26.43	4.8	-
Sole potato	7.7(75.8)	7.4(67.7)	84.94	-	23.7
winter maize + potato (additive series)	7.2(66.8)	6.9(60.0)	88.87	3.6	19.2
winter maize + potato (replacement series)	8.2(88.0)	8.2(80.3)	65.04	2.3	14.5
LSD (P= 0.05)	0.14	0.13		0.14	0.9
Weed management (WM)					
Weedy check	15.5(241.0)	14.8(208.5)	40.34	1.75	12.3
Weed free	1.0(0.00)	1.0(0.00)	76.46	4.4	21.5
Alachlor PRE at 1.5 kg/ha	7.5(57.3)	7.3(50.5)	72.24	3.8	20.9
Alachlor E-POST at 2.0 kg/ha	9.2(84.0)	9.2(80.5)	68.34	3.4	20.1
Atrazine PRE at 0.5 kg/ha	6.6(42.4)	6.1(33.9)	72.03	4.0	20.5
Atrazine POST at 0.75 kg/ha	7.5(57.0)	7.3(50.4)	68.50	3.9	19.4
LSD (P= 0.05)	0.08	0.09		0.13	0.7

*Figures in parenthesis are original values subject to "x+1 square root transformations

CONCLUSION

It was concluded that winter maize + potato (additive series) and pre-emergence application of atrazine at 0.5 kg/ha were most effective for controlling weeds and improving grain yield of maize and tuber yield of potato.

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Efficacy of oxyflourfen on weed suppression in transplanted finger millet

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Finger millet (*Eleusine coracana* (L.) Gaertn.) is the most important small millet grown in Andhra Pradesh in an area of 44,000 ha with a production of 54,000 tones (Ministry of Agriculture 2012). Among the various reasons, weed infestation is a major constraint which limits its productivity level from 34-61% (Prasad *et al.* 1991).Oxyflourfen (oxygold) is found to be effective against grasses and broad leaved weeds compared to sedges in finger millet (Pradhan *et al.* 2010). Although manual weeding is effective, it is laborious, costly and time consuming. The scarcity of manpower unables to take up hand weeding at critical period of weed infestation in finger millet.Under such situations, application of herbicides may provide best alternative to hand weeding for timely weed control and optimizing the yield of finger millet.

METHODOLOGY

A field experiment was carried out during *Kharif*, 2013 at S.V. Agricultural College Farm , Tirupati (Andhra Pradesh). The experiment consisted of 10 treatments laid out in a randomized block design with three replications. Two pre emergence herbicides viz., oxyflourfen and oxadiargyl were applied at 3 DAT. Also these pre-emergence herbicides were integrated with two post emergence herbicides, *viz.* azimsulfuron, chlorimuron-ethyl and hand weeding at 20 DAT. One treatment was incorporated as hand weeding twice at 20 and 40 DAT. These treatments were compared with unweeded check. The finger millet variety used was Vakula, by adopting seed rate of 3 kg/ha. The recommended dose of 60 N, 30 P_2O_5 and 30 kg K_2O /ha was applied through urea, single super phosphate and muriate of potash respectively. Data on weed dynamics, yield performance and economics were recorded.

RESULTS

Dactyloctenium aegyptium and *Digitaria sanguinalis* among grasses; *Cyperus rotundus* among sedges; *Eclipta alba* among broad leaved weeds (BLW) were more domoinant. Among the weed management practices tried, the lowest density and dry weight of the weeds *viz.*, grasses, sedges and BLW were recorded with pre-emergence application of oxyflourfen at 100 g/ha *fb* azimsulfuron at 20 g/ ha applied at 20 DAT, which was however on par with oxyflourfen *fb* hand weeding at 20 DAT. The higher weed control efficiency values of 98.1 and 97.4% were obtained with pre-emergence application of oxyflourfen *fb* azimsulfuron applied at 20 DAT and oxyflourfen *fb* hand weeding at 20 DAT respectively compared to unweeded check.Grain yield, straw yield, net returns and B:C ratio were significantly higher in the these treatments. These results corroborate with the findings of Pradhan *et al.* (2010). The yield reduction to a tune of 47% was observed with unweeded check compared to oxyflourfen *fb* azimsulfuron.

Table 1. Weed dynamics, yield and economics of transplanted finger millet as influenced by different weed management treatments

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	Weed control efficiency (%)	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (x10^3 Rs)	B:C Ratio
Oxyflourfen at 100 g/ha as pre-emergence	12.7(163.10)	10.28 (105.15)	56.1(48.50)	2.13	2.98	19.29	1.93
Oxadiargyl at 75 g/ha as pre-emergence	13.0(169.30)	10.77 (115.39)	51.8 (46.03)	2.12	2.96	18.88	1.90
Oxyflourfen *fb* hand weeding at 20 DAT	3.9(15.42)	2.57 (6.13)	97.4(80.72)	3.19	4.23	37.49	2.70
Oxadiargyl *fb* hand weeding at 20 DAT	10.8(116.11)	7.04 (49.02)	79.5(63.08)	2.47	3.56	23.51	2.03
Oxyflourfen *fb* azimsulfuron at 20 g/ha at 20 DAT	3.36(10.81)	2.22 (4.45)	98.1(82.07)	3.38	4.24	41.13	2.88
Oxadiargyl *fb* azimsulfuron	11.1(122.75)	7.01 (48.59)	79.7(63.22)	2.47	3.56	24.15	2.09
Oxyflourfen *fb* chlorimuron-ethyl at 5 g/ha at 20 D	6.47(41.40)	4.90 (23.53)	90.2(71.75)	2.83	3.77	31.83	2.52
Oxadiargyl *fb* chlorimuron-ethyl	10.9(120.20)	7.03 (48.93)	79.6(63.15)	2.48	3.56	25.11	2.18
Hand weeding twice at 20 and 40 DAT	6.15(37.28)	4.63 (20.97)	91.2(72.74)	2.83	3.77	28.31	2.15
Unweeded check (Control)	17.1(294.97)	15.49 (239.32)	0.0(0.52)	1.78	2.46	13.22	1.66
LSD (P = 0.05)	1.51	1.39	8.6	0.34	0.38	5.17	0.19

Values in parentheses are original. Data transformed to square root transformation.

CONCLUSION

Results revealed that the weed control practice involving either herbicides as pre- emergence application of oxyflourfen *fb* azimsulfuron applied at 20 DAT or integrated weed management practice of pre-emergence application of oxyflourfen *fb* hand weeding at 20 DAT were proved to be the best practices for effective weed suppression to obtain higher yield in transplanted finger millet.

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Integrated weed management in popcorn

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In Indian agriculture, Maize assumes a special significance on account of its utilization as food, feed and fodder besides several industrial uses. Popcorn [*Zea mays* L. var. *everta* (Sturtev.) L.H. Bailey] is one of the major speciality corns, which is popular as a snack food in many parts of world. Nature of weed problem in *rabi* maize is quite different from that of the rainy season maize. However, wider row spacing and liberal use of irrigation and fertilizers lead to more growth of weeds . The potential yield losses due to weeds can be as high as about 65% depending on the crop, degree of weed infestation, weed species and management practices (Yaduraju *et al.* 2006). Pre-emergence application of herbicides may lead to cost effective control of the weeds right from the start which otherwise may not be possible by manual weeding. The present study was carried out to find out economically effective methods of weed control for realizing higher productivity and profitability of *Rabi* popcorn.

METHODOLOGY

The experiment was carried out at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat) during *Rabi* 2010-11. The experiment comprised nine treatments, evaluated in randomized block design with three replications. The experimental soil was clayey in texture and low in available N and moderate in available phosphorus and potash. The popcorn (*Amber*) was sown in the last week of November with the seed rate of 15 kg/ha in the rows of 60 cm apart. All standard packages of practices were followed throughout the cropping season. Pre-emergence herbicides were applied next day of sowing.

RESULTS

Growth and yield attributes as well as cob and fodder yields were significantly influenced by different weed control practices (Table 1). Results showed that significantly higher plant height at harvest (159.40 cm), dry matter at harvest (179.24 g). cob length (19.00 cm), number of cobs per plant (2.07), number of grains per cob (421.33), grain weight per cob (86.96 g), grain yield (3.69 t/ha) and fodder yield (7.35 t/ha) were recorded under weed free, which remained statistically equivalent to HW & IC at 15 and 30 DAS, atrazine 0.5 kg/ha as PRE + HW & IC at 30 DAS and pendimethalin 0.9 kg/ha as PRE + HW & IC at 30 DAS. The improved growth and yield attributes under these treatments might be due to periodical removal of weeds by hand weeding or pre-emergence herbicide supplemented with manual weeding, which might have maintained high soil fertility and moisture status by means of less removal of plant nutrients and moisture through weeds. All the treatments significantly reduced the weed population (Table 1) compared to weedy check. Next to the weed free, HW & IC at 15 and 30 DAS recorded significantly the lowest weed population (Table 2), which remained statistically at par with atrazine 0.5 kg/ha as PRE + HW & IC at 30 DAS and pendimethalin 0.9 kg/ha as PRE + HW & IC at 30 DAS. Excluding weed free, the lowest dry weight of weed was observed under HW & IC at 15 & 30 DAS, though it was found statistically at par with atrazine 0.5 kg/ha as PRE + HW & IC at 30 DAS. These findings are in close conformity with those reported by Mathukia *et al.* (2014).

Table 1. Effect of different weed control treatments on growth and yield of *Rabi* popcorn

Treatment	Plant height (cm)	Dry matter per plant (g)	Grain weight per cob (g)	Grain yield (t/ha)	Fodder yield (t/ha)	WI	WCE
Atrazine + HW and IC	150.5	151.3	79.2	3.62	7.15	1.92	84.2
Pendimethalin + HW and IC	148.7	150.5	77.6	3.55	7.07	3.80	77.7
Atrazine and pendimethalin + HW & IC	139.9	138.8	65.6	2.01	5.03	45.47	70.3
HW and IC +Atrazine	140.9	145.8	74.6	2.77	5.55	24.78	71.3
HW and IC +2,4-D	144.3	148.8	67.6	3.12	6.11	15.38	72.2
HW and IC +2,4-D and Metsulfuron methyl	138.2	135.3	62.2	1.73	3.81	52.99	66.6
HW and IC twice	158.0	172.2	80.1	3.64	7.24	1.28	88.8
Weed free	159.4	179.2	86.9	3.69	7.35	0.00	100.0
Unweeded control	112.0	105.8	61.4	1.31	2.91	64.27	0.0
LSD (P=0.05)	17.8	25.4	11.1	0.67	1.10		

CONCLUSION

Effective and economical management of weeds with higher grain yield of popcorn in *Rabi* season can be obtained by pre-emergence application of atrazine 0.5 kg/ha *fb* HW & IC at 30 DAS or HW & IC at 15 & 30 DAS or Pendimethalin 0.9 kg/ha as pre-emergence *fb* HW & IC at 30 DAS under south Saurashtra Agro-climatic conditions.

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Optimizing irrigation scheduling and weed management strategies in furrow-irrigated raised-bed planted maize under semi-arid environment

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Rice-wheat is the most dominating crop sequence of Indo-Gangetic Plains. To meet high water requirement of rice, continuous cropping of this sequence has adversely affected the ground water resources. Maize could be an alternative to rice provided its productivity is enhanced to the level of economic competitiveness. The present yield levels of maize in India (2.48 t/ha) and Haryana (2.67 t/ha) are very low, *i.e.* < 50% of the world average (5.18 t/ha). In *Kharif* maize water management is essential for achieving potential yields with high water productivity. It also suffers heavily from weeds and yield losses can vary from 28-100% (Patel *et al*. 2006). Furrow irrigated raised bed system (FIRBS) of planting crops enhance yields, improves water productivity and facilitates better weed management (Kumar *et al*. 2014). Therefore, refinement of water and weed management practices and their integration under FIRBS plantation need to be evaluated for achieving higher and stable yields.

METHODOLOGY

Experiment was conducted at Research Farm of Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Kharif* 2013 to study irrigation scheduling and weed management strategies on furrow irrigated raised bed (FIRB) planted maize. The soil was slightly alkaline (pH=8.2) sandy loam in texture with low available N, medium P_2O_5 and K_2O. It contained 21.7% moisture at -0.03 MPa (FC) and 7.2% at -1.5 MPa (PWP). Four irrigation schedules, *viz*. irrigation at 80, 120, 160 and 200 mm cumulative pan evaporation (CPE) in main plots and five weed treatments in sub plots were studied. Maize hybrid HQPM-1 was dibbled on the top of bed keeping 75 cm row and 20 cm plant spacing. During the *Kharif* season of maize crop a total of 691.6 cm well distributed rainfall was received and therefore two irrigations were applied at 80 mm CPE only.

RESULTS

Lowest weed density was observed with irrigation at 80 mm CPE; statistically at par under irrigation at 120 mm CPE but significantly lower than irrigation at 160 and 200 mm. Weed dry matter was also significantly lower with irrigation at 80 mm CPE than 200 mm CPE but was statistically at par with irrigation at 120 and 160 mm CPE. Irrigation applied at 80 mm CPE resulted in highest (50.93%) weed contol efficiency (WCE), whereas irrigation at 200 mm CPE resulted in lowest (40.3%) WCE. At 40 days after sowing (DAS), the weed density as well as weed dry matter was maximum in weedy check and minimum in weed free treatment (Table 1). Among herbicidal treatments significantly lower weed density and weed dry matter was observed with the pre-emergence application of atrazine (750 g/ha). Application of tembotrione (120 g/ha) at 15-20 DAS and pre emergence pendimethalin (1000 g/ha) resulted in significantly higher weed density and weed dry weight than atrazine (750 g/ha) but were statistically at par with each other. Among herbicidal treatments, the weed control efficiency (WCE) was highest (65.16%) with the pre emergence application of 750 g/ha atrazine and lowest (31.86 %) with pre emergence application of pendimethalin (1000 g/ha). Application of irrigation at 80 mm CPE produced significantly higher maize grain yield of 5.01 t/ha as compared to irrigation at 120, 160 and 200 mm CPE. The difference in maize grain yield among the later three moisture regimes remained statistically at par (Table 1). The highest grain yield (5.17 t/ha) was recorded in weed free and lowest (2.74 t/ha) in unweeded check. The yield loss due to uncontrolled growth of weeds as compared to weed free treatment was 73.02%. Among herbicidal treatments, atrazine at 750 g/ha recorded maximum grain yield (5.05 t/ha) which was significantly higher than tembotrione at 120 g/ha and pendimethalin (PRE) at 1000 g/ha.

Table1. Weed growth and yield of maize under different irrigation and weed control treatments

Treatment	Weed density at 40 DAS (no./m^2)	Weed dry matter at 40 DAS (g/m^2)	Weed control efficiency (%)	Maize grain yield (t/ha)
Irrigation scheduling				
80 mm CPE	5.65 (49.83)	7.37 (84.00)	50.93	5.01
120 mm CPE	5.75 (49.92)	7.69 (92.07)	50.11	3.79
160 mm CPE	6.38 (63.58)	7.93 (96.14)	47.92	3.80
200 mm CPE	6.73 (66.33)	8.66 (118.13)	40.35	3.85
LSD (P=0.05)	0.56	0.35	-	0.37
Weed control treatmen				
Weed free	1.00 (0.00)	1.00 (0.00)	100.00	5.15
Weedy check	9.03 (81.42)	12.19 (147.11)	0.00	2.74
Pendimethalin (PRE), 1000 g/ha	7.88 (61.25)	10.08 (100.91)	31.86	3.79
Atrazine (PRE), (750 g/ha)	5.29 (30.08)	7.14 (52.58)	65.16	5.05
Tembotrione at 15-20 DAS, (120 g/ha	7.47 (55.17)	9.46 (88.86)	39.60	3.83
LSD (P=0.05)	0.48	0.34	-	0.26

Data on weed density and weed dry matter is square root transformed. Values in parentheses are original.

CONCLUSION

Pre emergence application of atrazine at 750 g/ha coupled with irrigation at 80 mm CPE was found to be most effective in controlling weeds and improving grain yield of maize during the *kharif* 2013 season.

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Integrated weed management with cultural manipulation for effective weed control and higher yield of sweet corn

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Recently, out of various specialty corns, sweet corn is a mutant type which is gaining popularity among nutritive and health conscious urban mass in India. Sweet corn, unlike seed corn is far less competitive in growth, lacks dense plant canopy and allows considerable light to enter for weed development. This factor coupled with the high nutrient requirement of the crop makes it susceptible to heavy weed infestation (Pierce 1989). Appropriate planting pattern has tremendous ability in checking losses due to weeds, improve resource use efficiency and maximize yield per unit area. These facts necessitate detecting the effect of cultural manipulation in combination with different weed control measures on weeds as well as crop growth and yield to suggest an efficient integrated weed management strategy for sweet corn.

METHODOLOGY

Field experiments were conducted during two consecutive *Rabi* seasons of 2004 and 2005 at S.V. Agricultural College, Tirupati. The experiment was laid out in split-plot design, with three replications. The treatments comprised of four planting patterns i assigned to main plots and four weed control practices *i.e* weedy check, two hand weedings at 15 and 30 DAS, pre-emergence application of atrazine 1.0 kg/ha + hand weeding at 30 DAS and pre-emergence application of atrazine 1.0 kg/ha + post-emergence application of paraquat 0.5 kg/ha at 30 DAS were allotted to sub plots. Post-emergence application of paraquat at 30 DAS was applied by directed spraying in between the crop rows, with the help of specially designed hood, to avoid spray drift. The test variety was '*Madhuri*', a super sweet and succulent maize type.

RESULTS

The density and dry weight total weeds were significantly influenced by different planting patterns and weed management practices whereas the interaction effect between them was not significant. The latter planting pattern of 75 x 20 cm resulted in the highest density and dry weight of total weeds (Table.1). The narrow row spacing of 60 cm along with higher plant population of 83,333 plants/ha with 60 x 20 cm might have provided lesser space for weed emergence and modified the microenvironment of the crop canopy by reducing light transmittance to the ground for weed growth up to 45 DAS as reported by Tisdale (1995). The highest yield of green cob as well as green fodder were recorded with 60 x 20 cm which were comparable with 75 x 16 cm. With regard to weed control practices, pre-emergence application of atrazine 1.0 kg/ha + hand weeding at 30 DAS resulted in significantly lesser density and dry weight of total weeds, highest green cob and fodder yield, which were comparable with two hand weedings and pre-emergence application of atrazine 1.0 kg/ha + post-emergence application of paraquat 0.5 kg /ha. The highest values of weed dynamics withj the lowest level of crop yield were recorded with weedy check. Post-emergence application of paraquat at 0.5 kg/ha or hand weeding imposed at 30 DAS were equally effective in controlling the second flush of weeds and provided congenial environment during the critical period for crop weed competition in sweet corn upto 45 DAS.

Table 1. Weed growth and yield of sweet corn as influenced by planting patterns and weed control practices

Treatment	Weed density (no./m^2)		Weed dry weight (g/m^2)		Green cob yield (t/ha)		Green fodder yield (t/ha)	
	2004	2005	2004	2005	2004	2005	2004	2005
Planting pattern								
75 x16 cm (83.333 plants/ha)	10.5(123.2)	10.9(137.2)	11.5(148.4)	11.6(159.6)	13.18	12.59	16.6	15.7
60 x20 cm (83,333 plants/ha)	9.8(104.4)	9.5(109.5)	10.6(126.7)	10.4(137.3)	13.97	13.19	17.6	16.7
75 x20 cm (66,666 plants/ha)	12.7(172.9)	12.8(194.0)	13.4(199.8)	13.7(218.1)	10.93	10.37	13.8	13.0
60 x25 cm (66,666 plants/ha)	120.0(158.1)	12.5(178.9)	12.9(189.7)	13.1(200.5)	11.77	10.93	15.0	14.1
LSD (P=0.05)	1.79	1.47	0.89	1.56	0.92	0.67	1.53	1.60
Weed control practices								
Weedy check	16.7(310.5)	19.3(375.6)	19.2(373.9)	21.0(448.0)	8.24	7.88	11.0	10.3
Two hand weedings at 15 and 30 DAS	8.8(79.3)	8.7(77.5)	9.8(98.9)	9.2(87.6)	13.52	12.74	16.2	15.5
Pre emergence application of atrazine 1 kg/ha + hand weeding at 30 DAS	8.5(72.6)	8.4(73.5)	9.35(88.7)	8.9(81.8)	14.22	13.41	18.0	17.1
Pre emergence application of atrazine 1 kg/ha + post emergence application of paraquat 0.5 kg/ha at 30 DAS	9.7(96.3)	9.2(87.0)	10.11(102)	9.8(98.4)	13.88	13.07	17.5	16.6
LSD (P=0.05)	1.67	0.95	1.45	1.33	0.93	1.00	1.86	1.73

*Values in paranthesis are original. Data transformed to square root transformation

CONCLUSION

Efficient control of weeds along with the highest green cob and fodder yield of sweet corn could be realized with cultural manipulation of crop with a planting pattern of 60 x 20 cm (83,333 plants/ha) and the integrated weed management practice of pre-emergence application of atrazine at 1.0 kg/ ha + hand weeding at 30 DAS.

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Efficacy of pre-emergence herbicide mixtures in maize

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Maize is the world's third most cereal crop after wheat and rice. It is known for its yield potential. Maize, being a rainy season and widely spaced crop, gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses ranging from 28-100% (Patel *et al.* 2006). Since labour is costly and scarce, timely weeding is not possible and this becomes major bottle neck in its production. There are very few herbicide options available for weed control in maize in India. Among the recommended herbicides, *viz.* atrazine, alachlor and pendimethalin, the former controls broad leaf weeds effectively, whereas the latter two are effective against grassy weeds. Keeping all these aspects in view, an attempt was made to find out effective pre emergent herbicide mixtures for broad spectrum weed control in maize, in comparison with recommended practice.

METHODOLOGY

A field experiment was carried out during *Kharif* season of 2014 at Agricultural Research Station, University of Agricultural Sciences, Dharwad. The soil was medium deep black soil. The experiment was laid out in RCBD with three replications involving 12 treatments. The herbicide mixtures, *viz.* atrazine + 2,4-D, atrazine + alachlor, atrazine + pendimethalin were employed in the study with their 100, 75 and 50% of their recommended doses. The seeds of '*M-900*' were dibbled manually at spacing of 60 x 20 cm. Recommended dose of fertilizers were applied as per package of practice. The herbicide mixtures were sprayed next day of sowing. Observations on weed density and weed dry weight were taken on 60 DAS, yield was taken and economics of the treatments were worked out.

RESULTS

In general, the weed density and weed dry weight of weeds were significantly reduced with the application of pre emergent herbicides mixtures compared to recommended practice. Significantly lower weed density and weed dry weight were recorded with herbicide mixtures, *viz.* atrazine + alachlor and atrazine + pendimethalin irrespective of their proportions indicating these herbicide mixtures were effective in controlling all types of weeds. Weed density and dry weight were significantly higher with atrazine at 0.5 kg/ha+ 2,4-D at 0.5 kg/ha. This was because of the fact that both atrazine + 2,4-D are effective on broad leaf weeds. And failed to control all types of weeds. Grain yield and net returns per ha were significantly superior with atrazine at 0.5 kg/ha + alachlor at 0.75kg/ha (at their 50% recommended dose) and atrazine 0.5 kg/ha + pendimethalin at 0.75kg/ha (at their 75% recommended dose) over the recommended practice (Patel *et al.* 2006).

Table 1. Efficacy of pre emergent herbicide mixtures on weed control in maize

Treatment	Total weed density (no./m^2)	Weed dry weight (g/ m^2)	Grain yield (t/ha)	Net returns ($x10^3$ Rs./ha)	B:C
Atrazine 1kg/ha + 2,4-D 1kg/ha+ IC	4.22 (17.33)	1.75 (2.58)	3.58	26.13	1.95
Atrazine 0.75kg/ha + 2,4-D 0.75kg/ha+ IC	4.29 (18.00)	1.76 (2.60)	3.48	22.75	1.77
Atrazine 0.5 kg/ha+ 2,4-D 0.5kg/ha+ IC	4.95 (24.00)	2.50 (5.76)	2.89	17.77	1.69
Atrazine 1kg/ha + Alachlor 1.5kg/ha+ IC	3.13 (9.33)	1.59 (2.03)	3.70	27.96	2.01
Atrazine 0.75kg/ha + Alachlor 1.12kg/ha + IC	3.29 (10.33)	1.65 (2.24)	3.97	31.96	2.15
Atrazine 0.50kg/ha + Alachlor 0.75kg/ha + IC	3.52 (12.00)	1.71 (2.43)	3.73	29.34	2.10
Atrazine 1kg/ha+ Pendimethalin 1kg/ha + IC	3.44 (11.33)	1.79 (2.75)	3.78	28.32	1.99
Atrazine 0.75kg/ha + Pendimethalin 0.75 + IC	3.29 (10.33)	1.78 (2.66)	3.81	29.66	2.08
Atrazine 0.50 kg/ha + Pendimethalin 1.25 kg/ha + IC	3.71(13.33)	1.86 (2.97)	3.41	24.54	1.92
Atrazine 1.25 kg/ha + IC (recommended practice)	4.71(21.67)	2.14 (4.12)	2.89	17.31	1.66
Weed free check	3.67 (2.02)	0.81 (0.15)	3.92	37.72	2.78
Weedy check	9.24 (86.67)	5.56 (30.64)	1.94	7.50	1.35
LSD (P=0.05)	0.88	0.33	0.38	5.75	0.23

IC: Intercultivation at 30 DAS

CONCLUSION

The herbicide mixtures, *viz.* atrazine 0.5 kg/ha + alachlor at 0.75 kg/ha (at their 50% recommended dose) and atrazine 0.5 kg/ha + pendimethalin at 0.75 kg/ha (at their 75% recommended dose) followed by one intercultivation was most effective in controlling the weeds and increase yield and net returns in maize.

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Evaluation of sequential application of herbicides on weed control and yield of maize

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Maize (*Zea mays* L.) is one of the most important cereal crop In Karnataka, it occupies an area of 13.31 lakh ha producing 44.44 lakh tonnes with an average productivity of 2.99 t/ha accounting 20% of the India's contribution in production (Anonymous 2012). Wide space provided to the maize, allows fast growth of variety of weed species causing a considerable reduction in yield by affecting the growth and yield components. However, meager information is available for Agricultural Research Station, Malnoor, Yadagir district of Karnataka eastern dry Zone an investigation was carried out to study the effect of sequential application of herbicides in maize.

METHODOLOGY

A field experiment was carried out during *Kharif* season of 2012-13 at Agricultural Research Station, Malnoor, Yadagir (Karnataka), to evaluate the sequential application of herbicides on weed control, growth and yield of maize under irrigated condition. The experiment was laid out in Randomized block design with thirteen treatment combinations and replicated thrice with a gross plot size of 5.4 m x 4.8 m and net plot size of 3.0 x 3.0 m. Maize genotype '*MAI-105*' was sowed in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, DAP and muriate of potash at 150 kg N, 75 kg P_2O_5 and 37.5 kg K_2O/ha, respectively. Data on weed growth, yield performance and economics were recorded.

RESULTS

Among the weed control treatments, Tankmix of atrazine at 0.625 kg/ha + pendimethalin at 0.75 kg/ha as PRE application recorded significantly higher weed control efficiency (68.87%) followed by sequential application of Atrazine at 1.25 kg/ha as PRE application *fb* 2,4-D Sodium salt at 2.0 kg/ha as POE application (60.79%). These treatments were on par with each other but significantly superior over other treatments. Application of Pendimethalin at 1.5 kg/ha as PRE application *fb* Metsulfuron methyl at 4.0 g/ha as POE application showed phytotoxicity on the crop stand there by less number of plants per plot and lower yield per plot. These results are inconformity with the previous workers (David *et al.* 2004 and Hennigh *et al.* 2010). Economic analysis of weed control treatments revealed that with the present structure and cost of the treatments and cost of treatments an economically viable method of controlling weeds in maize is application of Tankmix of atrazine at 0.625 kg/ha + pendimethalin at 0.75 kg/ha as PRE application recorded highest yield (5.64 t/ha) Gross returns (76.16×10^3 Rs/ha), net returns (54.93×10^3 Rs/ha) and higher cost benefit ratio (3.59) over hand weeding and other treatments. These results are on par with treatments Atrazine at 1.25 kg/ha as PRE application *fb* 2,4-D Sodium salt at 2.0 kg/ha as POE application and Atrazine at 1.25 kg/ha as PRE application. This might be due to the following reasons, *i.e* yield was increased in Tankmix of atrazine at 0.625 kg/ha + pendimethalin at 0.75 kg/ha as PRE application plots due to excellent control of weed infestation at early stage and less crop competition during the critical growth stage of the crop.

Table 1. Economics of different weed control treatments in production of maize

Treatment	Weed control efficiency (%)	Grain yield (t/ha)	Net returns ($\times 10^3$ Rs./ha)	Benefit Cost ratio
T_1. Atrazine 50 EC at 1.25 kg/ha as PRE application	64.38	5.417	52.79	3.58
T_2 Pendimethalin 30 EC at 1.5 kg/ha as PRE application	64.07	5.347	50.05	3.26
T_3. Tankmix of Atrazine at 0.625 kg/ha + Pendimethalin at 0.75 kg/ha as PRE application	68.87	5.642	54.93	3.59
T_4. Atrazine at 1.25 kg/ha as PRE application *fb* 2,4-D Sodium salt at 2.0 kg/ha as POE application	60.79	5.600	53.77	3.51
T_5. Atrazine at 1.25 kg/ha as PRE application *fb* Metsulfuron methyl at 4.0 g/ha as POE application	55.63	3.310	23.97	2.16
T_6. Atrazine at 1.25 kg/ha as PRE application *fb* one HW at 30 DAS	51.50	5.563	52.97	3.39
T_7. Pendimethalin at 1.5 kg/ha as PRE application *fb* 2,4-D Sodium salt at 2.0 kg/ha as POE application	72.10	5.453	49.99	3.12
T_8. Pendimethalin at 1.5 kg/ha as PRE application *fb* Metsulfuron methyl at 4.0 g/ha as POE application	58.51	3.242	21.25	1.94
T_9 Pendimethalin at 1.5 kg/ha as PRE application *fb* one HW at 30 DAS	50.78	5.333	48.07	3.01
T_{10}. Farmer's practice (IC at 20 DAS + HW at 40 DAS)	46.13	5.450	52.54	3.50
T_{11}. Hand weeding twice (20 DAS & 40 DAS)	38.08	5.470	51.41	3.29
T_{12}. Weed free check	84.55	5.733	51.37	2.97
T_{13}. Weedy check	00.00	3.057	22.43	2.19
LSD (P=0.05)	1.14	0.70	3.97	3975

CONCLUSION

With the findings it can be recommended that the Pre-emergent application Tankmix of atrazine at 0.625 kg/ha + pendimethalin at 0.75 kg/ha is effective in reducing the weed density, dry matter, weed control efficiency and for the increase in the yield of maize crop.

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Forage yield and quality of sorghum as influenced by of different pre- and post-emergence herbicides

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Sorghum is one of the important crops of the world grown for cereal as well as for fodder. It is known as a poor man's crop in India, and has the potentialities of being used solely either as food, feed or fodder. Weed infestation in forage sorghum crop is a major deterrent in increasing the forage productivity, especially during monsoon season due to wider row spacing, slow initial growth and congenial weather conditions for weed growth. Weeds compete with the crop for light, nutrients and moisture (Smith *et al*. 1990) resulting in decline in forage productivity. Keeping this in view, the present study was conducted to evaluate different pre- and post-emergence herbicides on forage yield and quality of sorghum.

METHODOLOGY

A field experiment was conducted during *Kharif* 2013 and 2014 to evaluate the efficacy of different pre- and post-emergence herbicides on loamy sand soil with neutral (7.9) pH. The experiment was laid out in Randomized Complete Block Design with 3 replications. Fertilizers were applied uniformly through urea and single super phosphate at 100 kg N/ha and 20 kg P_2O_5/ha, respectively to first cut and 100 kg N/ ha to subsequent cuttings. Data on weed growth, fodder yield and quality traits were recorded.

RESULTS

From the perusal of the data it was observed that all the herbicide combinations were effective in controlling the weed population but Pinoxaden, oxyflourfen, imazethapyr and their combinations were more or less phytotoxic effect on the sorghum crop. This phytotoxic effect resulted in significant decline in fodder yield of the crop. Among the treatments with no phytotoxic effect, minimum weed population and weed dry matter was observed in hand weeding (10.2/m2 and 63 kg/ha) and pre-emergence spray of atrazine at 0.375 kg/ha + pendimethalin at 0.75 kg/ha (14.6/m2 and 85 kg/ha). Both these treatments were statistically at par with each other but significantly better than the rest of the treatments. Maximum weed population and weed dry matter was in case of un-weeded control (211.0 /m2 and 1.27 t/ha). Weed control efficiency was maximum in case of hand weeding (95.2%) closely followed by pre-emergence spray of atrazine at 0.375 kg/ha + pendimethalin at 0.75 kg/ha (93.3%). Hand weeding resulted in highest total green fodder yield (92.53 t/ha) which was at par with pre-emergence application of atrazine at 0.375 kg/ha + pendimethalin at 0.75 kg/ha (90.99 t/ha) and with atrazine at 0.25 kg/ha + pendimethalin at 0.75 kg/ha (85.20 t/ha) but significantly better than all the other herbicide treatments. The post-emergence application propaquizalofop at 0.0625 kg/ha resulted in lowest total green fodder yield (37.43 t/ha) because of phytotoxic effect of the herbicide on the crop. It was observed that application of atrazine and pendimethalin kept the crop free from weeds for longer time and resulted in better crop growth attributes and fodder yield. These results were in conformity with the results obtained by Mishra et al (2012). Similar trend was observed in case of total dry matter yield. Crude protein content was highest in case of hand weeding (7.93%) followed by application of atrazine at 0.375 kg/ha + pendimethalin at 0.75 kg/ha (7.87%). Crude protein content was lowest in un-weeded control (7.39%). Crude protein yield followed the same trend as in case of total green fodder and dry matter yield.

Table 1. Weed growth, forage yield and quality as influenced by different weed control treatments (pooled data of *Kharif* 2013 and 2014)

Treatment	Weed population/m^2	Weed dry weight (kg/ha)	Weed control efficiency (%)	Plant height (1st cut) (cm)	Total green fodder yield (t/ha)	Total dry matter yield (t/ha)	Crude protein content (%)	Crude protein yield (t/ha)
Atrazine at 0.5 kg/ha (PE)	8.44 (70.2)	541	57.4	160.4	76.95	15.21	7.56	1.14
Pendimethalin at 0.75 kg/ha (PE)	7.21 (51.0)	422	66.8	164.2	77.65	15.63	7.67	1.19
Atrazine at 0.25 + Pendimethalin at 0.75 kg/ha (PE)	5.40 (28.2)	151	88.0	168.0	85.20	17.04	7.78	1.31
Atrazine at 0.375 + Pendimethalin at 0.75 kg/ha (PE)	3.94 (14.6)	85	93.3	170.5	90.99	17.93	7.87	1.40
Pinoxaden at 0.0375 kg/ha (Post-emergence)	6.80 (45.3)	249	79.9	113.7	62.13	11.94	7.82	0.930
Pinoxaden at 0.05 kg/ha (Post-emergence)	5.77 (32.3)	177	85.8	113.5	51.06	9.83	7.83	0.76
Oxyflourfen at 0.088 kg/ha (PE)	5.86 (33.4)	187	85.1	130.9	64.16	12.72	7.80	0.98
Oxyflourfen at 0.146 kg/ha (PE)	5.12 (25.3)	151	88.0	138.5	63.50	12.63	7.81	0.98
Imazethapyr + pendimethalin at 0.560 kg/ha (PE)	5.37 (27.8)	161	87.3	118.8	54.72	10.89	7.82	0.84
Imazethapyr + pendimethalin at 0.750 kg/ha (PE)	4.83 (22.3)	123	90.3	110.0	55.75	11.16	7.83	0.85
Propaquizalofop at 0.0625 kg/ha (Post-emergence)	3.49 (11.2)	67	94.7	112.0	37.43	7.60	7.84	0.59
Propaquizalofop at 0.0750 kg/ha (Post-emergence)	3.30 (9.9)	64	95.0	107.2	38.14	7.54	7.87	0.59
Hand weeding	3.35 (10.2)	63	95.2	171.6	92.53	18.36	7.93	1.44
Control	14.56 (211.0)	1274	-	127.3	66.56	12.36	7.39	0.91
LSD (P=0.05)	0.81	34	-	21.5	10.49	2.16	0.64	0.09

*Values in parentheses are original. Data transformed to square root transformation

CONCLUSIONS

From the results of 2-year experiment, it may be concluded that the pre-emergence application of atrazine at 0.375 kg/ha + pendimethalin at 0.75 kg/ha was most effective in controlling the weeds, improved the quality and gave maximum green fodder and dry matter yield.

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Eco-economic threshold period for controlling weeds in spring-maize

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Weed control thresholds have been used to reduce costs and avoid unacceptable yield loss. The eco-economic threshold period was discussed in this paper. Field experiments were conducted during 2013 and 2014 in Jingchuan and Liangzhou, two representative regions of the Gansu province in Northwest China, to study the functional relationships between the relative days of weedy or weedfree of natural weeds flora and the relative yield of maize. Calculating models of the eco-economic threshold period for controlling the weed flora was established. Results calculated by using these models showed that the eco-economic threshold period for controlling natural weed flora in spring maize ranged from 12.5-18.9%, 16-24 days after planting in Jingchuan regionÿand ranged from 10.4- 34.6%, 20-53 days after planting in Liangzhou region. It can cause yield loss of maize below 5%. This is the critical period to remove all of the weed damage and to maximally utilize the role of the weed flora in reducing the loss of waterÿsoil and nutrients during the growth season of spring maize.

Response of baby corn to different weed management practices and zinc fertilization

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A field experiment was conducted during *Kharif* season of 2014 at Agronomy research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University campus, Medziphema. The treatment combinations of five weed management practices, *viz.* weedy check, two hand weeding (20 & 40 DAS), Pendimethalin at 1 Kg/ha, Pendimethalin at 1 Kg/ha + one HW (20 DAS) and Pendimethalin at 1 Kg/ha + Glyphosate at 2.5 l/ha (20 DAS) and three levels of zinc fertilizer, *viz.* zinc at 5 kg/ha, zinc at 10 kg/ha and zinc at 15 kg/ha laid out in a factorial randomized block design with three replications. The results showed that two hand weeding (20 and 40 DAS) significantly increased plant height (cm), number of green leaves/plant, leaf area index, number of cobs plant^{-1} and the overall baby corn and green fodder yield. While, among the herbicides, Pendimethalin at 1 kg/ha + one HW (20 DAS) gave the highest baby corn yield and green fodder yield followed by Pendimethalin at 1 kg/ha + Glyphosate at 2.5 l/ha (20 DAS) and Pendimethalin at 1 kg/ha. From the present experiment, it was revealed that two hand weeding (20 & 40 DAS) was found to be the most suitable weed management practices with highest B:C ratio. Among, the herbicides Pendimethalin at 1 kg/ha + Glyphosate at 2.5 l/ha (20 DAS) gave the highest value of B:C ratio followed by Pendimethalin at 1 kg/ha + one HW (20 DAS). Among, the zinc levels, zinc at 15 kg/ha produced the highest corn yield and green fodder yield and the B:C ratio followed by zinc at 10 kg/ha.

Evaluation of pre- and post-emergence herbicides in foxtail millet during summer under irrigated conditions

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The area under foxtail millet has been growing tremendously for the past five years in scarce rainfall zone of Andhra Pradesh due to its ease of cultivation, higher production, less pest and disease incidence, less cost of cultivation and encouraging market prices thus resulting in more net returns to farmers. This crop is grown both under rainfed and irrigated situation. Of late, farmers are growing foxtail millet in rice fallows and the area has been increasing considerably. Under such situation, weeds pose serious threat to crop growth and ultimately reducing grain yield drastically. Weed control during early stages of crop growth period assumes greater importance (Ghosh 2000). However, the information on use of herbicides in foxtail millet is also very limited and scanty and hence the present study.

METHODOLOGY

The study was conducted at Regional Agricultural Research Station, Nandyal, Andhra Pradesh. The soil was low in organic carbon (0.42%), alkaline in soil pH (8.8), low in available Nitrogen (192 kg/ha), medium in available phosphorus (31.3 kg/ha) and high in available Potassium (412.0 kg/ha). The experiment was laid out in randomized block design and replicated thrice. Treatments comprised of of weed management practices. SiA 3156 variety was sown at a spacing of 22.5 cm x 10 cm and fertilized with 40 kg N and 20 kg P_2O_5/ha. Butachlor was applied as pre-emergence herbicide at immediately after sowing of the crop with sufficient soil moisture and 2,4-D was applied as post emergence herbicide at 20 days after emergence as per the treatments. The gross and net plot sizes were 4.0 x 3.0 m and 3.1 x 2.2 m respectively. The crop was harvested at physiological maturity. Data on weed dry weight/m^2 were recorded at 50 DAS and harvesting stages.

RESULTS

This study suggests that hand weeding is the most effective weed control method resulting in significantly higher grain yield (2.54 t/ha) as compared to application of butachlor at 0.5 kg/ha + 2,4-D at 0.5 kg/ha (1.84 t/ha), butachlor at 1.0 kg/ha + 2,4-D at 0.5 kg/ha (1.79 t/ha), butachlor at 1.0 kg/ha + 2,4-D at 1.0 kg/ha (1.78 t/ha) and unweeded control (1.584 t/ha) but was found to be on par with other treatments. The data in the table clearly indicates that at 50 DAS, higher WCE (43.6) was noticed with handweeded check followed by butachlor at 1.0 kg/ha + 2,4-D at1.0 kg/ha (40.3), butachlor at 1.0 kg/ha + 2,4-D at 0.5 kg/ha (40.2) and butachlor at 0.5 kg/ha + 2,4-D at 0.5 kg/ha (39.4). Interestingly, even though, the treatments including application of butachlor as pre emergence and 2,4-D as post emergence at varied doses resulted in higher WCE, but recorded significantly lower grain yield suggesting that the crop was also subjected to some sort of stress caused due to phytotoxicity along with efficient control of weeds.

Table 1. Effect of pre and post emergence herbicides on weed dry matter, WCE and grain& straw yields of foxtail

Treatment	Weed dry weight (g/m2)		WCE		Grain yield (t/ha)	Straw yield (t/ha)
	50 DAS	Harvest	50 DAS	Harvest		
T1-pre emergence application of butachlor at 0.5 kg/ha	6.07** (37.6)*	3.76(13.9)	22.6	28.1	2.365	4.34
T2-pre emergence application of butachlor at 1.0 kg/ha	6.07(40.8)	3.61(12.7)	22.6	30.9	2.053	3.48
T3-post emergence application of 2,4-D at 0.5 kg/ha	6.81(49.2)	4.90(24.1)	27.9	27.0	2.020	4.12
T4-post emergence application of 2,4-D at 1.0 kg/ha	5.34(31.1)	3.44(11.5)	31.9	34.2	2.225	3.75
T5- pre emergence application of butachlor at 0.5 kg/ha + post emergence application of 2,4-D at 0.5 kg/ha	4.45(23.7)	3.17(11.2)	41.3	39.4	1.843	3.77
T6- pre emergence application of butachlor at 0.5 kg/ha + post emergence application of 2,4-D at 1.0 kg/ha	4.61(24.3)	4.18(18.4)	43.3	35.3	1.994	3.97
T7- pre emergence application of butachlor at 1.0 kg/ha + post emergence application of 2,4-D at 0.5 kg/ha	4.80(27.9)	2.95(9.8)	38.8	40.2	1.791	3.65
T8- pre emergence application of butachlor at 1.0 kg /ha + post emergence application of 2,4-D at 1.0 kg/ha	5.86(45.1)	3.12(10.1)	25.3	40.3	1.781	3.72
T9-Hand weeded check	1.25(1.1)	3.13(9.1)	84.0	43.6	2.549	3.80
T10-Unweeded control	7.84(61.1)	7.84(61.1)	-	-	1.584	3.03
LSD (P=0.05)	3.2	1.5			0.603	0.95

*Figures in parentheses are original values. **Square root transformed ("X+0.5) values.

CONCLUSION

From this study, it can be concluded that, application of either pre emergence (butachlor at 0.5 or 1.0 kg/ha) or post emergence (2,4-D at 0.5 or 1.0 kg/ha) alone could control weeds to an optimum level without affecting grain yields as compared to combined application of pre and post emergence herbicides. Similar indications of weed control in finger millet with butachlor were reported by Kumara 2004.

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Performance of glyphosate for weed control in corn

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Reduction in grain yield to the extent of 32.4-42.3% has been estimated in corn by Sharma *et. al*. 2000. The control of weeds in corn is tedious job with hand weeding/hoeing due to uncertainty of rains and pre-emergence herbicides *i.e.* atrazine also not much effective against most of the annual or perennial weeds like *Cyperus rotundus, Sorghum helipence* etc. It is therefore, an effort was made to control these annual (grasses, non-grasses), perennial (*Cyperus* spp, *Sorghum helepens*) through glyphosate (41% SL) a non-selective herbicide in corn. The present investigation was carried out in corn with post-emergence application of glyphosate 41.0% SL during 2012-13 and 2013-14.

METHODOLOGY

A field experiment was conducted during *kharif* season of 2012 and 2013 at Norman E. Borlaug Crop Research Center of Govind Bhallabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand. Seven treatments were tested in randomized block design. Seed of corn variety '*Gaurav*' was planted on 04.07.2013 during 2012 and 13.07.2013 during 2013 at 60 cm row distance. Crop was raised with recommended agronomic practices. Crop was harvested on 17 October 2012 during 2012 and 25 October 2013 during 2013. Water for spray at 500 l/ha was used and knapsack sprayer was used with flat fen nozzle. Atrazine was used pre-emergence. Soil of the experimental plot was silty loam in texture having organic carbon 1.02%. The soil was medium in N, P_2O_5 & K_2O and pH of the soil was 7.3. Protected spray of glyphosate and paraquate was done in between two rows of maize during both the years.

RESULTS

On the basis of pooled analysis of two years data given (Table-1) revealed that highest grain yield of corn was recorded in the treatments glyphosate at 1800 g/ha which was significantly higher over weedy check (untreated) and 2,4-D Na salt applied at 1000 g/ha. Grain yield of corn was at par in all the glyphosate (900, 1800, 3600 g/ha) treated plots. Reduction in corn yield due to uncontrolled weeds was recorded 48.9%. Yield attributes (no. of grains/cob, cob length and 1000 grain weight) were recorded highest in glyphosate applied at 3600 g/ha. Corn yield was also found similar in atrazine at 750 and paraquat 500 ml/ha to glyphosate treated plots 1800 or 3600 g/ha. Total weed population was reduced in glyphosate applied at 3600 g/ha was at par with 1800 g/ha. The highest grain yield in corn was due to less number of weeds in the treatment of glyphosate applied either at 3600 g/ha or 1800 g/ha at 2-4 leaf stage of weeds. Because of proper weed management the cob length, number of grains/cob, 1000 grain weight were highest in glyphosate treated plots or atrazine. 2,4-D Na salt was not found so effective in controlling weeds in corn as compared to glyphosate as early post-emergence (2-4 leaf stage of weeds) or atrazine at 750 g/ha as pre-emergence.

Table 1. Total weed population, dry matter of weeds, corn yield and yield attributes influenced by various treatments (Pooled data 2012 & 2013)

Treatment	Total weed/m^2 at 45 days stage	Weed dry matter at 45 days stage	Weed control efficiency (%) at 45 days stage	Maize grain yield (kg/ha)	No. grains/cob	Cob length (cm)	1000 grain weight (g)
T_1- Untreated	6.5(573.9)	5.5(195.2)	00.0	195	201.7	10.9	27.5
T_2- Glyphosate at 900 g/ha	4.2(94.3)	3.6(32.4)	83.31	381	333.7	14.2	29.4
T_3- Glyphosate at 1800 g/ha	3.8(44.0)	3.2(29.7)	84.78	382	331.7	14.2	29.5
T_4- Glyphosate at 3600 g/ha	2.2(8.6)	3.0(28.8)	85.24	381	334.2	14.3	29.5
T_5- Atrazine at 750 g/ha	3.8(10.8)	3.4(30.2)	84.52	378	332.8	14.0	29.2
T_6- Paraquate at 500 g/ha	4.3(196.0)	4.4(84.8)	56.55	377	271.0	10.9	25.8
T_7- 2,4-D Sodium Salt at 1000 g/ha	4.0(191.3)	4.6(93.9)	51.17	257	211.7	9.9	28.8
LSD (P=0.05)	2.5	0.3	-	30	39.0	1.8	2.3

*Data pertaining to weeds was transformed log (X+1) ** Original data in Parentheses

CONCLUSION

On the basis of two years experiment it may be concluded that glyphosate at 1800 g/ha was found effective in controlling weeds and weed dry matter and influenced the grain yield economically using as protected spray to be applied 2-4 leaf stage of weeds to avoid the plant injury from the direct contact of non-selective systemic herbicide.

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Effect of weed management practices on weed flora and yield of baby corn

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Baby corn is a dehusked maize ear harvested within 2-3 days of silk emergence, but prior to fertilization. Due to its short duration, the crop can easily be fit in an intensive cropping system. Further, with ever increasing use of fertilizer and irrigation water, weed management has assumed significant important in modern intensive farming, as the total loss of crop yield with increasing cost of cultivation causes a greater economic loss to farmers (Arvadiya *et al*. 2012). Considering the agricultural importance, the work done on the influence of weed management in baby corn growth and yield. Therefore, the present experiment was planned to study the effect of different weed control practices on weed flora and productivity of winter baby corn under irrigated situation.

METHODOLOGY

The field experiment was carried out during winter seasons of 2010-11 and 2011-12 at Instructional Farm of BCKV, West Bengal. The soil of experimental field has sandy clay loam with organic carbon 0.59%, available N 173 kg/ha, available P_2O_5 13.70 kg/ha, available K_2O 236 kg/ha and soil pH 6.8. Eight weed management practices were evaluated in randomized block design with three replications. The baby corn variety ‘Early Composite’ was sown with a spacing of 45 cm × 30 cm during middle of November in each year. The crop was fertilized with recommended dose of fertilizers like 120:60:40 kg N: P_2O_5: K_2O /ha.The package of recommended practices was adopted to maintain the crop. The required quantity of all the herbicides was applied uniformly as pre-emergence at 3 DAS using knapsack sprayer. The treatment with paddy straw mulch was applied after germination and establishment of seedlings in the field. In general, weather conditions were favourable for plant growth and no severe pest and diseases noticed during both the years of experimentation.

RESULTS

Besides weed free check, the higher yield of baby corn (1.464 t/ha) was recorded with two hand weeding at 20 and 40 days after sowing due to significantly lower weed dry weight, higher weed control efficiency (88.32%), lower weed index (4.63%) and higher crop nutrient uptake than other treatments. This treatment was followed by straw mulch at 10 t/ha and increased the yield by 68.98% over weedy check. Integrated weed management practices like pre-emergence atrazine or metribuzin at 1 kg/ha coupled with one hand weeding at 30 DAS exhibited superiority over the respective atrazine or metribuzin at 2 kg/ ha alone. Maximum net return (Rs 44,600 /ha) and benefit-cost ratio (2.75) were realized with hand weeding twice.

Table 1. Weed control efficiency and weed control index, yield and economics of baby corn as influenced by weed management practices (pooled data of 2 years)

Treatment	WCE (%)	WI (%)	Baby corn yield (t/ha)	Green fodder yield (t/ha)	Cost of cultivation ($\times 10^3$ ₹ /ha)	Net return ($\times 10^3$ ₹/ha)	BCR
Atrazine at 2 kg/ha	54.83	16.68	1.25	33.11	22.44	37.85	2.68
Metribuzin at 2 kg/ ha	43.54	20.0	1.20	32.74	24.22	33.92	2.40
Paddy straw mulch at 10 t/ ha	81.10	6.52	1.43	37.60	26.57	42.11	2.58
Hand weeding (HW) at 20 and 40 DAS	88.32	4.63	1.46	38.41	25.48	44.60	2.75
Atrazine at 1 kg/ha + HW at 30 DAS	73.69	9.84	1.36	35.31	24.03	41.12	2.71
Metribuzin at 1 kg/ ha + HW at 30 DAS	65.31	12.90	1.31	35.13	24.92	38.29	2.53
Weed free	100.0	0.00	1.53	39.26	37.39	35.92	1.95
Weedy check	0.00	40.26	0.88	23.54	21.22	21.12	1.99
LSD (P=0.05)			0.17	0.12	-	-	-

CONCLUSION

The present study concluded that hand weeding twice at 20 and 40 DAS is an effective weed management practice in reducing weed growth, producing maximum yield and economic benefits in winter season baby corn

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Effect of early post-emergence herbicides and herbicide mixtures on weed control in maize

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Maize is one of the most important food crops in India and is increasingly gaining an important position in crop husbandry because of its higher yield potential and short crop duration. Manual weeding is a common practice, but it is labour intensive, costly and often not done at proper stage. Mostly farmers adopt manual weeding only after sufficient weed growth. It is essential to remove the early flush of weeds at right time. For this, the pre-emergent herbicides can be used for by keeping the maize fields weed free in the first 30-35 days of crop growth. But farmers are unable to apply pre-emergent herbicides at time of sowing, since they give priority on completion of sowing. Moreover, there is acute shortage of labour even for sowing operation. Hence, there is need to use early post emergent herbicides, which can be conveniently applied after 15-20 days of sowing, that too when the pressure of completing the sowing is over. Hence, a field trial was conducted to evaluate early post emergent herbicides or herbicide mixtures in maize under assured rainfall conditions.

METHODOLOGY

A field experiment was conducted at Main Agricultural Research Station, Dharwad, Karnataka, India during *Kharif* (rainy season) 2014. The soils of experimental site was black clayey soil (vertisols). The experiment was laid out in RCBD with three replications involving 8 treatments. The treatment details are given in Table 1. Maize hybrid *'900-M Gold'* was sown at 60 x 20 cm and recommended dose of fertilizers was applied as per package of practices. Observations on weed density and weed dry weight were recorded in 0.5 m^2 area at 60 DAS. The yield data was recorded and net returns were worked out based on price prevailed during 2014.

RESULTS

The herbicide tank mixtures, *viz.* topramezone 12.5 g/ha + atrazine 625 g/ha and topramezone 12.5 g/ha + 2,4-D 500 g/ha recorded significantly lower weed density and weed dry weight which were on par with recommended weed management practice of pre emergent application of atrazine followed by one hand weeding and one intercultivation. Grain yield per ha was significantly higher with the application of these herbicide tank-mixtures compared to their single applications. However interestingly, these herbicide mixtures were on par with recommended weed management practice and with weed free treatment. Weed free check recorded significantly higher net returns and it was on par with topramezone 12.5 g/ha + atrazine 625 g/ha and topramezone 12.5 g/ha with 2,4-D 500 g/ha. This result is in conformity with the findings of Walia *et al.* (2007).

Table 1. Weed density, weed dry weight, grain yield and net returns as influenced by weed management treatments in maize

Treatment	Weed density (No./m^2)	Weed dry weight (g/ m^2)	Grain yield (t/ha)	Net returns ($x10^3$ Rs./ha)
Topramezone 25 g/ha at 20 DAS (Early Post-emergence)	6.04 (36.00)	4.26 (18.06)	5.70	80.04
Atrazine 1.25 kg/ha at 20 DAS (Early Post-emergence)	6.17 (37.67)	4.46 (19.43)	5.71	84.96
2, 4-D Na salt 1.0 kg/ha at 20 DAS (Early Post-emergence)	6.54 (42.33)	4.73 (21.83)	5.60	82.26
Topramezone 12.5 g/ha + Atrazine 625 g/ha at 20 DAS (Early Post-emergence) (Tank mixture)	4.06 (16.00)	3.13 (9.49)	6.79	97.25
Topramezone 12.5 g/ha + 2, 4-D Na salt 500 g/ha at 20 DAS (Early Post-emergence) (Tank mixture)	4.72 (22.00)	3.77 (14.15)	6.60	91.74
Atrazine (PRE) 1.25 kg/ha + IC+ HW (RPP)	3.89 (14.67)	2.87 (8.00)	6.88	99.53
Weed free	2.11 (4.00)	1.62 (2.13)	7.10	97.58
Weedy check	10.12 (102.33)	8.28 (68.13)	4.97	68.46
LSD (P=0.05)	0.54	0.91	0.84	9.93

*Values in parantheses are original. Data transformed to square root transformation

CONCLUSION

The herbicide mixtures, *viz.* topramezone 12.5 g/ha + atrazine 625 g/ha and topramezone 12.5 g/ha + 2,4-D 500 g/ha were most effective in controlling a wide range of weeds and increase grain yield and net returns in maize. The herbicide mixtures were superior compared to single application.

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Evaluation of pre-emergent application of metribuzin at different doses for weed control in maize

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Maize is an important cereal crop and now it has assumed the status of commercial crop because of its multiple uses including industrial uses. It is known for its high yield potential. We are unable to exploit its full yield potential in view of many constraints in its cultivation. Weeds form an impediment in its production especially in assured rainfed and irrigated areas. At present, atrazine is the recommended pre-emergent herbicide for weed management in the crop. There may be several herbicide molecules with greater bioefficacy against weeds in maize. Metribuzin is one among them, but its performance has to be studied as pre-emergent herbicide at different doses.

METHODOLOGY

A field experiment was conducted at UAS, Dharwad, Karnataka, India under assured rainfall conditions during the *Kharif* seasons of 2013. The soils of experimental site was black clayey soil (vertisols), The experiment was laid out in RCBD with three replications involving 14 treatments consisting of different doses of pre-emergent herbicide metribuzin, which were compared with atrazine at 1.25 kg/ha and farmers' practice (Table 1). Maize hybrid '*900-M Gold*' was sown at 60 x 20 cm and recommended dose of fertilizers was applied as per package of practices. Observations on weed density and weed dry weight were recorded in 1 m^2 area at 60 DAS. The yield data was recorded and phytotoxicity ratings were expressed in the scale ranging between 0–10.

RESULTS

The grain yield of maize was significantly higher with recommended pre-emergent herbicide i.e. atrazine at 1.25 kg/ha which was on par with farmers' practice. Further the yield levels obtained with metribuzin at 250, 300, 350, 400, 450 and 500g were on par with atrazine at 1.25 kg/ha. Metribuzin at higher doses, *viz.* 500, 550 and 600 g/ha were effective against weeds compared to lower doses, but were found phytotoxic; while at lower doses, the weed control efficiency was lower with higher weed density and weed dry weight. These results are in conformity with the findings of Murthy *et al.* (1992).

Table 1. Weed density, weed dry weight, grain yield and Phytotoxicity rating in maize as influenced different doses of metribuzin

Treatment	Weed density at 60 DAS (no./m^2)	Weed dry weight (g/ m^2)	Grain yield (t/ha)	Phytotoxicity rating (0-10 Scale)
Metribuzin 150 g/ha + IC	5.38 (28.80)*	2.30 (4.50)*	4.38	0
Metribuzin 200 g/ha + IC	5.07 (25.50)	2.12 (4.07)	4.81	0
Metribuzin 250 g/ha + IC	4.91 (23.66)	1.92 (3.21)	4.92	0
Metribuzin 300 g/ha + IC	4.75 (22.17)	1.75 (2.60)	4.90	0
Metribuzin 350 g/ha + IC	4.60 (20.83)	1.75 (2.41)	5.01	0
Metribuzin 400 g/ha + IC	4.01 (16.33)	1.62 (2.16)	5.03	1
Metribuzin 450 g/ha + IC	3.14 (9.50)	1.61 (2.12)	5.19	1
Metribuzin 500 g/ha + IC	2.66 (6.66)	1.53 (1.85)	4.97	1
Metribuzin 550 g/ha + IC	2.87 (4.38)	1.49 (1.74)	3.65	2
Metribuzin 600 g/ha + IC	2.66 (6.67)	1.37 (1.40)	3.46	3
Atrazine 1.25 kg/ha + IC	3.45 (11.50)	1.69 (2.38)	5.30	0
Farmers' Practice (2HW+2IC)	1.96 (3.50)	1.00 (0.55)	5.49	-
Weedy check	7.21 (51.66)	5.40 (28.98)	1.84	-
LSD (P=0.05)	0.31	0.35	0.40	-

*Values in parantheses are original. Data transformed to square root transformation; IC – Intercultivation; HW– Hand weeding

CONCLUSION

Under rainfed condition metribuzin can be recommended for maize crop as pre-emergent herbicide at lower doses (250 and 450 g/ha), while higher doses (500-600 g/ha) caused injury to crop.

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Effect of early post-emergence herbicides on soil dehydrogenase activity and grain yield of maize

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Maize is an important cereal crop known for its high production potential. Timely weed management is an important aspect to realise maximum yield. Weed management with early post-emergent herbicide may become a viable alternative to the current methods of weed control in view of labour scarcity at the time of sowing. To have broad spectrum weed control, we may have to mix two herbicides having effectiveness against different weed flora. In doing so, their effect on soil dehydrogenase activity should not be ignored. Hence, a field trial was conducted to study the effect of early post emergent herbicides/herbicides mixtures on soil dehydrogenase activity and maize yield.

METHODOLOGY

A field experiment was conducted at Main Agricultural Research Station, Dharwad, Karnataka, India during rainy season of 2014. The soil of experimental site was black clayey (Vertisols). The experiment was laid out in RCBD with three replications involving 8 treatments. The treatment details are given in Table 1. Maize hybrid '*900-M Gold*' was sown at 60 X 20 cm and recommended dose of fertilizers was applied as per package of practices. The soil dehydrogenase activity was studied at 7 and 15 DAS after application herbicides and data on maize grain yield was recorded.

RESULTS

After 7 DAS, dehydrogenase activity was significantly higher with application of tank-mixtures, *viz*. topramezone 12.5 g/ha + atrazine 625 g/ha and topramezone 12.5 g/ha + 2,4-D Na salt 500 g/ha which was on par with weed free treatment. In weedy check also, dehydrogenase activity was significantly higher. The dehydrogenase activity was significantly lower in atrazine at 1.25 kg/ha compared to all other treatments. Almost similar trend was followed after 15 DAS also. Grain yield of maize was significantly higher with tank mixtures *viz*., topramezone 12.5 g/ha + atrazine 625 g/ha and topramezone 12.5 g/ha + 2, 4-D 500 g/ha which was on par with recommended weed management practices, *i.e.* atrazine 1.25 kg/ha + IC + HW. This finding is corroborating with Ehsan and Hossein (2006).

Table 1. Soil dehydrogenase activity and grain yield as influenced by early post emergent herbicides in maize.

Treatment	Grain yield (t/ha)	Dehydrogenase activity (µg TPF/g soil/day)	
		7 DAS	15 DAS
T_1 - Topramezone 25 g/ha at 20 DAS (Early Post-emergence)	5.707	3.01	3.35
T_2 - Atrazine 1.25 kg/ha at 20 DAS (Early Post-emergence)	5.713	1.60	2.22
T_3 - 2, 4-D Na salt 1.0 kg/ha at 20 DAS (Early Post-emergence)	5.604	2.81	2.11
T_4- Topramezone 12.5 g/ha + atrazine 625 g/ha at 20 DAS (Early Post-emergence) (Tank mixture)	6.791	3.92	4.17
T_5 - Topramezone 12.5 g/ha + 2, 4-D Na salt 500 g/ha at 20 DAS (Early Post-emergence) (Tank mixture)	6.609	3.80	3.81
T_6 - Atrazine (PRE) 1.25 kg/ha + IC+ HW (RPP)	6.882	2.61	3.04
T_7 - Weed free	7.103	4.25	4.59
T_8 - Weedy check	4.973	5.27	5.69
LSD (P=0.05)	0.842	1.00	0.86

PRE- Pre-emergent, IC- Intercultivation, HW- Hand Weeding, RPP- Recommended Package of Practice

CONCLUSION

The early post emergent herbicide mixtures, *viz*. topramezone 12.5 g/ha + atrazine 625 g/ha and topramezone 12.5 g/ha + 2,4-D 500 g/ha was significantly higher compared to their single application with respect to maize grain yield and soil dehydrogenase activity.

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Effect of weed management options on yield and economics of maize

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In India, maize occupies third position next to rice and wheat cultivation and plays a pivotal role in Indian agricultural economy. Yield loss due to weeds in maize *(Zea* mays) varies from 28-93%, depending on the type of weed flora and the intensity and duration of crop-weed competition (Sharma and Thakur 1998).

METHODOLOGY

A field experiment was conducted on sandy loam soil during *Kharif* 2011 at college farm. College of Agriculture, Rajendranagar. Hyderabad. The experiment was laid out in randomized block design with 10 treatments and three replications. Medium duration maize hybrid '*DHM-117*' was sown on 24th July at a spacing of 60 x 25 cm. The common fertilizer schedule adopted for all the treatments was 200-60-40 N-P_2O_5-K_2O kg/ha in the form of urea, single super phosphate and muriate of potash respectively. The required quantities of herbicides were calculated as per the treatments and applied as aqueous spray by using the spray fluid (water at 500 l/ha) using Knapsack sprayer with flat fan nozzle.

RESULTS

The results showed that the farmers practice of eliminating weeds through intercultivation at 20 DAS *fb* hand weeding at 30DAS recorded lowest weed density and weed dry matter production and thereby highest weed control efficiency (%) and gave maximum grain yield of 5.12 t/ha which was statistically on par with herbicidal treatment of atrazine at1.0 kg/ha *fb* intercultivation at 20 DAS (4 85 t/ha) followed by pre emergence application of atrazine at 1.0 kg/ha *fb* topramezone 40 ml/ha (4.64 t/ha). Benefit cost ratio was highest with PE application of atrazine at 1.0 kgha *fb* topramezone 40 ml/ha at 25 DAS followed by PE application of atrazine 1.0 kg/ha *fb* intercultivation at 20 DAS.) Topramezone would be complement to current weed management program in grain maize (Thomas *et al.* 2010). Alternatively it can be used in sequential application to pre emergence soil applied treatments or in a total post emergence program in mixtures with other herbicides (Porter *et al.* 2005).

Table 1. Weed control efficiency, yield and economics of maize as influenced by different weed control treatments

Treatment	Weed control efficiency at 60 DAS (%)	Seed yield (t/ ha)	Stalk Yield (t/ha)	Net Returns (x 10^3 Rs/ ha)	B:C Ratio
T_1 – Atrazine at 1.0 kg/ha as pre- emergence 1-2 DAS	71.6	4.13	6.87	30.055	1.73
T_2 - Atrazine at 1.0 kg/ha as pre- emergence *fb* intercultivation at 20 DAS	86.4	4.85	7.38	35.493	1.82
T_3 - Atrazine at 1.0 kg/ha as pre- emergence at 1-2 DAS	77.5	4.31	6.94	31.421	1.76
T_4 - Atrazine at 1.0 kg/ha as pre- emergence *fb* atrazine 1.0 kg/ha as post- emergence at 25 DAS	84.3	4.48	7.26	33.418	1.82
T_5 - Atrazine at 1.0 kg/ha pre- emergence *fb* topramezone 40 ml/ha post- emergence at 25 DAS	85.3	4.64	7.30	34.470	1.88
T_6 - Atrazine at 0.5 kg/ha + topramezone at 40 ml/ha at 2-3 leaf stage (early post emergence) 12 DAS	82.6	4.31	7.045	31.490	1.76
T_7 - opramezone at 40 ml/ha post emergence at 25 DAS	73.8	3.80	6.30	26.332	1.51
T_8 – Metribuzin at 0.75 kg/ha post emergence at 16 DAS	80.7	1.91	3.89	3.915	0.20
T_9 - Intercultivation at 20 DAS *fb* nand weeding at 30 DAS	89.2	5.12	7.93	37.549	1.77
T_{10} – Weedy check (Control)	0.0	2.58	5.38	14.401	0.88
LSD (P=0.05)	4.9	0.27	0.83		

CONCLUSION

It is clear that weed menace in maize during *Kharif* season where continuous rains pose a serious problem, can be managed efficiently through integration of pre-emergence application of atrazine at 1.0 kg/ha *fb* topramezone at 40 ml/ha as post-emergence spray to sustain high productivity and profitability under situations of scarcity and non availability of labour and slushy soil conditions.

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Nutrient and yield losses due to weeds in maize-based cropping systems under mid-hill condition

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Maize-wheat is the most important cropping system in mid hills of Himachal Pradesh. Despite enormous growth of maize-wheat system, reports of stagnation in the productivity, with possible decline in production in future, have raised doubts on its sustainability. Earlier studies have indicated superiority of alternative vegetable based cropping systems over the traditional cropping systems (Rana *et al.* 2011, Sharma *et al.* 2009). Weed control is a most limiting factor in crop production (Buhler 1992). With prolonged cultivation of maize-wheat system, many weed species have increased to a greater extent. Nevertheless with diversification of the system, the behaviour of weeds in maize as a function of preceding *rabi* and summer season crop may change.

METHODOLOGY

A field experiment was carried out in a continuing experiment, at the Bhadiarkhar farm of the Krishi Vishvavidyalaya. Eight cropping systems were evaluated in a randomized block design with four replications. The crops were raised in accordance with the recommended package of practices for the region. For weed studies three situations were established, *i.e.* S_1 Usual weed control practice (*Kharif* as well as *Rabi*) using herbicides or manual weed control, S_2 No weed control/weedy without herbicide spray or hand weeding (*Kharif* as well as *Rabi*) and S_3 Additional weed control usually handweeding after herbicide spray or manual control (*Kharif* as well as *Rabi*).

RESULTS

There were 28 weed species found growing in association with different maize based cropping systems during a period of two years. The weeds such as *Bidens pilosa*, *Galinsoga parviflora*, *Stellaria media*, *Alopecurus myosuroides*, *Lolium temulentum*, *Ageratum* spp, *Polygonum* spp, *Avena ludoviciana*, *Cynodon dactylon etc.* which appeared in the S_1 situation (standard weed control practice) were completely eliminated when additional control effort was tried in S_3. However, when additional weed control measure was adopted in the S_3, species like *Rumex* spp, *Poa annua*, *Polygonum plebegium*, *Trifolium repens*, *Polypogon monspelensis* invaded the fields and a range of crops. Maize + asparagus bean – radish – onion gave 245 and 503.9% higher maize grain equivalent yield over the traditional maize - wheat cropping sequence during 2012-13 and 2013-14, respectively. The nutrient losses due to weeds were huge under the cropping systems. Nitrogen depletion by weeds ranged from 608–695 and 309.1–461.2 kg/ha/annum during 2012-13 and 2013-14, respectively. Phosphorus depletion was in the rage of 121.6–177.1 and 71.1–99.6 kg/ha/annum during 2012-13 and 2013-14, respectively. Potassium depletion varied from 202.7–432.5 and 118.4–166.0 kg/ha/annum during 2012-13 and 2013-14, respectively. Weeds inflicted huge losses in yield ranging from 12.8 (C_3) to 41.4% (C_5) during 2012-13 and from 12.6 (C_7) to 39.4% (C_2) during 2013-14 based on maize grain equivalent yield. Mean maize grain equivalent yield loss varied from 15.7% in C_6 cropping system to 35.6% in the C_1 cropping system.

Table 1. Maize grain equivalent yield of different cropping systems and their influence on total NPK depletion (kg/ha/annum) by weeds and Losses in yield due to weeds (mean of 2 years)

Crop sequence	MGEY* (kg/ha/annum)	Total (*Kharif* + *Rabi*) NPK losses by weeds (kg/ha)			Losses (%) in yield due to weeds				
					Crop/season				
		N	P	K	*Kharif*	*Intercrop*	*Rabi* (I)	*Rabi* (II)	Overall
2012-13									
C_1 M-W	9339	622.5	124.5	207.5	13.8		44.4		36.9
C_2 Mgc + Fb – P - Ss	16085	608.0	121.6	202.7	11.8	59.5	18.8	40.0	24.7
C_3 M+S - G	16404	682.3	136.5	227.4	20.0	40.1	10.0		12.8
C_4 Mgc – Br - Po	23390	612.4	122.5	204.2	21.4		41.7	46.7	40.6
C_5 M + Ab – Ra - O	32216	686.5	137.3	228.8	14.3	50.7	52.2	28.0	41.4
C_6 Mgc + Ub – C - Fb	17396	693.7	138.7	231.2	6.7	50.4	11.1	20.0	13.5
C_7 Mgc + Rb – C - Bw	14977	695.4	139.1	231.8	31.6	58.4	20.0	40.0	26.1
C_8 Mgc + Ab – Br - Ra	27538	679.4	177.1	432.5	25.0	75.2	20.0	26.3	23.6
LSD (P=0.05)	2984	58.9	11.8	19.6					
2013-14									
C_1 M-W	6879	444.2	97.9	163.1	25.0		38.5		33.7
C_2 Mgc + Fb – P - Ss	32939	309.1	71.1	118.4	8.3	64.1	11.1	46.7	39.4
C_3 M+S - G	9974	461.2	99.6	166.0	20.0	50.7	35.7		32.4
C_4 Mgc – Br - Po	28612	351.5	76.7	127.7	14.3		40.0	28.0	29.6
C_5 M + Ab – Ra - O	41544	397.5	86.2	143.6	14.3	76.8	11.1	17.4	14.8
C_6 Mgc + Ub – C - Fb	15491	366.7	78.4	130.6	15.4	73.9	5.9	30.8	18.2
C_7 Mgc + Rb – C - Bw	20998	343.5	76.7	127.8	14.3	59.4	14.3	9.1	12.6
C_8 Mgc + Ab – Br - Ra	16477	344.2	75.8	126.4	23.1	48.5	18.2	20.0	21.8
LSD (P=0.05)	2101	30.7	11.3	11.4					

**MGEY, maize grain equivalent yield*;

CONCLUSION

The findings of the present investigation conclusively inferred that weeds are dynamic in nature. When existing weed species are controlled, land is invaded by a variety of other species of weeds. This clearly indicated that crop production is more or less a fight against weeds. Weeds inflict huge yield and nutrient losses thereby depriving the crops for want of nutrients. Therefore, strong management strategy has to be designed based on the prevalent species, management practices followed and the cropping system adopted.

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Integrated weed management in pearlmillet-based intercropping system under arid conditions

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Pearl millet (*Pennisetum glaucum* L.) and cluster bean (*Cyamopsis tetragonoloba* L.), being drought hardy crop, widely grown in arid region of Rajasthan. In the region, pearl millet and cluster bean occupy about 48 and 95%, respectively of total area covered under these crops in the state. Severe weed infestation is one of the major constraints to realize potential yield of both crops in the region and caused yield reduction to the tune of 20-80%. Though conventional methods are very effective, but are expensive, time consuming and tedious. Many herbicides are not broad spectrum and some weed species may develop resistant to particular herbicide, besides posing threat to the environment. Integrated weed management is a holistic approach that integrates different methods of weed control to provide the crop with an advantage over weeds (Harker and O'Donovan 2013). Considering the above facts in view, the present investigation was carried out under arid condition of Rajasthan.

METHODOLOGY

Field experiments were conducted during *Kharif* 2012 and 2013 at Central Arid Zone Research Institute, Jodhpur (Rajasthan), to study the effect of integrated weed management practices on the productivity and profitability of pearl millet based intercropping system. Twenty treatment combinations consisting of four intercropping and five weed management practices (Table 1) were laid out in factorial randomized block design with three replications. Pearl millet '*HHB 67*' and cluster bean '*RGC 936*' were grown following the recommended package of practices. Replacement series was used for intercropping system and observation on weeds, yield and economics were recorded at harvest.

RESULTS

Effect on weeds

The experimental field was mainly infested with broad-leaved weeds, which constituted about 92% of total weed flora. Cluster bean sole recorded significantly lowest density and dry weight of weeds as well as highest weed control efficiency (31.0%) followed by pearl millet + cluster bean (2:1). However, highest density and dry weight of weeds were registered with pearl millet sole. This was owing to lesser smothering effect of pearl millet sole on weeds than rest of the treatments (Kiroriwal and Yadav 2013).

All the weed management treatments significantly reduced density and dry weight of weeds over weedy check. Two hand weeding at 25 and 45 DAS recorded lowest weed density, dry weight of weeds and highest weed control efficiency (81.5%), but remained at par with pendimethalin 1.0 kg/ha (PE) + one hand weeding and pendimethalin 1.0 kg/ha (PE)+ imazythapyr 40 g/ha (POE).

Table 1. Influence of weed management practices on weeds, yield and economics in pearl millet

Treatment	Weed density (no./m^2)	Weed dry weight (g/m^2)	Weed control efficiency (%)	Cluster bean equivalent seed yield (kg/ha)	Net returns (x10^3 ₹/ha)	B:C ratio
Cropping System						
Cluster bean sole	74.9	18.7	31.0	570.14	43.6	3.02
Pearl millet sole	102.4	27.1	0.0	127.95	11.2	0.10
Cluster bean+ pearl millet (2:1)	81.9	21.0	22.5	458.00	31.1	2.38
Cluster bean+ pearl millet (2:2)	86.0	22.3	17.7	449.46	31.0	2.46
LSD (P=0.05)	14.2	3.2	-	62.80	-	-
Weed Management						
Weedy check	247.3	51.4	0.0	245.25	14.7	1.56
Two weeding at 25 and 45 DAS	33.5	9.5	81.5	483.12	31.7	2.02
Pendimethalin 1.0 kg(PE)+ one hand weeding at 25 DAS	38.3	12.5	75.7	464.35	31.9	2.31
Pendimethalin 1.0 kg/ha(PE)+ one mechanical weeding at 25 DAS	65.4	23.2	54.9	374.72	24.5	1.98
Pendimethalin 1.0 kg/ha(PE)+ imazythapyr 40 g/ha at 25 DAS	48.6	14.5	71.8	439.8	30.2	2.38
LSD (P=0.05)	16.4	8.6	-	32.8	-	-

Effect on yield and economics

Amongst intercropping treatments, cluster bean sole recorded significantly highest cluster bean equivalent seed yield (CEY). Pearl millet sole resulted in significantly lowest CEY, which was 77.56% lower than that of CEY obtained with cluster bean sole. Highest net return and B: C ratio was also fetched by cluster bean sole. Better smothering effect coupled with higher market value of cluster bean seed than pearl millet led to increase in CEY and net returns.

Two hand weeding being comparable with pendimethalin 1.00 kg/ha + one hand weeding produced significantly highest CEY than remaining weed management treatments. Maximum net returns and B:C ratio were obtained with pendimethalin 1.00 kg/ha + one hand at 25 DAS weeding followed by two hand weeding at 25 and 45 DAS.

CONCLUSION

It was concluded that cultivation of cluster bean sole coupled with the application of pendimethalin 1.0 kg/ha (PE) + one hand weeding at 25 DAS found most remunerative treatments under arid region of Rajasthan

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Effect of integrated weed management on sugarcane

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Sugarcane (*Saccharum officinarum* L.), a remunerative cash crop, occupies important position in Indian agriculture. The longer time (3-5 weeks) required by the crop to germinate, slow initial crop growth, wider spacing, heavy manuring coupled with frequent irrigation provides congenial condition for weed growth that leads to intense competition of weed with crop plants for nutrients, moisture, light, CO2 and space. For getting higher yield from sugarcane crop, weed management play a vital role. Keeping these points in view, an experiment was planned.

METHODOLOGY

The field experiment was conducted during the year 2011-2012 at Instructional Farm, Department of Agronomy, Navsari Agricultural University, Navsari, Gujarat. Treatments comprised of fourteen weed management practices arranged in randomized block design with three replications. Sugarcane '*Co 99004*' was planted at 90 cm row spacing and was managed as per the standard package of practices. Data on weed, sugarcane and economics were recorded.

RESULTS

Predominant weed species found in the experimental field were *Cyperus rotundus* L., *Eragrostis* major, *Brachiaria* spp., *Oryza sativa* L., *Echinochloa colonum* L., *Phyllanthus moderaspatenia* L., *Alternanthera sessilis* L., *Euphorbia hirta* L., *Digera arvensis* Forsk, *Melilotus indica* (L.), *Physalis minima* L., *Corchorus acutangulus* L. and sedges like *Cyperus rotundus* L., *Cyperus iria* L. Three hand weedings (HW) at 30, 60 and 90 days after planting (DAP) and two intercultures (IC) at 45 and 90 DAP recorded the lowest dry weight of weed 1.43 t/ha at final earthing up. While, highest dry weight of weed (7.07 t/ha) at final earthing up was recorded under unweeded control. Most of the integrated weed management treatments were found effective to reduce the dry weight of weeds as compared to unweeded control. These results were as per expectation as conventional method and different herbicide application as pre-emergence and post-emergence and pre-emergence + intercrop (sunnhemp) check weed growth up to 90 DAP and late emerged weeds flush may be smothered by intercrop and vigorous sugarcane crop growth.

Three hand weedings (HW) at 30, 60 and 90 days after planting (DAP) along with two interculturings (IC) at 45 and 90 DAP recorded significantly higher number of tillers (28.0) per meter row length at 90 DAP, plant height (499 cm), millable cane height (409 cm), number of millable canes (111600/ha) and number of internodes per millable cane (35.5), cane yield (128.4 t/ha) at harvest followed by the application of metribuzin 1.0 t/ha as pre-emergence + one HW and IC at 60 DAP as compared to the unweeded control treatment.

Table 1. Effect of integrated weed management on dry weight of weeds, weed control efficiency, yield attributes, cane yield and economics of sugarcane

Treatment	Dry weight of weed at final earthing-up (t/ha)	Weed control efficiency (%)	Cane yield (t/ha)	Cost of cultivation (x10^3 ₹ /ha)	Net returns (x10^3 ₹ /ha)	B:C ratio
Unweeded control	7.07	-	63.8	127.9	38.0	0.30
3HW at 30, 60 and 90 DAP and 2IC at 45 and 90 DAP	1.43	78.6	134.4	141.7	207.6	1.46
Atrazine 2.0 kg/ha as PE	3.60	49.9	109.3	129.8	154.2	1.19
Atrazine 2.0kg/ha as PE + one HW and one IC at 60 DAP	2.89	56.3	123.9	134.6	187.3	1.39
Pendimethalin 1.0 kg/ha as PE + one HW and IC at 60 DAP	3.70	45.4	118.5	134.6	173.3	1.29
Metribuzin 1.0 kg/ha as PE + one HW and IC at 60 DAP	3.16	69.6	128.4	135.0	198.8	1.47
Atrazine 2.0 kg/ha as PE + 2,4-D Na salt 1.0 kg/ha as PoE applied at 60 DAP	6.13	31.6	115.7	130.4	170.4	1.31
2,4-D Na salt 1.0 kg/ha as PoE + paraquat 0.5 kg/ha as PoE applied at 30 DAP followed by 60 DAP	4.66	72.6	108.7	129.3	153.1	1.18
2,4-D Amine salt 1.0 kg/ha as PoE + paraquat 0.5 kg/ha as PoE applied at 30 DAP followed by 60 DAP	4.20	75.5	111.4	129.4	160.2	1.24
2,4-D Amine salt 1.0 kg/ha as PoE + metribuzin 0.5 kg/ha as PoE applied at 30 DAP followed by 60 DAP	4.05	76.9	113.0	129.9	163.8	1.26
2,4-D Amine salt 1.0 kg/ha as PoE + atrazine 1.0 kg/ha as PoE applied at 30 DAP followed by 60 DAP	3.90	39.4	116.0	129.7	171.8	1.32
Pendimethalin 1.0 kg/ha as PE + sunnhemp as a smother crop harvested and mulched at 60 DAP	6.74	56.0	99.1 (156)*	134.2	123.6	0.92
Metribuzin 1.0 kg/ha as PE + sunnhemp as a smother crop harvested and mulched at 60 DAP	4.91	60.0	106.9 (52)*	134.6	143.5	1.07
Atrazine 1.0 kg/ha as PE + sunnhemp as a smother crop harvested and mulched at 60 DAP	5.41	35.0	96.8 (118)*	133.4	118.3	0.89
LSD (P=0.05)	1.02		17.92			

*Data presented in parenthesis indicate dry weight of sunnhemp (kg/ha)

Three hand weedings at 30, 60 and 90 days after planting and two intercultures at 45 and 90 DAP obtained higher net realization (207.6 x103 Rs./ha) followed by the application of metribuzin 1.0 t/ha as pre-emergence + one HW and IC at 60 DAP (198.8 x 103/ha) and atrazine 2.0 t/ha as pre-emergence + one HW and one IC at 60 DAP (187.3 x10^3 /ha). However, B:C ratio was found more or less similar among these best three treatments.

CONCLUSION

Based on the results of the field experimentation, it seems quite logical to conclude that potential cane production and economic weed management can be achieved in sugarcane by three hand weedings at 30, 60 and 90 DAP and two intercultures at 45 and 90 DAP. However, under scarcity of labours, application of metribuzin 1.0 t/ha or atrazine 2 kg/ha as pre-emergence with 500 L water/ha + one hand weeding and interculturing at 60 DAP is the best option.

Efficacy of ethoxysulfuron for control of *Cyperus rotundus* in sugarcane

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Sugarcane, being a slow growth at initial stage and a long duration crop faces many fold competition with annual grasses, broad leaved and perennials weeds like *Cyperus rotundus* between 60 to 120 days of its planting, which causes heavy reduction in cane yield ranging from 40-67% (Singh *et al.* 2011). Management practices play an important role in realizing potential yield of sugarcane crop. Sugarcane, being a widely spaced allows wide range of weed flora to grow profusely in the interspaces between the rows. Frequent irrigations and fertilizer application during early growth stages increase the weed menace by many fold**.** To escape yield loss and to achieve maximum yield of sugarcane a weed free environment during the critical period of crop - weed competition is essential which could be achieved by the application of effective herbicides**.** It is well established fact that cultural method of weed management is most effective to control weeds but in present scenario timely availability of agricultural labourers is a big problem in agriculture and day by day increasing labour charges further increase the cost of cultivation. Therefore, herbicidal control of weeds has been suggested to be economical in sugarcane (Sarala *et al.* 2011). Several herbicides have however been tried in sugarcane but successful control of *Cyperus rotundus* could not be achieved. The present investigation was undertaken to study the bio-efficacy of ethoxysulfuron (Sunrice 15 WG) for the control of *Cyperus rotundus* (nut sedge) in sugarcane.

METHODOLOGY

A field experiment was conducted during 2009-10 and 2010-11 at N.E. Borlaug Crop Research Center of GBPUA & T, Pantnagar, Uttarakhand to evaluate the bio-efficacy of ethoxysulfuron (Sunrice 15 WG) for the control of *Cyperus rotundus* in sugarcane. Soil of the experimental field was silty-loam in texture, medium in organic carbon (0.67%), available phosphorus (29.6 t/ha) and potassium (176.4 t/ha) with pH7.2. Experiment with six treatments comprised of three doses of ethoxysulfuron 46.87 t/ha, 56.25 and 60g/ha at 3-4 leaf stage of *Cyperus rotundus* compared with 2, 4 –D sodium salt 80 WP at 1000 g /ha along with three hoeing at 30, 60 and 90 days after planting (DAP) of sugarcane crop and untreated control was laid out in randomized block design with three replications. Ethoxysulfuron and 2, 4-D (Na salt) were applied at 3-4 leaf stage of *Cyperus rotundus* by using Maruti foot sprayer fitted with flat fan nozzle as spray using water volume of 500 liters per hectare. Three budded setts of sugarcane variety *'CoP 90223'* were planted keeping a row spacing of 75 cm on March 3, 2009 and April 9, 2010 respectively. The Sugarcane crop was harvested on December 7, 2009 during first year and December 13, 2010, during second year respectively. Observations on density and dry weight of weeds were recorded at 30 and 60 days after execution of treatments. Data pertaining to density and dry matter accumulation of total weeds were subjected to log transformation by adding 1.0 to original values prior to statistical analysis.

RESULTS

The major weeds of experimental field in untreated control plots were: *Cyperus rotundus, Echinochloa spp., Digitaria sanguinalis, Dactyloctenium aegyptium, Trianthema monogyna, Digera arvensis* and *Ipomoea spp.* in both the years. Besides these, *Brachiaria reptans* and *Cleome viscosa* were also observed as major weeds during 2010. All the weed control treatments caused significant reduction in the dry weight of *Cyperus rotundus* and density and dry weight of total weeds over untreated control during both the years at both the stages. Among the herbicidal treatments, the lowest weed density and dry weight of total weeds were observed with ethoxysulfuron at 60 g/ha though the differences were non-significant when compared with its lower dose at 56.25 at 30 and 60 DAA and 46.87 t/ha at 60 days after application during both the years (Table 1). Application of ethoxysulfuron at all the doses effectively controlled the *C. rotundus*, and broad leaved weeds viz. *T.monogyna*, *D. arvensis*, *C. viscosa* and *Ipomoea spp.* In herbicidal treatments, application of ethoxysulfuron 15 WG at 60 g/ha recorded higher weed control efficiency of 62.9 and 56.5% at 30 DAA, and 44.1 and 40.0% at 60 DAA at during 2009 and 2010 respectively. Highest cane yield was recorded with three hoeing at 30, 60 and 90 DAP followed by ethoxysulfuron 15 WG at 60g/ha (82.3 and 86.8 t/ha) Weed index gives the magnitude of yield reduction due to weed competition. The weed index was zero at thrice hoeing at 30, 60 and 90 DAP whereas, in herbicidal treatments it was lower in treatment ethoxysulfuron 15 WG at 60 g/ha which recorded the weed index of 19.6%.

Table 1. Effect of ethoxysulfuron 15 WG on total weed density, dry weight, weed control efficiency and cane yield of sugarcane

Treatment	Dose (g/ha)	Total weed density at 60 DAA (no./m²)		Total weed dry weight at 60 DAA /m²				Cane yield (t/ha)	
		2009	2010	2009	WCE %	2010	WCE %	2009	2010
Ethoxysulfuron 15 WG	46.87	4.08 (58)	4.16 (63)	4.48 (86.8)	39.76	4.63 (101.2)	31.34	69.2	72.3
Ethoxysulfuron 15 WG	56.25	3.91 (49)	3.87 (47)	4.41 (81.1)	43.71	4.52 (90.4)	38.67	76.8	80.6
Ethoxysulfuron 15 WG	60.00	3.87 (47)	3.83 (46)	4.40 (80.6)	44.07	4.49 (88.5)	39.96	82.3	86.8
2,4-D Na salt 80WP	1000.0	4.32 (74)	4.23 (68)	4.57 (95.7)	33.59	4.62 (100.4)	31.89	68.3	70.0
Hoeings at 30, 60 & 90 DAA	-	1.95 (6)	2.30 (9)	0.69 (1)	99.30	0.83 (1.3)	99.12	102.0	108.3
Untreated control	-	4.83 (124)	4.71 (110)	4.98 (144.1)	-	5.00 (147.4)	-	47.5	48.7
LSD (P=0.05)	-	0.37	0.32	0.35	-	0.37	-	6.8	7.2

Figures in parentheses indicate original values which were transformed to $\log_e$ (x+1)

CONCLUSION

It was concluded that application of ethoxysulfuron 15 WG 60 g/ha or 56.25 t/ha at 3-4 leaf stages of *Cyperus rotundus* was found to be more effective for controlling the *Cyperus rotundus* as well as broadleaf weeds viz., *T. monogyna*, *D. arvensis*, *C. viscosa* and *Ipomea* spp. in spring planted sugarcane.

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Efficacy of different herbicides in wheat intercropped in autumn sugarcane

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Sugarcane is an important agro-industrial crop in India plays a pivotal role in national economy, sugarcane characteristically widely spaced, initially slow growing and long duration crop, lends ample scope for intercropping with income generating crops for nutrition and economic security especially of small and marginal cane growers. Autumn-planted sugarcane is very suitable for intercropping because of its slow growth rate during the winter and early spring due to prevalence of low temperature. Wheat is the major staple food crop of our country and is the viable option to be intercropped in sugarcane. Among the factors for low productivity, negligence towards weed management is the most important one, as the losses due to weeds range from 30-70% reduction in cane yield (El- Shafai *et al*. 2010). Infestation by different species of weeds in wheat is the one of the major problems faced by the farmers. The intensive cropping system coupled with better irrigation and fertiliser application has provided congenial growing conditions of wide range of grassy and non-grassy weeds, in general and *Phalaris minor* in particular where it has emerged as major weed of wheat causing yield reduction to the tune of 15-50% or sometime more depending upon the weed density and type of weed flora (Jat *et al*. 2003). Keeping in the view the facts, the present study was planned to evaluate the efficacy of different herbicides in wheat intercropped in autumn sugarcane.

METHODOLOGY

A field experiment was conducted during *Rabi* 2011-12 and 2012-13 at Gurdaspur (Punjab) on clayey loam soil to study the efficacy of different herbicides in wheat intercropped in autumn sugarcane. The experiment was laid out in using randomized block design (RBD) having three replications and it comprised of eight treatments, *viz*. isoproturon 75 WP at 1.25 t/ha, sulfosulfuron 75 WG at 32.5 g/ha, sulfosulfuron + metsulfuron 75 WG at 40 g/ha, mesosulfuron + iodosulfuron 3.6 WDG at 400 g/ha, clodinafop 15 WP at 400 g/ha, fenoxaprop-p-ethyl 10 EC at1.0 l/ha, metribuzin 70 WP at 375 g/ha and a weedy check. The data on weed density/ m^2, dry matter of weeds (g/m^2), yield attributes of wheat and grain yield of wheat and sugarcane crop were recorded at harvest. To assess the efficacy of different herbicides in wheat intercropped with sugarcane, weed control efficiency was also calculated.

RESULTS

Results revealed that all the weed control treatments recorded significant reduction in the density of weeds and biomass of weeds compared with weedy check. However, sulfosulfuron+ metsulfuron 75 WG at 40 g/ha was observed to be significantly superior over the application of isoproturon 75 WP at 1.25 t/ha, metribuzin 70 WP at 375 g/ha, fenoxaprop-p-ethyl 10 EC at 1.0 l/ha and clodinafop 15 WP at 400 g/ha for reducing the density of weeds and biomass of weeds with the highest grain yield but at par with sulfosulfuron 75 WG at 3 2.5 g/ha and mesosulfuron + iodosulfuron 3.6 WDG at 400 g/ha in both the years of study. Highest weed control efficiency was recorded in sulfosulfuron + metsulfuron 75 WG at 40 g/ha closely followed by sulfosulfuron 75 WG at 32.5 g/ha and mesosulfuron + iodosulfuron 3.6 WDG at 400 g/ha. This study indicated increased cane and cane equivalent yield with sulfosulfuron + metsulfuron 75 WG at 40 g/ha over the application of isoproturon 75 WP at 1250 g/ha, metribuzin 70 WP at 375 g/ha, fenoxaprop-p-ethyl 10 EC at 1.0 l/ha and clodinafop 15 WP at 400 g/ha, however the differences among sulfosulfuron + metsulfuron 75 WG at 40 g/ha, sulfosulfuron 75 WG at 32.5 g/ha and mesosulfuron + iodosulfuron 3.6 WDG at 400 g/ha were found to be non-significant.

CONCLUSION

The present study indicated that post emergence application of sulfosulfuron + metsulfuron appeared to be productive and profitable in wheat crop intercropped with sugar cane and resulted in maximum grain yield. However, it was closely followed by mesosulfuron + iodosulfuron and sulfosulfuron in performance.

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Creeper weed management in sugarcane in sandy-loam soils of southern agro-climatic Zone of Andhra Pradesh

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Sugarcane is one of the important cash crops in Andhra Pradesh, India. Sugarcane being long duration and wide spaced crop with slow growth, poses problem of weeds. The weeds grow luxuriantly in the inter-row spaces and compete with sugarcane crop for moisture and nutrients. Among the weed flora creeper weeds not only render harvesting a tedious task but also reduce yield by 15-25%. Maintenance of weed free environment in the early stages of crop growth up to 90 days after planting is essential since heavy weed infestation can cause yield reduction up to 40-67%. Weed control treatments significantly minimized weed infestation in the crop thereby resulting in higher cane yields (Chauhan *et al*. 1982; Peddiappan *et al*. 1999). Hand weeding is uneconomical due to higher cost and scarcity of labour at the time of weeding and harvesting. Thus it is economical to control creeper weeds with post emergence herbicides in sugarcane.

METHODOLOGY

The study was conducted during the cropping seasons of 2009-10 and 2010-2011 with two plant crops and one ratoon crop (cv. '2003V46') at the Agricultural Research Station, Perumallapalle Andhra Pradesh. The soil was sandy loam with pH 8.5, low in organic carbon and available nitrogen, and medium in available P2O5 and high in available K2O. Nine weed control (as detailed in Table 1) was laid out in a randomized block design with three replications and a plot size of 36 m^2. Planting was done in furrows at 80 cm row spacing and fertilized with 224 kg N, 112 kg P_2O_5 and 112 kg K_2O per ha. The crop was irrigated through drip method. Herbicidal spray was done in aqueous solution of 11.25 t/ha. Creeper weed samples for population count and dry weight were collected from each plot of the three replications before harvest of the crop. Yield and yield attributing parameters were recorded at harvest.

RESULTS

The predominant creeper weeds observed in the present study were: *Coccinia indica*, *Ipomoea* sp., *Rhycosia minima*, *Clitoria turnaetea and Melothria* sp. Creeper weed population and weed dry matter accumulation were significantly reduced with the weed control treatments under study compared to control (Table 1) in plant as well as ratoon crops. Post-emergence applications of metribuzin at 1.25 kg/ ha + 2,4-D sodium salt at 2 kg/ha reduced weed biomass significantly, and recorded the lowest dry weight of weeds and maximum WCE which was comparable with hand weeding at 30 DAP, 60 DAP + 2,4-D sodium salt at 75 DAP. These results are in accordance with earlier findings wherein post-emergence directed spraying of 2,4-D sodium salt at 0.2% +1% urea effectively controlled the climber weeds (ARS, Cuddalore). All the weed control practices significantly reduced the creeper weed flora and their dry weight. Creeper weeds were more effectively controlled by Almix (combination of metsulfuron-methyl + chlorimuron-ethyl 20 WP) and ethoxysulfuran in combination with metribuzin that as individual applications.

Table 1. Effect of weed control treatments on weed number and dry weight, and yield attributes of sugarcane (mean of two years data of plant crop)

Treatment	No. of creeper weeds/36 m^2 before harvest	Creeper weed dry weight (kg/ha)	Weed control efficiency (%)	Cane yield (t/ha)	Cost of cultivation (`/ha)	B:C ratio
T1 Control (no weeding)	39.0	192.2	-	57.8	0.00	1.37
T2 Hand weeding at 30 and 60 DAP	20.0	54.5	71.5	101.2	25,000	1.85
T3 2, 4-D sodium salt @ 2 kg at 60 DAP	22.0	79.8	58.5	86.9	3,274	1.99
T4 Hand weeding at 30, 60 DAP + 2, 4-D sodium salt @ 2 kg at 75 DAP	21.0	30.5	84.0	110.3	26,000	2.17
T5 Metribuzin @ 1.25 kg +2,4-D sodium salt @ 2 kg at 75 DAP	19.0	34.5	82.1	103.3	4,874	2.32
T6 Almix @ 20 g at 75 DAP	24.0	68.8	64.2	82.8	2,040	1.92
T7 Metribuzin @ 1.25 kg + Almix @ 20 g at 75 DAP	25.0	72.2	62.2	89.3	5,152	1.81
T8 Ethoxysulfuran @ 50 g at 75 DAP	26.0	84.5	55.9	83.7	1,264	1.96
T9 Metribuzin @ 1.25 kg + ethoxysulfuran @ 50 g at 75 DAP	22.0	66.3	65.6	95.3	4,376	2.15
CD (P=0.05)	-	67.3	-	10.8	--	--

In both plant and ratoon crop (data not presented here) all the weed control treatments resulted in significant increase in yield and yield attributes of the crop (Table 1). Hand weeding at 30, 60 DAP + 2, 4-D sodium salt at 2 kg/ha at 75 DAP recorded highest cane yield and it was on par with mertibuzin at 1.25 kg/ha + 2,4-D sodium salt at 2 kg/ha. These results in accordance with Singh *et al.* (2008). Among herbicides, almix and ethoxysulfuran performed better in combination with metribuzin and resulted in realizing higher cane yield. The highest net returns and cost benefit ratio were realized with metribuzin at 1.25 kg/ha + 2, 4-D sodium salt at 2 kg/ha followed by hand weeding at 30, 60 DAP + 2,4-D sodium salt application at 2 kg/ha at 75 DAP (Table 3) Thus, post emergence application of metribuzin at 1.25 kg/ha + 2, 4-D sodium salt at 2 kg/ha was effective and economical in controlling creeper weeds in sugarcane plant and ratoon crops.

CONCLUSION

Uncontrolled growth creeper weeds reduced the yield of sugarcane crop by 30-47% in comparison to hand weeding at 30 DAP and 60 DAP. Among the post emergence herbicides 2,4 D sodium salt at 2 kg/ha + metribuzin at 1.25 kg/ha realized highest value of cost benefit ratio (2.32) followed by metribuzin at 1.25 kg/ha + ethoxysulfuran at 50 g/ha (2.15).Weed management practices did not influence juice percent significantly.

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Effect of integrated weed management in spring-planted sugarcane under Konkan condition

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Slow germination and initial slow growth of sugarcane coupled with wider row spacing, frequent irrigations, heavy manuring and fertilizer applications provide ample scope to weeds for their growth in sugarcane fields especially during the initial period of 2-3 months after planting. In general, none of the single, either mechanical or chemical method proves to be effective and economical for control of weeds. Therefore, present investigation for use of herbicides and their integration with hand weeding was taken up.

METHODOLOGY

An experiment was conducted at the Agronomy Farm, College Agriculture, Dapoli during 2006-2009 to study the effects of various pre emergence (PE) herbicides (ametryn and metribuzin) and post emergence (PoE) herbicides (2,4-D, MSM and glyphosate) besides their integration with hand weeding at different growth stages of spring planted sugarcane variety '*Co 8014*' which were replicated four time and all recommended package of practices. The data on weed growth, yield performance and economics were also worked out.

RESULTS

Major weed flora were: *Oryza sativa, Digitaria ciliaris, Echinochloa colona* (among grasses), *Cyperus rotundus* (sedge); *Mimosa rubicaulis, Mimosa pudica, Convolvulus arvensis, Alternenthera sessilis, Physalis minima, Ludwigia octovalvis, Ageratum conyzoides, Celosia argentea, Amaranthus viridis, Cardiospermum helicacabum*, and *Commelina benghalensis* (among broad leaf weeds). However, the dominant weed flora were: *M. rubicaulis, M. pudica, C. arvensis* (during first year) and *Physalis minima* (during second year).

Compared to the weedy check, all the treatments under study caused significant reduction in weed growth during first year and so was the case during second and third year pooled data too except the fact that weedy check was at par with PE use of ametryn alone. Amongst these effective treatments, PoE application of glyphosate 1.5 kg/ha integrated with hand weeding once at 60 DAP topped the rank in exhibiting highest weed control efficiency when compared with the most effective treatment of farmer's practice involving four hand weedings at 30, 60, 90 and 120 DAP.

Accordingly millable cane population and cane yield was significantly influenced due to different weed control treatments. Compared to the best treatment of 4 HWs 30, 60, 90 and 120 DAP, weed competition index (WCI) was lowest in case of the treatment of PoE application of glyphosate at 1.5 kg/ha + 1 HW 60 DAP followed by the treatments viz. PE application of metribuzin + 2HWs 60 and 90 DAP and PE application of ametryn + 2 HWs 60 and 90 DAP. Quality of sugarcane in terms of brix per cent in juice, sucrose per cent in juice and percentage of commercial cane sugar did not vary much due to different weed controls treatments. However, yield of commercial cane sugar followed similar trend as that of yield of millable canes. As compared to the best treatment of farmer's practice, reduction in yield of commercial cane sugar was least in case of the treatment viz. glyphosate + 1HW 60 DAP followed by use of metribuzin +2 HWs 60 and 90 DAP and use of ametryn + 2 HWs 60 and 90 DAP (Su et al 1992)

Table 1. Effect of weed control measures on mean weed growth, cane population, cane yield, quality attributes and yield of sugar

Treatment	First year (at harvest)		Mean of 2nd & 3rd year 120 DAP		Cane yield (t /ha)	Brix % juice	Sucrose % juice	CCS (%)	CCS (t/ha)
	At harvest	WCE (%)	Pooled	WCE (%)					
Ametryn 1.0 kg/ha (PE) (*fb*) hand weeding twice at 60 and 90 DAP	32.9	93.2	31.3 (5.66)	85.3	79.55	20.6	18.2	12.4	9.9
Metribuzin 0.5 kg /ha (*fb*) hand weeding twice at 60 and 90 DAP	72.0	85.3	26.0 (5.22)	87.8	83.71	20.9	18.1	12.3	10.3
Glyphosate 1.5 kg/ha before crop emergence (*fb*) hand weeding once at 60 DAP	20.6	95.7	28.0 (5.38)	86.8	89.85	21.4	18.3	12.4	11.1
Farmers practice hand weeding four times at 30, 60, 90 and 120 DAP	12.3	97.4	88.3(8.94)	72.5	91.21	20.7	18.3	12.5	11.4
Weedy check	489.7	--	212.5(14.44)	--	36.56	20. 8	17.9	12.3	4.49
LSD (P=0.05)	71.5	--	(1.14)	--	5.49	--	--	--	--

Highest net returns were obtained in case of post emergence of application of glyphosate in combination with hand weeding once at 60 DAP followed by farmer's practice where hand weeding was done four times 30, 60, 90 and 120 DAP. The B:C ratio was also maximum in case of glyphosate + 1 HW followed by the treatments viz. pre emergence application of metribuzin + 2 HWs 60 and 90 DAP and farmers practice (four hand weedings at 30, 60, 90 and 120 DAP).

CONCLUSION

For effective and economical weed management in seasonal sugarcane (December-January planting), application of post emergence spray of glyphosate at 1.5 kg / ha (3.66 kg/ha commercial herbicide containing 41%) 20 days after planting in combination with hand weeding once at 60 days after planting (DAP) or follow hand weeding four times at 30, 60, 90 and 120 DAP.

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Effect of auxin inhibitor herbicides on alfalfa seed development and viability

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Feral alfalfa contributes to pollen contamination and lowers genetic purity in alfalfa seed production fields when it is located in the vicinity of foraging pollinators working alfalfa seed fields. Of particular concern is glyphosate resistant (GR) feral alfalfa in conventional and organic alfalfa seed growing regions. Feral plants can reproduce and give rise to additional sources of pollen contamination. If a bee visits a GR feral plant and moves on to forage a conventional plant, the seed produced by the conventional plant will carry the GR trait resulting in adventitious presence. Therefore, an important strategy is to control feral plants found along roadsides apart from cultivated fields. Auxin inhibitor herbicides applied during seed development may reduce seed production and development (Rinella *et al.* 2010). This study was conducted to determine the effect of four auxin inhibitor herbicides; dicamba, 2,4-D, triclopyr and aminopyralid on seed development in glyphosate resistant alfalfa.

METHODOLGY

Glyphosate resistant alfalfa, var. Genuity (R44BD16) was treated July 25, 2012, July 10, 2013, and July 11, 2014 with dicamba (0.8 kg/ha), 2,4-D (1.1 kg/ha), triclopyr (0.8 kg/ha), and aminopyralid (0.09 kg/ha) when alfalfa plants contained green seed pods and 5% or less tan colored (mature) seed pods. Non treated control plants were included for comparison. Six plants were selected per herbicide treatment and treatments were arranged in a randomized complete block design. Herbicides were applied with a 2-nozzle backpack sprayer equipped with 8002XR flat fan nozzles calibrated to deliver 190 l/ha. Two weeks after herbicide application, plants were harvested, air dried,and seed yield determined. Seed viability was assessed with germination tests by placing 300 seed from each plant in Petri dishes with moistened paper at 20^0C for 3 weeks and counting germinated seed. The ability of seedlings to emerge from planted seed was tested by planting 50 seed from each plant into potting soil in greenhouse containers.

RESULTS

Auxin inhibitor herbicides applied during the early pod fill period decreased alfalfa seed yield per plant 53-77% (by weight) compared to non treated plants. Seed germination averaged 42, 48, and 72% in 2012, 2013, and 2014, respectively, and was not significantly affected by treating with the four herbicides during early pod fill stage. However, seeds grown from plants treated with dicamba, 2,4-D, and triclopyr caused deformed and abnormal seedlings. Dicamba tended to cause the greatest percentage of deformed seedlings (16 and 37% respectively). Normal seedlings developed from seeds collected from aminopyralid treated and non treated plants. In 2012 and 2014, seedling emergence was reduced by 57-77% from dicamba treated plants; 44-69% from 2,4-D and triclopyr treated plants, but was not significantly reduced in 2013 compared to non treated. Seedling emergence from seed collected from aminopyralid treated plants was similar to non treated checks in all three years.

CONCLUSION

The combined effects of reduced seed yield and lower percent seedling emergence from seed from dicamba, 2,4-D, and triclopyr treated plants could greatly reduce ability of feral alfalfa plants to reproduce. These three herbicides could be useful components of an integrated management program for feral alfalfa.

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A brief discourse of weeds - their occurrence in mulberry with general management strategies

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Sericulture is an unique combination of art and science of rearing silkworms (*Bombyx mori* L.) which produce cocoons being reeled for silk yarn thereby generating income for the rural population of our country (India) in general and many states of the subcontinent in particular. Silk yarn which is converted into multi-coloured fabrics is the final outcome of 28-30 days hectic and voracious feeding of these tiny insects on mulberry leaf, the only food for them as they are monophagous in nature and cannot sustain their life in the absence of quality mulberry leaf. Sericulture is a prominent agro-based industry playing an important role in poverty alleviation and helping in percolating economy from rich to poor. The quantity of mulberry leaf decides the magnitude and the size of rearing silkworms while as the quality has a profound influence upon productive potential of silkworm seed and the post cocoon characters which along with other reeling interventions have a direct bearing upon the quality of yarn produced. However like any other agricultural crop, the mulberry gardens are also infested with different weed species which not only impede the quality of leaf but also reduce the yield of mulberry thus resulting in low output and tremendous losses to the stakeholders. As such the control of weeds and their management strategies are vital for increased crop growth of any crop along with mulberry as well. The present paper is an attempt to discuss the weed types and their impact on mulberry.

Nutrient uptake and quality of onion as influenced by graded levels of nutrients and weed management practices

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Onion bulb is rich in minerals, especially calcium and phosphorus besides having fairly good quantities of carbohydrates, proteins and vitamin C. Under suitable agro-climatic conditions, mineral nutrition is the main factor which influences the growth and yield of onion to a larger extent, since onion is known as a heavy feeder of minerals excessive fertilizers and delayed nitrogen application will hamper the keeping quality of onions (www.iihr.res.in). Onion is a very poor competitor of weeds due to its short stature, non-branching habit, sparse foliage and extremely slow growth during initial stages. Uncontrolled weed growth reduces the bulb yield up to 40-80% (Verma and Singh 1996). Hence, to optimize the agro techniques for higher productivity and better quality of onion, the present study has been undertaken.

METHODOLOGY

Field experiments were conducted at S.V. Agricultural College Farm, Tirupati during *rabi* 2005-06 and 2006-07 in split plot design, replicated thrice. The treatments comprised of combination of three nutrient levels [N_1 (40-40-30 kg/ ha N, P_2O_5, K_2O), N_2 (80-50-40 kg/ ha N, P_2O_5, K_2O) and N_3 (120-60-50 kg/ ha N, P_2O_5, K_2O)] and two times of N application [T_1 ($^1/_2$ basal + $^1/_2$ 30 DAT) and T_2 ($^1/_3$ basal + $^1/_3$ 30 DAT + $^1/_3$ 45 DAT) allotted to main plots and four weed management practices [W_1 (unweeded check), W_2 (hand weeding twice at 20 and 40 DAT), W_3 (pre-emergence application of oxyfluorfen 0.24 kg/ ha+ HW at 40 DAT), and W_4 (pre-emergence application of pendimethalin 0.75 kg/ha + HW at 40 DAT)] assigned to sub plots. Fertilizers were applied through urea, single super phosphate and muriate of potash as per the treatments. Data on nutrient uptake and quality were recorded.

RESULTS

Nutrient uptake (nitrogen, phosphorus and potassium) by onion shoots and bulbs was the highest with N_3 (120-60-50 Kg/ha N, P_20_5, K_20), followed by N_2 with distinct disparity between them and the lowest was with N_1 (40-40-30 Kg/ha N, P_20_5, K_20). Similarly highest nutrient uptake (Table-1) was recorded with hand weeding twice, which was however, on par with pre-emergence application of either oxyfluorfen 0.24 kg/ha or pendimethalin 0.75 kg/ha + hand weeding at 40 DAS and the lowest nutrient uptake was noticed with unweeded check. Quality parameters of onion (TSS and ascorbic acid content) were the highest with N_3 (14.02% TSS and ascorbic acid 12.58 mg 100/g), which was distinctly higher than with N_2 and N_1. The weed management practices significantly altered TSS content (13.32%) and the highest ascorbic acid content (12.19 mg 100/g) was recorded with IWM treatments and it was comparable with hand weeding twice (13.24% and 12.09 mg 100/g). The lowest quality parameters were noticed with unweeded check. Weight loss (%) of onion bulbs during storage was the lowest with N_1 (40-40-30 Kg/ha N, P_20_5, K_20) and it was the highest with N_3 (120-60-50 Kg/ha N, P_20_5, K_20), whereas it was not significantly influenced by weed management practices.

Table 1. Nitrogen uptake (kg/ ha) and quality of onion as influenced by nutrient and weed management practices

Treatment	Nutrient uptake at harvest (kg/ ha)						Quality		*Weight loss (%)
	N		P		K		TSS (%)	Ascorbic acid (mg/ 100 g)	
	Shoots	Bulbs	Shoots	Bulbs	Shoots	Bulbs			
Nutrient levels									
N_1	36.75	27.54	9.19	8.87	42.19	38.08	11.73	10.84	19.87 (11.58)
N_2	51.33	48.88	12.91	16.36	56.16	65.59	12.70	11.76	20.75(12.58)
N_3	60.84	72.35	16.55	24.39	64.85	92.62	13.93	12.57	22.12(14.24)
LSD (P=0.05)	3.77	1.95	1.00	0.62	4.21	2.53	0.26	0.17	0.81
Time of N application									
T_1	49.10	49.31	12.74	16.46	53.76	65.04	12.85	11.74	20.95(12.84)
T_2	50.19	49.88	13.03	16.62	55.04	65.81	12.73	11.71	20.88(12.76)
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management practices									
W_1	32.82	26.43	8.10	8.81	35.71	34.94	12.16	11.20	20.52(12.34)
W_2	57.08	58.91	14.98	19.61	62.68	77.70	13.17	12.09	21.11(13.04)
W_3	55.66	57.58	14.58	19.23	61.06	75.95	12.98	11.92	21.04(12.94)
W_4	53.00	55.46	13.88	18.51	58.16	73.12	12.86	11.68	20.98(12.89)
LSD (P=0.05)	3.80	3.82	0.99	1.22	4.16	4.95	0.48	0.27	NS

*40 days after harvest.; Data in parentheses are original values, which were subjected to angular transformation

CONCLUSION

The study has revealed that onion can be successfully grown with the supply of 120-60-50 Kg/ha N, P_20_5, K_20, following IWM practice of pre-emergence application of either oxyfluorfen or pendimethalin 1 to 3 DAT, followed by hand weeding at 40 DAT.

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Herbicide combinations for control of complex weed flora in peas

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The garden pea (*Pisum sativum* var. *hortense*) is one of the most important cool season frost hardy vegetable crops. Weed problem is very serious due to frequent irrigation and high fertility which provides congenial conditions for their growth and development. Weeds have been reported to cause 81% losses in its yield (Singh *et al*. 1996). Manual weeding is labour intensive, cumbersome and time consuming, and mechanical methods are reported to cause injury to root system (Casarini *et al*. 1996). Various pre-plant incorporation and pre-emergence herbicides have been recommended for weed control in peas. In present study, the new post-emergence herbicides, *viz*. imazethapyr alone and in combination with imazamox (odissey) have been evaluated.

METHODOLOGY

A field experiment was conducted during the winter season of 2012-13 and 2013-14 under mid hill condition of Himachal Pradesh, to elucidate the effect of different herbicide combinations for weed control ingarden pea. The treatments comprised pendimethalin 1500 g/ha at pre emergence, pendimethalin followed by (*fb)* imazethapyr 1000 *fb* 100 g/ha at pre *fb* post (45 DAS), imazethapyr *fb* imazethapyr 100 *fb* 100 g/ha at pre *fb* post (45 DAS), imazethapyr+ pendimethalin 1200 g/ha at pre emergence, imazethapyr + pendimethalin 1500 g/ha at pre emergence, imazethapyr+ pendimethalin *fb* imazethapyr 1000 *fb* 100 g/ha at pre *fb* post (45 DAS), imazethapyr+ imazamox 60 g/ha at post (45DAS), imazethapyr+ imazamox 90 g/ha at post (45DAS), pendimethalin *fb* imazethapyr + imazamox 1000 *fb* 60 g/ha at pre *fb* post (45 DAS), pendimethalin *fb* 1HW 1000 g/ha at pre *fb* HW (45 DAS), weed free and weedy check.

RESULTS

The results revealed that the total weed density and dry weight was significantly influenced due to different weed control treatments at all stages of crop growth during both the years (Table 1). Pendimethalin (1000 g/ha) *fb* 1HW being on a par with pendimethalin *fb* imazethapyr + imazamox (1000 *fb* 60 g/ha) and weed free resulted in significantly lower total weed count and dry weight. All weed control treatments were significantly superior to weedy check in influencing plant height, pods per plant, pod length, seeds per pod and green pod yield. Pendimethalin (1000 g/ha) *fb* 1HW was on a par with pendimethalin *fb* imazethapyr + imazamox (1000 *fb* 60 g/ha) and weed free resulted in significantly higher green pod yield.

Table 1. Effect of treatments on weeds and yield of field pea

Treatment	Dose (g/ha)	Time of application	Total weed count at 90 DAS (no./m²)		Total weed dry weight at 120 DAS (g/m²)		Pod yield (t/ha)	
			2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Pendimethalin	1500	Pre emergence	18.5(342.4)	18.2 (329.6)	12.4(154.1)	12.1(145.6)	6.57	6.57
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	16.5(272.0)	15.8 (250.7)	10.7(114.1)	10.7(114.1)	6.29	6.49
Imazethapyr*fb* imazethapyr	100 *fb* 100	Pre *fb* post (45 DAS)	19.2(368.0)	18.6 (346.7)	12.5(155.7)	12.3(149.3)	6.21	6.37
Imazethapyr + pendimethalin	1200	Pre emergence	15.0(224.0)	14.6 (213.3)	10.2(104.0)	10.2(104.0)	5.97	6.25
Imazethapyr + pendimethalin	1500	Pre emergence	14.1(197.3)	13.7 (186.7)	12.0(142.9)	11.2(124.8)	6.13	6.41
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	12.2(149.3)	12.0(144.0)	10.2(102.4)	10.2(102.4)	6.09	6.81
Imazethapyr + imazamox	60	Post (45DAS)	12.7(160.0)	12.7 (160.0)	9.8(94.4)	9.8(94.4)	6.0.1	6.69
Imazethapyr + imazamox	90	Post (45DAS)	13.9(192.0)	13.9 (192.0)	10.3(105.1)	10.5(109.3)	6.53	6.81
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* post (45 DAS)	10.1(101.3)	10.1 (101.3)	8.3(67.2)	8.8(76.3)	7.01	7.25
Pendimethalin *fb* 1HW	1000	Pre *fb* HW (45DAS)	8.4(69.3)	8.4(69.3)	8.3(67.2)	8.1(65.1)	7.17	7.33
Weed free	-	-	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	7.21	7.37
Weedy check	-	-	24.6(602.7)	24.0 (574.9)	17.1(293.3)	17.1(292.8)	4.34	4.74
LSD (P=0.05)			0.9	1.2	1.0	0.9	0.56	0.90

DAS - Days after sowing; HW - Hand weeding; Data transformed to square root transformation ($\sqrt{x+1}$), values given in parentheses are the means of original values

CONCLUSION

Pre-emergence pendimethalin (1000 g/ha) *fb* 1HW and pendimethalin *fb* imazethapyr + imazamox (1000 *fb* 60 g/ha) resulted in significantly higher green pea pod yield and can be effectively used for the control of mixed weed flora.

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Evaluation of post-emergence herbicides in controlling grassy weeds in jute

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In Coastal Andhra Prtadesh jute (*Corchorus olitorius* L.) is exclusively grown as seed crop in an area of around 35,000-40,000 hectares. In general, majority of weed seedlings emerge before or along with jute crop and reduces fiber yield ranging from 75-80% (Sahoo and Saraswat 1988). Lack of effective herbicides and the increased risk involved in application of herbicides to jute crop are the major bottle necks in realization of potential seed yield of jute. Presently farmers are doing hand weeding in jute crop which is a costly and laborious process. Keeping this in view, the present experiment was carried out to find out the most suitable post-emergence herbicide for control of grassy weeds in Jute.

METHODOLOGY

A field experiment was carried out at the research Farm, RARS, Lam during *kharif* from 2011 to 2014 to evaluate the bio-efficacy of post emergence herbicides in controlling grassy weeds and seed yield of jute. The study consists of seven treatments (Table 1) with three replications in a randomized block design. The predominant grassy weeds observed were *Echinochloa colona, Dinebra arabica, Panicum javanicum, Digitaria sanguinalis, Chloris barbata* and *Dactyloctenium aegyptium.* All weeds other than grasses were removed at the early stage and allowed the grasses to compete with the crop and left to the treatments. Data on weed density and dry weight were analysed after subjecting it to the square root transformation. The soil of the experiment is clayey soil with high water holding capacity, with pH 7.8, EC. 0.24 dS/m, medium in available N, and high in available phosphorus and potassium. Post- emergence herbicides were applied with knapsack sprayer at 20 DAS. The quantum of spray fluid used was 500 l/ha.

RESULTS

The highest seed yield (1.40 t/ha) was observed with hand weeding at 20 and 40 DAS followed by post-emergence application (20 DAS) of quizalofo-ethyl at 50g/ha as at (1.20 t/ha), propaquizafop 63 g/ha (1.19 t/ha), quizalofop-p- terfuryl 40 g/ha (1155 kg/ha) and fenoxaprop ethyl 56 g/ha (1.04 t/ha). The net returns and benefit cost ratio were higher with quizalofo-ethyl 50g/ha (Rs. 39,468/- and 2.94) than all other treatments including hand weeding at 20 and 40 DAS (Rs. 36,177/- and 2.07) followed by propaquizafop 63 g/ha (Rs. 39,225/- and 2.92), quizalofop-p- terfuryl 40 g/ha (Rs. 36,777/- and 2.75) and fenoxaprop-ethyl 56 g/ha (Rs. 32,107/- and 2.61). Though the hand weeding at 20 and 40 DAS results in higher seed yield, the expensive labour made the hand weeding treatment less remunerative. Similar results were reported by Sitangshu Sarkar (2006). All grassy herbicides recorded higher benefit cost ratios compared to the hand weeding at 20 and 40 DAS

Table 1. Mean values of Weed control efficiency (WCE), Seed yield, Net returns and benefit cost ratios of jute as influenced by Weed management practices

	Treatment	WCE (%)	Seed yield (t/ha)	Net returns (`/ha)	B:C Ratio
T_1	Weedy check	--	0.81	21,427	2.12
T_2	Hand weeding at 20 and 40 DAS	87.3	1.40	36,177	2.07
T_3	Pendimethalin 500g /ha as pre-emergence	78.3	0.79	19,313	1.95
T_4	Fenoxaprop-ethyl 56 g/ha at 20 DAS	71.2	1.04	32,107	2.61
T_5	Quizalofop-ethyl at 50 g/ha at 20 DAS	79.7	1.20	39,468	2.94
T_6	Quizalofop-p-terfuryl 40 g/ha at 20 DAS	78.7	1.15	36,777	2.75
T_7	Propaquizapop 63 g/ha at 20 DAS	76.7	1.19	39,245	2.92
	LSD (P=0.05)	-	0.20	-	-

CONCLUSION

The study indicates that the application of quizalofop ethyl at 50 g/ha applied as post-emergence at 20 DAS will control the grassy weeds in jute crop and helps in realizing the potential seed yield there by obtaining higher net returns and benefit: cost ratio.

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Weed flora and weed management practices in fodder crops

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Like food crops, weeds are an important constraint for fodder production. Weeds not only reduce the total fodder production but also impair the quality of fodder. Weeds mixed with fodder crops like *Trianthema* sp. and *Coccinia grandis* in maize, sorghum, and cowpea, *Cichorium intybus* and *Coronopus didymus* in berseem, *Spilanthes calva* in maize affect quality fodder production and the weeds like *Rumex dentatus* and *Poa annua* in berseem, *Amaranthus viridis* and the grasses like *Echinochloa* sp., *Paspalum disticum, Eleusine indica, Digitaria* sp. in maize and sorghum, *Chenopodium album* in summer cowpea reduce green fodder yield. With these views the present investigation was under taken to generate information on weed flora associated with fodder crops and their management at fodder farm of IVRI, Bareilly.

METHODOLOGY

Survey of weed flora was under taken in different fodder crops during late rainy season, winter season and early summer season with the use of 1 m^2 quadrate. The dominant weeds were identified in respective fodder crops based on the population recorder at 15 days interval.

RESULTS

Weed flora: The dominant and associated weed flora with different fodder crops are listed in Table 1. Among the dominant weed flora *Trianthema portulacastrum* and *T. monogyne* were highly obnoxious appearing in all the fodder crops grown during summer and rainy season. The weed *Coccinia grandis* (Ivy gourd) was also aggressive in maize raised in summer after harvesting of oat, however, maize raised after harvesting of berseem was free from this weed.

Weed management: High plant density and faster growth of maize plant have effectively restricted the growth of weeds. was found admixed with berseem seed and it became difficult to separate chicory seed by ordinary methods. Treatment of berseem seeds with 10% common salt removes the kasani/chicory (*Cichorium intybus*) seeds from berseem seeds. Turing the berseem fields to oat cultivation and oat fields to berseem cultivation could be effective for breaking cycle perpetuation of *Coronopus didymus, Rumex dentatus, Cichorium intybus* and *Poa annua.* Oat acted as a very good smother crop because of its fast tillering capacity and dense canopy development. Oat crop made the ecosystem completely unfavourable for these weeds. No-tilled surface seeded berseem delayed emergence of *Coronopus didymus* compared to puddled seeded berseem.

Table 1. Weed flora associated with different fodder crops

Fodder crop	Associated weed	Dominant weed
Maize, sorghum and cowpea	Grasses: *Cynodon dactylon, Echinochloa colona, Echinochloa glabrescens* *Paspalum disticum, Eleusine indica, Digitaria longiflora, Digitaria ciliaris, Dactyloctenium aegyptium, Setaria glauca* Sedge: *Cyperus rotundus* Broad-leaved: *Trianthema portulacastrum, Trianthema monogyne, Coccinia grandis, Ageratum conyzoides, Cleome viscosa, Physalis minima, Amaranthus viridis, Commelina benghalensis, Commelina diffusa, Spilanthes calva*	Grasses: *Echinochloa glabrescens, Eleusine indica, Digitaria longiflora, Digitaria ciliaris, Setaria glauca* Sedge: *Cyperus rotundus* Broad-leaved: *Trianthema portulacastrum, Trianthema monogyne, Amaranthus viridis, Spilanthes calva*
Berseem	Grass: *Poa annua* Broad-leaved: *Rumex dentatus, Cichorium intybus, Coronopus didymus, Spilanthes calva, Medicago denticulate*	1st cutting: *Coronopus didymus* 2nd and 3rd cutting: *Rumex dentatus, Cichorium intybus, Poa annua* 4th cutting: *Rumex dentatus, Cichorium intybus, Poa annua, Rumex dentatus*
Oat	Grass: *Poa annua* Broad-leaved: *Rumex dentatus*	

CONCLUSION

Weed management practices like stale seedbed preparation, treatment of berseem seeds with 10% common salt, use of cowpea and oat as smother crops, turning the berseem fields to oat cultivation and oat fields to berseem cultivation, no-tilled surface seeding of berseem, monitoring and control of black cut warm and army warm before sowing of maize, sorghum and cowpea, removing weeds from bunds and field boundaries before flowering could be effective for managing weeds in fodder crops.

Effect of nitrogen and weed management on weed control efficiency and yield of fodder turnip

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Turnip (*Brassica compestris var. rapa*) is a winter, short duration crop, which fit well in intensive crop rotations. The use of herbicides has great scope in fodder crops as they provide effective control of weeds and when applied at normal doses do not have any adverse effect on palatability of fodder and animal health. Nitrogen management is also the most important factor for optimum growth and development of turnip and effect weed growth. So, present study was conducted to know the effect of nitrogen and weed management on yield and weed control efficiency of fodder turnip.

METHODOLOGY

An experiment was conducted during *rabi* season in 2013 at FRMC, NDRI, Karnal, The soil of the experimental field was clay loam in texture, neutral in reaction, medium in organic matter and phosphorus, high in potassium and low in nitrogen. The experiment was executed in split plot design with four levels of nitrogen (0, 50, 100, and 150 kg N/ha) in main plots and four weed management practices (pendimethalin 1.0 kg/ha, hand weeding, isoproturon 0.75 kg/ha and weedy check) in sub plots with four replications. Turnip variety '*Purple top*' was used as test crop.

RESULTS

Major weed species observed in experimental field were *Trianthema portulacastrum, Coronopus didymus* L., *Parthenium hysterophorus, Cynodon dactylon, Cyperus rotundus* L., *Anagallis arvensis* L., *Chenopodium album, Commelina benghalensis L., Phalaris minor, Melilotus alba etc.* Application of 150 kg N/ha recorded significantly higher weed population. Weed population increased up to 50 kg N/ha than decreased significantly (Table 1). Higher weed dry matter was recorded with 150 kg N/ha. Weed control efficiency decreased up to 50 kg N/ha then increased with increase in the dose of nitrogen. Higher weed control efficiency was observed with pendimethalin. The highest GFY was observed with 150 kg N/ha. The results were in conformity with the findings of Jan Krezel and Kolota, (2008). Pendimethalin 1.0 kg/ha recorded the highest green and dry fodder yields

Table 1. Effect of nitrogen application and weed management on turnip yield and weeds

Treatment	Shoot Yield (t/ha)	Shoot DM yield (t/ha)	Root Yield (t/ha)	Root DM Yield (t/ha)	Total Yield (t/ha)	Total DM yield (t/ha)	Weed dry weight (g/m^2)		Weed control efficiency (%)
							30 DAS	60 DAS	
N level (kg/ha)									
0	17.93	2.60	32.01	3.51	49.94	6.11	2.50	3.61	56.81
50	21.43	3.00	38.10	4.02	59.44	7.01	3.16	4.81	50.77
100	25.94	3.44	46.33	4.52	72.27	7.96	3.57	2.96	63.29
150	29.23	3.59	52.20	4.58	81.42	8.17	3.85	2.41	65.41
LSD(P =0.05)	0.42	0.10	0.75	0.08	1.18	0.25	0.05	0.05	0.45
Weed management									
Pendamethalin 1.0 kg/ha	27.43	3.55	48.98	4.63	76.42	8.18	2.50	1.44	83.23
Hand weeding	26.35	3.50	47.06	4.61	73.42	8.11	2.73	1.91	77.55
Isoproturon at 0.75 kg/ha	24.33	3.27	43.45	4.31	67.78	7.58	2.85	2.12	75.50
Weedy check	16.32	2.30	29.14	3.09	45.45	5.39	5.01	8.35	0.00
LSD (P =0.05)	0.54	0.06	0.96	0.15	1.50	0.14	0.04	0.11	0.77

CONCLUISION

It was concluded that application of 150 kg N/ha and pendimethalin gave maximum green and dry fodder yield.

REFERENCE

Jan Krezel, Eugeniusz Kolata. 2008. The effects of nitrogen fertilization on yielding and biological value of Chinese cabbage grown from seedlings for autumn harvest. *Journal Elemental* **13**(2): 255-260.

Integrated weed management in jute

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Jute is the most important commercial crop of eastern and north-eastern states of India mainly grown in West Bengal, Bihar, Assam, Tripura, Meghalaya, Orissa and eastern part of Uttar Pradesh. Among production constraints, weeds exert greater stress and losses in jute . Intermittent rain associated with hot and humid climate during the jute growing season in alluvial plains encourages profuse eed growth and cause 60-75% yield loss may occur in jute (Sarkar *et al*. 2010). In general, grasses are the dominant weeds.Very few selective herbicides are available to control of grassy weeds. Hence, the present investigation was undertaken to find out the suitable integrated weed management strategy in jute crop.

METHODOLOGY

The experiment was conducted at JRS, Katihar to validate the weed management practices for Bihar region during *Kharif* 2013. Soil of the experimental site was silty loam in texture with slightly saline in pH (7.6), low in organic C (0.49%) and available N (160 kg/ha) and medium in available Phosphorus (20 kg/ha) and low in available potassium ((84 kg/ha). Jute variety JRO-524 was used as the test crop. Experiment was carried out with eight treatments (Table 1) replicated thrice in a randomized block design.

RESULTS

In experimental trial grassy weeds like *Cynodon dactylon*, *Echinochloa colona*, *Digitaria* sp, *Eleusine indica* were the major weeds. All weed control treatments used in experiment increased fibre yield due to checking the growth of weeds. The treatment with use of quizalofop-ethyl at 60 g/ha at 15 DAE + 1 HW at 20 days after herbicide application was found the best among other herbicides used in experiment. However, treatment with two hand weeding recorded on par with treatment use of quizalofop-ethyl at 60 g/ha at 15 DAE + 1 HW at 20 days after herbicide application with respect to fibre yield (2.98 t/ha), weed control index and benefit: cost ratio, but the cost of cultivation is high compared to other treatments. Hence use of quizalofop-ethyl at 60 g/ha at 15 DAE + 1 HW at 20 days after herbicide application is more economical than two hand weeding.

Table 1. Integrated weed management practices on Jute growth, fibre yield, weed biomass, weed control efficiency and economics

Treatment	Basal diameter (cm)	Fibre Yield (t/ha)	Weed biomass dry weight (q/ha)		Weed control Index	Gross returns, Rs/ha	Net returns, Rs/ha	B:C ratio
			15 DAE	45 DAE				
Butachlor 50% EC at 1.0 kg/ha at 2DAS* +1HW at 20 DAE	1.65	1.85	1.33	2.07	58.10	42473	22405	1.12
Butachlor 50% EC at 1.5 kg/ha at 2DAS +1HWat 20 DAE**	1.75	2.10	1.29	1.73	64.84	48300	28122	1.39
Butachlor 5% G at 1.0 kg/ha at 2DAS +1HW at 20 DAE	1.75	2.14	1.23	2.33	52.91	49220	28972	1.43
Butachlor 5% G at 1.5 kg/ha at 2DAS +1HW at 20 DAE	1.78	2.33	1.20	1.83	62.85	53513	32965	1.60
Pretilachlor 50% EC at 1.0 kg/ha at 2DAS +1HW at 20 DAE	1.88	2.53	1.17	1.67	66.22	58267	37819	1.85
Quizalofop ethyl at 60 g/ha +sticker at 1.0 ml /lit at 15 DAE +1HW at 35DAS	1.67	2.77	1.34	1.27	74.47	63787	42639	2.02
Unweeded check	1.52	1.30	2.67	4.95	0.00	29900	13252	0.80
Two HW (15 DAE and 35 DAE)	1.90	2.98	1.03	1.12	77.53	68617	45969	2.03
LSD (P=0.05)	0.11	0.31	0.43	0.47	9.29	10194	10194	0.49

DAS*: Days after sowing, DAE**: Days after emergence of crop

CONCLUSION

Application of quizalofop ethyl at 60 g/ha at 15 DAE + one hand weeding at 20 days after herbicide application was more effective in controlling weeds in jute crop.

REFERENCE

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Effect of chemical weed control on fodder and seed productivity of berseem

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Berseem (*Trifolium alexandrium* L.) is the most important legume forage crop of *rabi* season cultivated on about 2 million ha area in the country. It is widely accepted because of multicut, fast regeneration high fodder yield and provides the nutritious fodder to livestock from November to April. Among the different weeds, *Cichorium intybus* isone of the major obnoxious weed found associated with berseem and used to give more competition stress (Kewat *et al.* 2005). Consequently, it causes substantial reduction (30-40%) in tonnage besides deteriorating the quality of seeds.

METHEDOLOGY

An experiment was carried out in randomized block design with three replications to evaluation the effect of weed management on forage and seed yield of berseem (*Trifolium alexandrinum* L.) The ten treatments comprised with chemical, Cultural, chemical+ cultural practices of weed control along with weedy check. T1-Weedy Check T2-week free cheek, T3-One hoeing at 3 weak after sowing (WAS) and one HW (hand weeding) at 5 WAS, T4- pendimethalin at 1.00 kg/he, T5-pendimethalin at 1.00 kg/ha + one HW at 5 WAS, T6- oxyfluorfen at 0.100 kg/ha, T7- oxyfluorfen at 0.100 kg/ha + one HW at 5 WAS, T8- pendimethalin at 1.00 kg/ha + imazethapyr at 0.150 kg/ha (Immediate after 1st cut), T9 – oxyfluorfen at 0.100 kg/ha + imazethapyr at 0.150 kg/ha (immediate after 1st cut), T10 –imazethapyr at 0.150 kg/ha (immediate after 1st and 2nd cut), and were tested in a randomized block design with three replications. Pendimethalin and oxyfluorfen were applied as pre-emergence (one day after sowing) and imazethapyr was applied as post emergence (immediately after 1st and 2nd cut).

RESULTS

Among all the treatments, treatment T2-weed free check gave highest green fodder (640.6 q/ha), dry matter (97.6 q/ ha)and crude protein yield (15.3 q/ha) as well as seed yield (5.32 q/ha) and Stover yield(53.0 q/ha) , and it was closely followed by treatment oxyfluorfen at 0.100 kg/ha+ imazethapyr at 0.150 kg ai/ha (immediate after harvest of 1st cut) which recorded 627.8, 94.7, 14.7, 5.23 and 51.4 q/ha of green fodder, dry matter, crude protein, seed and stover yield respectively.

Treatment weedy check recorded the lowest yield of green fodder, dry matter, crude protein, seed and stover. Yield attributing characters viz. plant height and leaf: stem ratio were also found maximum in weed free check.In regard of economics, gross mandatory returns was higher in weed free check followed by treatment one hoeing at 3WAS and one hand weeding at 5 WAS *i.e.* 149333/ha and 144412/ha, respectively where as net monetary return (114043/ha) and B:C ratio (4:52) was maximum in T9 oxyfluorfen 0.100 kg ai/ha + imazethapyr .150 kg/ha (immediate after 1st cut).

Table 1. Effect of weed management on forage and seed yield of berseem

Treatment		GFY (t/ha)	DMY (t/ha)	CPY (t/ha)	Seed yield (t/ha)	NMRs ($x10^3$ `/ha)	B:C ratio	WCE %
T_1	Weedy Check	26.8	3.6	0.50	0.15	33.93	1.74	-
T_2	Weed Free	64.1	9.8	1.53	0.53	111.33	3.92	80.8
T_3	One hoeing at 3 WAS and one HW at 5 WAS	61.7	9.1	1.41	0.52	108.91	4.06	75.6
T_4	Pendimethalin at 1.00 kg	53.4	7.6	1.14	0.40	94.88	3.92	53.5
T_5	Pendimethalin at 1.00 kg + one HW at 5 WAS	54.6	7.8	1.17	0.50	96.51	3.72	59.4
T_6	Oxyfluorfen at 0. 100 kg	57.6	8.3	1.27	0.51	105.06	4.26	59.8
T_7	Oxyfluorfen at 0.100 kg + one HW at 5 WAS	60.3	8.8	1.36	0.51	103.74	4.03	68.2
T_8	Pendimethalin at 1.00 kg + imazethapyr at (immediate after 1st cut)	55.9	8.0	1.22	0.61	102.27	4.13	61.4
T_9	Oxyfluorfen at 0.100 kg + imazethapyr at 0.150 kg (immediate after 1st cut)	62.7	9.5	1.47	0.52	114.04	4.52	79.2
T_{10}	Imazethapyr at 0.150 kg (immediate after harvest 1st and 2 nd cut)	57.8	8.4	1.28	0.51	105.41	4.25	67.2
LSD (P=0.05)		10.3	1.8	0.26	0.17	-	-	-

GFY - Green forage yield, DMY – Dry matter yield, CPY – Crude protein yield, B:C ration – Benefit: cost ratio

CONCLUSION

Treatment receiving oxyfluorfen at 0.100 kg/ha + imazethapyr 0.150 kg/ha (immediate after harvest of 1st cut) was the best, which was next to weed free check from the point of higher forage yield, seed production and crude protein yield.

REFERENCE

Kewat ML, Agrawal SB and Shukla VK. 2005. Effect of weed control on seed yield of Berseem (*Trifolium alexandrium* L.). *Forage Research* **31**(2): 78-80.

Cover crops as tool for control of weeds in coffee plantations

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Cover crops have become viable options for sustainable agriculture because of contributions to soil fertility by addition of bio-mass, to protect the soil against erosion, ameliorate soil structure, improved crop performance and suppress the pests including weeds. Since, coffee is a wide spaced crop, there is a large scope for inter seeded cover crops in initial stages of plantation (up to 5 years). In coffee plantations, weeds pose a severe problem particularly during early stages of establishment and cause 50% of nutrients loss and compete for moisture, light and act as host for sucking pests. Weed menace is a severe problem especially in young coffee plantations and open patches occurred due to removal of white stem borer affected plants.

METHODOLOGY

In coffee plantations, cover/green manure crops like green gram (*Vigna radiata*), Cowpea (*Vigna sinensis*), Sunhemp (*Crotolaria juncea*), Dhaincha (*Susbanea rostrata*) and Horse gram (*Dolichos biflorus*) were tried in open patches and in between the two rows of coffee. Cover/green manure crops seeds at 15-20 kg/ acre are to be broadcasted after mixing with sand in the proportion of 1:5 (*i.e.* 1 kg cover crop seeds mixed with 5 kg sand) for appropriate germination and good plant stand. Harvesting will be done at 55-60 days after sowing. In Central Coffee Research Institute and other research stations of Coffee Board, the experiments were conducted on cover and green manure crops for their suitability in coffee. The experiments were included both perennial and annual cover crops for their suitability.

RESULTS

The annual cover crops are most ideal for coffee because they will decompose easily in soil, whereas, the perennial cover crops will remain in the field throughout the year and will pose problem during harvest of coffee. The experimental results in coffee plantations showed that cover crops cowpea (5508 kg/ha) followed by horse gram (3193 kg/ ha) were found most suitable in both Robusta and Arabica estates with respect to biomass production, weed suppression and nutrient contribution. These cover crops possess broader leaves, better ground coverage, good nodulation, fast growing nature and contributed good amount of nitrogen to the soils by way of biomass. Significantly higher nutrients were contributed by cowpea (20.8, 5.4 and 21.2 kg/ha N, P and K) followed by horse gram (11.2, 3.2 & 11.4 kg/ha N, P and K). Thus, these nutrients added to the soil has favoured good growth of coffee plants, besides saving nutrients to the tune of Rs. 989/ha (Table.1). The weed control efficiency was to the extent of 92% in cowpea and 90% in horse gram.

Table 1. Fresh, dry biomass of cover crops, weed dry weight, weed suppression (%) and nutrient contribution from different cover crops in coffee plantations

Treatment	Fresh biomass (t/ha)	Dry biomass (kg/ha)	Weed dry weight (g/m^2)	Weed suppression (%)	Nutrient contribution (kg/ha)		
					N	P	K
Greengram	1.89	0.75	13.6	89	7.0	1.8	7.0
Cowpea	5.51	2.16	9.9	92	20.8	5.4	21.2
Sunnhemp	0.99	0.45	17.5	86	3.4	1.0	3.0
Dhiancha	0.72	0.30	22.9	82	2.0	0.4	1.8
Horsegram	3.19	1.26	11.6	90	11.2	3.2	11.4
Control			128.3	0	0.0	0.0	0.0
LSD (P=0.05)	0.21	0.17	24.0	-			

CONCLUSION

The cowpea and horse gram are most efficient cover crops in coffee plantations because of their adoptability in shaded condition, higher biomass production, weed suppression and nutrients' contribution.

Effect of different weed management practices on weeds and fodder yield of napier-bajra hybrid

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Napier-*bajra* hybrid, also known as N-B hybrid, is an inter-specific hybrid between pearl millet (*Pennisetum glaucum*) and napier grass (*Pennisetum purpureum*). It is a vegetatively propagated perennial grass which has highest green fodder yield per unit time and space due to its profuse tillering, more leafiness, vigorous and erect growing habit. However, under north-western conditions, the growth of N-B hybrid is adversely affected due to winter dormancy from November to February. So, most of the fodder yield is obtained between March to November. Even during this period, weed infestation particularly early in the season significantly suppresses the growth and tillering of hybrid and thus reduces productivity. Till date, little information is available regarding the weed management techniques in N-B hybrid, hence this study was undertaken with an objective to evaluate different herbicides, their mixtures and intercropping options for effective weed control.

METHODOLOGY

A field experiment was conducted during *kharif* 2013 at PAU Seed Farm, Nabha, (Punjab) in a randomized block design with three replications and fifteen treatments (Table-1). N-B hybrid variety PBN 233 was planted on 30th May, 2013 at 60 x 60 cm spacing using stem cutting at 27500/ha and other management practices were followed as per recommended package of practice. Irrigation was applied immediately and different pre-emergence herbicides were sprayed after four days of planting as per the treatments either alone or tank mixed using 500 l water per ha. In intercropping treatments, one row of maize variety J-1006 or pearl millet variety FBC-16 was sown in between two rows of N-B hybrid. Weeds count, plant height, tillers per plant and green fodder yield recorded at the time of first cut (58 days after planting) are presented herein.

RESULTS

The most dominant weeds were *Cyperus rotundus, Trianthema porulacastrum, Echinochloa crusgalli, Dactyloctenium aegyptium and Acrachne racemosa.* The lowest weed population was recorded with two hand weeding treatment which was significantly at par with pre-emergence tank mix application of atrazine 1.00 + pendimethalin 0.75 kg/ha. Among the herbicide treatments, the highest weed control efficiency of 88.6 and 85.3% was recorded with atrazine 1.00 + pendimethalin 0.75 kg/ha and atrazine 1.00 + pendimethalin 0.56 kg/ha, respectively. Higher efficacy of these two herbicides mixtures has been reported by Walia *et al.* (2007), particularly for the control of hardy weeds.

Table 1. Weed population, WCE, growth and green fodder yield of napier-bajra hybrid as influenced by different weed management practices

Treatment	Total weeds (no./m^2)	Weed control efficiency (%)	Plant height (cm)	Tillers/ plant	Green fodder yield (t/ha)
Atrazine 0.50 kg/ha	8.94 (79.1)	46.7	64.5	16.3	22.64
Atrazine 0.75 kg/ha	8.84 (77.3)	47.9	65.8	17.0	26.50
Atrazine 1.00 kg/ha	8.29 (68.0)	54.2	71.0	19.7	32.35
Pendimethalin 0.56 kg /ha	8.28 (67.6)	54.5	76.2	20.1	36.09
Pendimethalin 0.75 kg/ha	7.83 (60.4)	59.3	78.7	20.9	36.16
Atrazine 0.50 kg + pendimethalin 0.56 kg/ha	6.61 (43.1)	70.9	82.2	23.1	38.12
Atrazine 0.50 kg + pendimethalin 0.75 kg/ha	6.08 (36.0)	75.7	81.3	23.7	38.77
Atrazine 0.75 kg + pendimethalin 0.56 kg/ha	5.42 (28.4)	80.8	82.2	22.3	38.65
Atrazine 0.75 kg + pendimethalin 0.75 kg/ha	5.00 (24.0)	83.8	83.8	23.6	40.40
Atrazine 1.00 kg + pendimethalin 0.56 kg/ha	4.76 (21.8)	85.3	82.7	24.1	39.31
Atrazine 1.00 kg + pendimethalin 0.75 kg/ha	4.22 (16.9)	88.6	85.7	25.0	41.06
N-B hybid + pearl millet	8.23 (67.1)	54.8	75.2	14.3	37.27
N-B hybid + maize	8.62 (73.8)	50.3	77.8	15.8	40.60
Two hand weeding –21 and 42 DAP	3.46 (11.1)	92.5	84.7	23.0	41.27
Unweeded check (control)	12.22 (149.3)	-	53.8	12.7	14.60
LSD (P=0.05)	0.87	-	11.4	4.2	4.29

Figures in parentheses are the original values

Highest green fodder yield was recorded with two hand weeding treatment and lowest under unweeded check, revealing the yield loss of 64.6% due to uninterrupted growth of weeds. Among herbicide treatments, atrazine 1.00 + pendimethalin 0.75 kg/ha recorded highest green fodder yield (41.06 t/ha) which was at par with hand weeding treatment and other tank mix application treatments. Intercropping in N-B hybrid with either fodder maize or fodder pearl millet suppressed the weed growth and produced equivalent green fodder yield to other better weed control treatments.

CONCLUSION

Pre-emergence tank mix application of atrazine and pendimethalin can be effectively used for higher weed control efficiency and better green fodder yield of napier-bajra hybrid

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Bioefficacy of pendimethalin against weeds in cotton and its residual effect on succeeding jowar

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Cotton *(Gossypiun herbaceum L.)* is being a wide row spaced and initial slow growth crop. Weeds compete with the crop and reduce the yield to an extent of upto70% (Rao *et al.* 2007; Madhu *et al.* 2014). Though ample information is available on use of pendimethalin EC formulation but information on use of capsulated suspension formulation which can be used under limited moisture conditions is meager under Krishna Agro Climate Zone of Andhra Pradesh. Keeping these in view, the present investigation was undertaken.

METHODOLOGY

A field experiment was conducted during rainy seasons of 2008-09 and 2009-10 at Regional Agricultural Research Station, Lam, Guntur (AP) to test the bio-efficacy of pendimethalin 38.7% CS against weeds and its residual effect on succeeding jowar crop. Nine treatments consisting of pendimethalin 38.7% CS at varying doses along with standard herbicides (fluchloralin, trifluralin and pendimethalin EC) and recommended practice (Table1) were tested in a randomized block design with three replications. Cotton variety RCH_2 (Bt) was sown in experimental field along with all recommended package of practices except weed management. Data on weed growth, yield and yield attributes were recorded. Immediately after final picking of cotton, jowar seeds were sow n to study the residual effect on germination of jowar during first year and germination and yield of jowar during second year.

RESULTS

The dominant weed flora of the experimental field consisted of *Echinochloa colona*, *Leptochloa chinensis*, (grasses), *Cyperus rotundus*, (sedge), *Trianthema portulacastrum*, *Digera arvensis*, *Phyllanthus niruri*, *Cleome viscosa*, *Corchorus acutangulus*, *Merremia emerginata* (broad leaf weeds).

All the treatments significantly reduced weed density and dry weight over unweeded check except the lower dose of pendimethalin 483g/ha, fluchloralin 1125 g/ha and trifluralin 960 g/ha during first year. Among the treatments, pendimethalin 38.7% CS at 1354.5 g/ha recorded the lowest weed growth and on par with its next lower dose of 677.25 g/ha and also with existing EC formulation of pendimethalin 750g/ha except during first year in case of weed dry weight (Table 1).

Pendimethalin CS rates ranging from 483-1354.5 g/ha did not show any symptoms of injury like germination loss, thickening of leaves, leaf tip injury and necrosis on any part of the cotton plant. Among pendimethalin CS treatments, pendimethalin CS at 1354.5 g/ha recorded the highest number of bolls/plant followed by its lower dose of 677.28 g/ha and was on par with pendimethalin EC of 750 g/ha. During both the years, significantly higher seed cotton yield was obtained with the highest dose of pendimethalin 1354.5 g/ha and was on par with its lower dose of 677.25 g/ha during second year. The increased yield in these treatments could be due to effective weed control in the initial stages which helped in better crop growth, yield components and yield. However, none of the treatments could reach the level of standard recommended practice of pre emergence application of pendimethalin EC 750 g/ha *fb* inter cultivation at 30 and 60 DAS which recorded the highest yield during both the years. On an average uncontrolled weed growth caused 74% reduction in yield compared to recommended practice.

Table 1. Effect of different treatments on weed growth, yield components and yield of cotton

Treatment	Weed Density (No/ m^2)		Weed dry weight (g/m^2)		No. of bolls/plant		KapasYield (kg/ha)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Pendimethalin 38.7% CS483 g	10.6(113.7)	11.5 (137.7)	20.5 (420.0)	15.8 (250.0)	16.7	11.58	1100	1165
Pendimethalin 38.7% CS580.5 g	10.4(109.0)	9.7 (99.7)	18.1 (330.0)	149 (223.3)	17.5	12.3	1505	1242
Pendimethalin 38.7% CS677.25 g	9.7(93.0)	9.1 (84.7)	15.5 (256.7)	14.4 (206.7)	20.1	13.3	1736	1248
Pendimethalin 38.7% CS1384.5 g	7.7(58.7)	7.4 (55.7)	15.2 (250.0)	10.4 (108.3)	29.5	14.0	2083	1379
Fluchloralin1125 g	10.5(110.3)	11.1 (116.0)	18.6 (363.0)	17.5 (305.0)	13.4	10.6	1042	1044
Pendimethlin 30% EC750 g	9.6(93.7)	9.2 (90.3)	16.2 (280.0)	14.1 (200.0)	19.7	13.1	1736	1179
Trifluralin960 g	10.5(127.0)	8.5 (76.3)	20.5 (420.0)	16.8 (283.3)	12.9	9.9	885	480
Pendimethlain 30%EC 750 g fb inter cultivation at 30 and 60DAS	5.3(31.0)	6.8 (49.3)	6.9 (60.0)	10.1 (102.7)	43.5	22.6	3067	1754
Weedy Check	13.9(195.0)	14.6 (212.0)	22.3 (503.0)	22.3 (498.3)	10.3	7.6	828	436
LSD (P=0.05)	2.0	2.8	4.6	1.3	4.6	3.6	315	251

Figures in parenthesis are original values. Data transformed to square root of x+1

The germination of succeeding Jowar crop is normal with all pendimethalin CS treatments during the both years of study.

CONCLUSION

It can be concluded that pre- emergence application of pendimethalin 38.7% CS at 677.25 g/ha can be a good substitute for pendimethalin EC at 750 g/ha for weed control in cotton.

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Integrated weed management in *Bt* cotton in UKP command area of Karnataka, India

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Cotton (*Gossypium hirsutum* L.) a very important commercial crop of India, sustains the cotton textile industry in the country. The cotton production suffers from many constraints like weeds, insect pests and diseases etc. Weeds are responsible for losses in cotton yield to an extent of 60% (Moolchand *et al.* 2012). Presently, to enhance the productivity; weeds are controlled by cultural, mechanical, biological, chemical and integrated methods. Importantly, the critical period of weed competition is from 15-60 days and weed management systems during this period should prevent weed interference, be economical and sustainable, reduce weed seed bank in soil, prevent weed resistance and neither injure cotton nor reduce quantity of lint yield. Weedicides are crop/species specific and their dose and time of application is location and crop specific. Therefore, the current research is environed to develop an integrated weed management technique involving pre- and post-emergence herbicides either singly or in sequence along with intercutlivation as an economically viable alternative in cotton production.

METHODOLOGY

A field experiment was conducted during *Kharif*2012-13 and 2013-14 at ARS, Bheemarayanagudi, Shahapur (Karnataka) falling under UKP Command area in Karnataka, India. The soil of experimental site was medium deep black soil, medium in organic carbon (0.7%), available phosphorus (33 kg/ha P_2O_5), low in available nitrogen (252 kg/ha) and high in potash (297 kg/ha). The experiment comprised of fourteen treatments *viz*., unweeded check (T_1), weed-free check (T_2), diuron 80 WP at1 kg/ha PRE *fb* IC and HW at 30, 45 and 60 DAS, T_3), pendimethalin 38.7 CS (at 0.68 kg/ha PRE *fb* IC and HW at 45 DAS, T_4), propaquizafop 10 EC (at 0.1 kg/ha POE at 20 and 40 DAS *fb* IC at 60 DAS, T_5), quizalofop p tefuryl 4.41 EC (at 0.044 kg/ha POE at 20 and 40 DAS + IC at 60 DAS, T_6), fenoxaprop p ethy l 9.3 EC (at 0.1 kg/ha POE at 20 and 40 DAS fb IC at 60 DAS, T_7), quizalofop ethyl 5 EC (at 0.05 kg/ha POE at 20 and 40 DAS *fb* IC at 60 DAS, T_8), pyrithiobac sodium 10 EC (at 0.125 kg/ha POE at 20 and 40 DAS *fb* IC at 60 DAS, T_9). In treatments T_{10}-$T_{14,}$ pendimethalin as pre-emergence followed by propaquizafop 10 EC at 0.1 kg/ha (T_{10}), quizalofop p tefuryl 4.41 EC at 0.044 kg/ha(T_{11}), fenoxaprop p ethyl 9.3 EC at 0.1 kg/ha(T_{12}),quizalofop ethyl 5 EC at 0.05 kg/ha(T_{13}) and pyrithiobac sodium 10 EC at 0.125 kg/ha(T_{14}) as post-emergence at 30-35 DAS *fb* IC at 60 DAS. The experiment was laid out in a randomized complete block design with three replications. Cotton (cv. Arya *Bt* BG II) was sown on 10th July of 2012 and 13th July, 2013 with a spacing of 90 x 60 cm. Fertilizer application (150:75:75 kg /ha N, P_2O_5 and K_2O) was done as per the recommendation. The dry matter of weeds and weed index (%) were evaluated besides observations on cotton plant height (cm), seed cotton yield (kg/ha), gross return (Rs/ha) and B:C ratio and the data were subjected to statistical analysis and interpretation.

RESULTS

The dry weight of weeds reduced significantly due to different weed management practices (Table 1). At 20 DAS, the lowest dry weight of weeds (16.33 g/m^2) was recorded in recommended practice, *i.e.*, diuron 80 WP at 1 kg/ha PRE followed by other treatments receiving pendimethalin 38.7CS at 0.68 kg/ha PRE. This might be due to the decreased weed population under these herbicides. Further, among sequential application of herbicides, pendimethalin 38.7 CS at 0.68 kg/ha PRE fb pyrithiobac sodium 10 EC at 0.125 kg/ha POE + IC recorded significantly lower weed dry weight at 20 DAS and was on par with pendimethalin 38.7 CS at 0.68 kg/ha PRE fb quizalofop-ethyl 5 EC at 0.05 kg/ha POE + IC, pendimethalin 38.7 CS at 0.68 kg/ha PRE *fb* propaquizafop 10 EC at 0.1 kg/ha POE + IC which were significantly superior to all other treatments (Table 1). This indicates that sequential application of pre-and post-emergence herbicides supplemented with intercultivation at 60 DAS was superior to other treatments.

Table 1. Weed dry weight, weed index, seed cotton yield, gross return and B:C ratio as influenced by different weed control treatments in *Bt.* cotton (pooled data of 2012-13 and 2013-14)

Treatment	Dry weight of weeds (g/m^2)			Weed index (%)	Seed cotton yield (kg/ha)	Gross return (Rs./ha)	B:C
	20 DAS	40 DAS	60 DAS				
T_1 Weedy check	1.56 (34.33)	2.25(177.9)	2.38(236.74)	47.11	1634	71328	2.44
T_2 Weed free	0.30(0.00)	0.30(0.00)	0.30(0.00)	0.00	3073	134252	3.42
T_3 Diuron 80 WP *at* 1 kg	1.26(16.33)	1.61(38.44)	2.07(116.21)	24.96	2337	102187	3.18
T_4 Pendimethalin 38.7 CS *at* 0.68 kg	1.30(18.10)	1.97(90.63)	2.12(131.30)	31.12	2136	93373	3.00
T_5Propaquizafop 10 EC *at* 0.1 kg	1.55(33.39)	1.72(50.86)	1.71(49.34)	25.45	2318	101281	2.99
T_6 Quizalofop p tefuryl 4.41 EC *at* 44 g	1.55(33.82)	1.83(65.75)	1.75(54.86)	37.52	1938	84659	2.62
T_7 Fenoxaprop p ethyl 9.3 EC *at* 100 g	1.54(33.08)	1.86(70.62)	1.77(57.26)	40.39	1835	80108	2.40
T_8 Quizalofop ethyl 5 EC *at* 0.5 kg	1.54(33.04)	1.72(50.56)	1.73(51.26)	25.85	2287	99885	3.04
T_9 Pyrithiobac sodium 10 EC *at* 125 g	1.5433.01	1.70(48.89)	1.64(42.32)	19.58	2499	109242	2.95
T_{10} Pendimethalin *fb* propaquizafop	1.30(17.82)	1.35(20.45)	1.61(39.36)	11.25	2714	118593	3.57
T_{11} Pendimethalin *fb* Quizalofop p tefuryl	1.31(18.38)	1.45(26.18)	1.70(48.15)	23.38	2371	103644	3.19
T_{12} Pendimethalin *fb* Fenoxaprop p ethyl	1.30(18.09)	1.42(27.50)	1.73(51.81)	24.58	2340	102278	3.09
T_{13} Pendimethalin *fb* Quizalofop ethyl	1.31(18.37)	1.32(18.95)	1.60(38.03)	11.33	2651	115775	3.54
T_{14} Pendimethalin *fb* Pyrithiobac sodium	1.31(18.50)	1.18(13.02)	1.54(33.55)	7.85	2921	127612	3.67
LSD (P= 0.05)	0.05	0.14	0.07	5.70	376	14564	0.44

*Figures in the parenthesis are original values, Data subjected for transformation using $(x+1)^{½}$, where x is weed dry matter, For T_{10} to T_{14} dosages remain same

The highest seed cotton yield was produced in weed-free chkec. Among the herbicidal treatments, pendimethalin 38.7CS at 0.68 kg/ha PRE fb pyrithiobac sodium 10WP at 0.125 kg/ha + IC recorded significantly higher seed cotton yield. Treatments receiving pendimethalin fb quizalofop ethyl + IC

(26.51 q/ha) and pendimethalin *fb* propaquizafop + IC were also on par with weed- free check. The lowest seed cotton yield was obtained in unweeded check (16.34 q/ha). The increased seed cotton yields in sequential herbicidal applications (T_{14},T_{13},T_{10}) along with intercultivation can be attributed to weed free/low weedy situation during initial stage and further control of new growth of weeds by application of post-emergence herbicides at 30-35 DAS followed by physical method of control through intercultivation at 60 DAS.

Maximum gross return was obtained in weed-free check and was on par with integrated practice of pendimethalin + pyrithiobac sodium + IC; both were superior to all other treatments (Table 1). The net return per rupee spent was also the highest in pendimethalin followed by pyrithiobac sodium coupled with one intercultivation (Table 1). Eventhough the weed-free check had higher B:C ratio, farmers are not able to maintain the weed-free condition throughout the cropping period. The alternative left would be the integrated weed management practice involving pendimethalin 38.7 CS at 0.68 kg/ha PRE *fb* pyrithiobac sodium 10WP at 0.125 kg/ha or quizalofop ethyl 5 EC at 0.05 kg/ha or propaquizafop 10 EC at 0.1 kg/ha at 30-35 DAS *fb* IC at 60 DAS.

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Comparative study of various weed control treatments in Bt cotton

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Cotton plays an important role in agrarian and industrial activities of nation and has unique place in economy of India. Numerous *Bt* cotton hybrids have been released for commercial cultivation though only few have been grown predominately by farmers. The economically viable production technology (Mehta *et al.* 2009) of *Bt* cotton has helped in increasing net income of cotton farmers. Weed infestation is the major constraint of cotton cultivation in Punjab. Weeds compete with crop for resources like water, nutrients and space. Mechanical and cultural controls of weeds are expensive, time consuming and laborious. Chemical weed control has become necessity as an effective and time saving method. The application of only pre-emergence herbicides is not effective against all weeds. Combined application of pre and post emergence herbicides offer great potential for effective weed control. Therefore, a need was felt to develop a rational, sustainable, effective weed management for cotton crop under Punjab conditions. The experiment was laid out to find the suitable management strategy for effective weed control in *Bt* cotton hybrid.

METHODOLOGY

The field experiment was conducted at PAU, Regional Research Station, Bathinda during *Kharif* 2014 with Bt cotton hybrid MRC 7017 BG-II. The experiment consisted of eight treatments (Table 1) was laid out in a Randomized complete block design with three replications. The soil of Experimental site was loamy sand with pH 8.5, low in OC (0.38%), low in N, medium in P & K. The recommended dose of fertilizer is 150 kg N/ha and 30 kg P/ha. The cultural practices and plant protection measures were given as per the recommendations. The data was analyzed statistically by adopting standard procedure.

RESULTS

Seed cotton yield under the treatments, pendimethalim fb quizalofopethyl + one hoeing (T_3), pyrithiobac Sodium fb quizalofopethyl + one hoeing (T_5) and glyphosate directed spray (T_6) was at par with weed free check treatment (T_7). In treatments T_3 and T_5, combinations of pre and post-emergence herbicides controlled most of the weeds. While, directed spray of non-selective herbicide glyphosate (T_6) was also killed all the weeds. These treatments are equally effective against weeds as weed free check (T_7). Frequent weedings in weed free check (T_7) resulted in significantly low weed dry weight. Weed dry weight under the treatments, pendimethalin *fb* quizalofop-ethyl + one hoeing (T_3), pyrithiobac Sodium *fb* quizalofop-ethyl + one hoeing (T_5) and Glyphosate directed spray (T_6) was also at par with weed free check treatment. Similar trend was found for number of bolls per plant as was recorded for seed cotton yield. Boll weight was not affected by different treatments.

Table 1. Effect of weed control treatments on seed cotton yield and yield attributes.

Treatment	Seed Cotton Yield (kg/ha)	No. of Bolls per plant	Boll weight (g)	Weed dry weight at 60 DAS (g/m²)
T_1 - Pendimethalim 1.0 kg PE + One hoeing	2129	46.1	4.11	54.5
T_2 - Quizalofopethyl 50 g PoE + One hoeing	2206	43.4	4.33	90.0
T_3 - Pendimethalim 1.0 kg PE fb Quizalofopethyl 50 gPoE + One hoeing	2618	48.9	4.64	20.3
T_4 - Pyrithiobac Sodium 62.5 g PoE + One hoeing	2030	42.7	4.08	55.5
T_5 - Pyrithiobac sodium 62.5 g fb Quizalofopethyl 50 g PoE + One hoeing	2571	47.4	4.56	26.5
T_6 - Glyphosate 1.0 kg directed spray at 45 DAS	2684	48.5	4.40	31.2
T_7 - Weed Free Check	2771	51.3	4.48	14.4
T_8 - Weedy Check	1850	28.4	3.98	146.3
LSD (P=0.05)	308	8.8	NS	22.1

PE – Pre-emergence, PoE – Poste-emergence, coinciding with 2 to 4 leaf stage of weeds

CONCLUSION

Pendimethalim @ 1.0 kg or pyrithiobac sodium at 62.5g/ha as pre emergence application followed by quizalofop-ethyl at 50g/ha at 2-4 weed leaf stage + one hoeing gives effective weed control in Bt cotton. Similarly, directed spray of Glyphosate at 1.0 kg/ha at 45 DAS controls weeds effectively.

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Integrated weed management in *Bt* cotton

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Cotton is one of the most important commercial crop of India which plays an important role in the Indian economy. Being a long duration and widely spaced crop, the yield loss of seed cotton in India due to weed competition ranges between 50 to 85% (Venugopalan *et al.* 2009). Weed management plays very crucial role because wide spacing, initial slow growth, continuous rainfall and heavy use of nutrients provide enough room for profuse growth of weeds. Looking to the variety of weed flora, feasibility and conveniences, it is difficult to adopt any single method of weed management, thereby emphasizing integrated approach in this regard. Keeping this in view, this experiment was planned to tackle the weed management in Bt. cotton.

METHODOLOGY

A field experiment was conducted at Regional Agricultural Research Station, Nandyal under Rainfed condition during 2014-15. The soil of experimental site is medium deep black, low in organic carbon (0.36 %), high in available P_2O_5 (45 kg/ha) and high in available K_2O (536 kg/ha). The experiment consisted of eight treatments wherein PE herbicide pendimethalin and POE herbicides *viz.,* quizalofop ethyl, pyrithiobac sodium and glyphosate were used in different combinations supplemented with hand hoeing, weed free and weedy checks. These treatments were evaluated under randomized block design with three replications. *Bt* Cotton variety "JAADOO" was sown on second fortnight of August at 90 cm x 45 cm and fertilized with 120:60:60 kg NPK/ha. Nitrogen was applied through urea in three equal splits (40 kg/ha) at an interval of 30 days. Weed population was counted from one square meter area at 30 and 60 DAS, while weed dry weight was recorded from fixed area in each plot at 30 and 60 DAS and at harvest and the weed data were subjected to square root transformations. The observations related to growth and yield were recorded and subjected to statistical analysis.

RESULTS

Weed flora of the experimental site consisted of about 42% grassy weeds and 58% broad leaved weeds. Dominant weed species were *Panicum repens, Dinebra retroflexa* (grasses), *Trianthema portulacastrum, Cyanotis auxillaris, Digera arvensis, Abutilan indicam, Amaranthus viridis, Microcantha* sp and *Phyllanthus maderaspatensis* (among broad leaf weeds). Among the weed control treatments, less number of weeds as well as lower dry weed weight was recorded with pendimethalin at 0.75 to 1.0 kg/ha as pre emergence + one hoeing at 30 DAS. At 60 DAS all herbicides in combination with one hoeing recorded significantly lower weed density and weed dry weight compared to weedy check. Among weed management practices weed free check recorded lower weed density and dry weed weight at 30 and 60 DAS. However, higher weed control efficiency was recorded with weed free check followed by pendimethalin at 0.75-1.0 kg /ha as pre emergence + one hoeing. The higher weed control efficiency could be attributed due to lower weed dry bio-mass.

Most of the growth parameters, yield attributes and yield were affected remarkably due to different weed management practices. All herbicidal treatments in combination with one hoeing resulted in higher number of sympodial branches, bolls per plant and boll weight compared to weedy check. The highest seed cotton yield was recorded with application of pendimethalin at 0.75-1.0 kg/ha as pre emergence + one hoeing in combination with quizalofop-ethyl 50 g/ha at 2-4 weed leaf stage + one hoeing. However, the lowest seed cotton yield was recorded under weedy check treatment. The higher yield under the integrated weed management practices may be attributed to better weed control thereby reduction in the crop weed competition in early growth stage, leading to increase in the seed cotton yield.

Table 1. Weed density, dry weed weight and weed control efficiency as affected by different weed management treatments in *Bt* cotton

Treatment	60 DAS Weed count (no/m²)	60 DAS Dry weed weight (g/m²)	Weed control efficiency (%)	Seed cotton yield (kg/ha)	Net return (Rs/ha)	B:C Ratio
Pendimethalin@0.75 to 1.0 kg as pre emergence (PM) + one hoeing	5.9 (34.6)	4.6 (21.1)	80.8	3609	98392	3.5
Quizalofop-ethyl 50g at 2-4 weed leaf stage + one hoeing	5.0 (25)	5.9 (34.7)	52.6	3989	112632	3.9
Pendimethalin@0.75 to 1.0 kg as PM + one hoeing + Quizalofop-ethyl 50 g/ha at 2-4 weed leaf stage (PoE) + one hoeing	4.0 (16.3)	4.2 (18)	65.7	4125	116550	3.9
Pyrithiobac sodium @ 62.5 g/ha at 20-30 DAS + one hoeing	5.0 (25.3)	5.0 (25.2)	53.6	3603	97914	3.5
Pyrithiobac sodium @ 62.5 g/ha at 20-30 DAS + one hoeing + Quizalofop-ethyl 50 g/ha at 2-4 weed leaf stage + one hoeing	4.0 (17)	4.6 (21.3)	59.4	3974	107812	3.5
Glyphosate @ 1.0 kg/ha at 45 DAS	5.3 (29.3)	7.3 (53)	27.5	3216	85392	3.3
Weed free check	0.7 (0)	0.7 (0)	94.5	3773	92374	2.8
Weedy check	10.2 (104)	10.7 (115)	-	2236	48968	2.4
LSD (P=0.05)	1.3	0.8		498	-	-

Values in parenthesis are original values; The data were subjected to square root transformations.

In terms of economics, the higher net monetary returns (Rs.116,550/ha) were accrued with application of pendimethalin @ 0.75 to 1.0 kg/ha as pre emergence + one hoeing coupled with quizalofop-ethyl 50 g/ha at 2-4 weed leaf stage + one hoeing + one hoeing. Higher cost benefit ratio (was recorded with quizalofop-ethyl 50 g/ha at 2-4 weed leaf stage + one hoeing and pendimethalin @ 0.75 to 1.0 kg/ha as pre emergence + one hoeing coupled with quizalofop-ethyl 50 g/ha at 2-4 weed leaf stage + one hoeing + one hoeing.

CONCLUSION

From the study it can be concluded that PE application of pendimethalin @ 0.75-1.0 kg/ha + one hoeing followed by POE application of quizalofop-ethyl @ 50 g a.i/ha + one hoeing at 2-4 weed leaf stage would be more effective and economical for better weed control and higher monetary returns in Bt cotton.

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Weed management in rainfed Bt cotton

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Cotton (*Gossypium spp.* L.) is one of the important cash crop in India, which plays an important role in the nation economy, it is popularly known as white gold. India ranks 1st in area and 2nd in production of the cotton. In Vidarbha, cotton is grown predominantly as a rain fed crop in about 15.60 lakh ha^{-1} with production 35.50 lakh bales and productivity of 228 kg ha^{-1}. Weed control under rainy period is biggest hurdle in crop production. The more acute weed competition effects are noticed from 15 to 55 days after emergence (Sreenivas 2000). The traditional method of weed control is expensive, tedious and time consuming. Under such circumstances, use of effective herbicides gives better and timely weed control. Hence, the present investigation was undertaken.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during the *Kharif* season of 2012. The experiment was laid out in randomized block design with eight treatments replicated thrice. The experimental site was high in nitrogen, medium in phosphorous and fairly rich in potash and slightly alkaline in reaction. Sowing of rain fed Bt. Cotton CV, MRC-7326 was done at spacing of 90 x 60 cm on 2nd July 2012, with RDF 60:30:30 NPK Kg/ha Herbicides were applied as per the treatments and Phytotoxicity symptoms on crop was recorded by using a visual score scale of 0-10.

RESULTS

The major weed flora during *Kharif* season in cotton crop in the selected area composed of varied weed species viz. *Commelina benghalensis*, *Cynodon dactylon*, *Cyperus rotundus*, *Euphorbia hirta*, *Tridax procumbense*, *Parthenium hysterophorus*, *Alternanathera triandra*, *Xanthium strumarium*, *Portulaca oleraca*, *Amaranthus viridis* and *Corchorus acutangulus*. None of the herbicide under study showed any phytotoxicity symptoms on crop. The lowest weed count was observed under treatment 2 Hand weeding + 1 Hoeing but was at par with treatment Cotton + green gram (cover crop). This might be due to smothering effect of intercrop. Under herbicide treatments, pyrithiobac sodium at 0.075 kg/ha at 20-40 DAS + Hoeing at 40 DAS recorded lowest weed count but found at par with Pendimethalin at 1.25 kg/ha 1 PE + Hoeing at 30 DAS this might be due to better control of weeds by post emergence herbicide, similar trend was also observed in weed dry matter and weed control efficiency. The highest seed cotton yield (kg/ha) NMR (Rs/ha) and B:C ratio was noticed in Pyrithiobac sodium at 0.062 kg/ha PoE 20-40 DAS + Hoeing at 40 DAS but at par with all treatments except weedy check.

Table 1: Weed growth, Weed control efficiency, seed cotton yield and economics as influenced by herbicide treatments in cotton

Treatment	Weed population/ m^2 at harvest	Weed dry matter g/ m^2 at harvest	Weed control efficiency (%)	Seed cotton yield (kg/ha)	NMR (Rs/ha)	B:C Ratio
T1: Weedy check	90.66	191.29	-	859	2792	1.09
T2: 2 Hand weeding + 1 Hoeing	41.66	84.56	55.79	1356	15686	1.40
T3: Cotton + green gram (*cover crop*)	48.99	99.45	48.01	1289	19144	1.58
T4: Pendimethalin @ 1.25 kg PE + Hoeing at 30 DAS	50.66	103.85	45.71	1351	20690	1.60
T5: Quizalofop ethyl @ 0.075 kg PoE 20-40 DAS + Hoeing at 40 DAS	59.66	122.30	36.06	1343	21057	1.63
T6 : Pyrithiobac sodium @ 0.062 kg PoE 20-40 DAS + Hoeing at 40 DAS	59.32	121.61	36.42	1377	22038	1.65
T7 Pyrithiobac sodium @ 0.075 kg PoE 20-40 DAS + Hoeing at 40 DAS	51.99	106.58	44.28	1375	21587	1.63
T8 Propaquizafop @ 0.075 kg PoE 20-40 DAS + Hoeing at 40 DAS	63.32	129.81	32.13	1263	17513	1.52
SE (m) ±	3.64	7.45	-	85	3532	-
CD P= 0.05	11.18	22.88	-	261	10840	-

CONCLUSION

It can be concluded that 2 Hand weedings + 1 Hoeing followed by Pyrithiobac sodium at 0.062 kg/ha PoE at 20-40 DAS + Hoeing at 40 DAS proves better in controlling weed, dry matter accumulation, weed control efficiency, higher seed cotton yield, NMR and B:C ratio.

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Effect of split application of nutrients through fertigation on weed growth and seed cotton yield of Bt cotton

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The fertilizer application methods influence the weed population in many ways. In conventional method of fertilizer application, the weeds are more benefited than the crop and grow more vigorously and compete with the crop for resources. Among the different advantages of drip fertigation over conventional soil application of fertilizer, reduced weed competition is one of the major advantages because weed infestation depends on availability of nutrients to weed and drip fertigation reduces weed infestation as fertilizers are applied in the active root zone of the crop. Therefore, an attempt has been made to study weed growth under split application of N and K through fertigation in comparison with conventional band method of fertilizer application.

METHODOLOGY

The field experiment was conducted at Research farm of Agronomy Department, Dr.PDKV, Akola (M.S.) on Bt.cotton (MRC 7326) under fertigation during 2012-13 on clay loam soil. The experiment was laid out in randomized block design with five treatments and four replications. The recommended dose of fertilizer used for cotton was 100:50:50 NPK kg/ha. The total rainfall received during the crop growth period was 701.1 mm in 52 rainy days. The experimental site was established with inline drip irrigation system (16 mm) with a lateral installed at 120 cm with 60 cm dripper spacing. The recommended dose of fertilizer was applied as per the treatments through fertigation tank of 90 lit capacities. Phosphorus was applied as basal and N and K through irrigation water were supplied as urea and muriate of potash in five splits as per the treatments. In drip band application method half of the nitrogen and full dose of phosphorus and potash were applied as basal application at the time of sowing and remaining half dose of nitrogen was top-dressed at 30 and 60 days after sowing (DAS). Data on total weed density and weed dry weight were recorded at 20 and 40 DAS.

RESULTS

The weed density and weed dry weight were significantly more in conventional soil fertilizer application method as compared to four drip fertigation levels at 20 and 40 DAS. Drip fertigation significantly reduced the weed density and dry weight as against conventional soil application method due to application of fertilizers through fertigation at the active root zone of the crop which benefited crop more than weed. With regards to split application of N and K, conventional soil application resulted in significantly more weed density and weed dry weight as compared to other four drip fertigation levels. The three fertigation levels (75%, 100% and 125% NK) were found at par with each other in respect of weed density at 20 DAS and higher level of drip fertigation (125% NK) had significantly more weeds compared to the lower level of drip fertigation of 50 per cent NK. The same trend as weed density was observed in case of weed dry weight at 20 and 40 DAS. Higher cost of weeding was reported in conventional soil application method as compared to fertigation treatments as more labors were required for weeding in conventional soil application treatment.

Table 1: Weed density, weed dry weight, cost of weeding and seed cotton yield as influenced by furrow band application and drip fertigation methods in Bt cotton

Treatment	Weed density (No/m²)		Weed dry weight (g/m²)		Cost of weeding (₹ / ha)	Seed cotton yield (kg/ha)	NMR (₹ / ha)	B:C ratio
	20 DAS	40DAS	20DAS	40 DAS				
T_1-100 % RDF through drip soil application	161.63	141.48	69.36	58.05	5280	2519	45294	1.76
T_2- Fertigation with 50 % RDNK	133.20	114.05	52.65	45.80	4080	2212	37405	1.68
T_3- Fertigation with 75 % RDNK	139.63	121.83	58.28	48.64	4440	2620	51374	1.89
T_4- Fertigation with 100 % RDNK	144.65	124.95	59.60	48.83	4800	3030	65339	2.08
T_5- Fertigation with 125 % RDNK	148.40	129.98	61.35	51.88	5040	3326	75108	2.19
Mean								
Drip soil application (T_1)	161.63	141.48	69.36	58.05	5280	2519	45294	1.76
Drip fertigation (T_2 – T_5)	141.47	122.70	57.97	48.79	4590	3427	57307	1.96
LSD (P=0.05)	12.16	10.53	6.44	5.67	--	294	11753	--

The increase in seed cotton yield by mean drip fertigation was 26.5% over conventional soil application. This might be due to less competition of weeds with crop and better availability of nutrients to cotton crop in drip fertigation as compared to soil application method. The higher level of drip fertigation (125% NK) was significantly superior over all other fertigation levels and drip soil application in respect of seed cotton yield. The yield obtained with 75 per cent NK/ha by fertigation was comparable with that of 100 per cent fertilizer dose through soil application indicating a saving of 25% fertilizers by fertigation with better weed control. The higher mean NMR and B:C ratio was also recorded in drip fertigation methods as compared to conventional soil application method.

CONCLUSION

It is concluded from the study that of fertilizer application in splits through drip irrigation minimized the weed density and weed dry matter at various growth stages and reduced the cost of weeding and increased the seed cotton yield, NMR and B:C ratio as compared to conventional soil application of fertilizers .

Sequential application of herbicides for enhancing weed control efficiency in Bt cotton

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Cotton is the most remunerative and important cash crop of India in general and Gujarat in particular. After the development of high yielding, pest and diseases resistance Bt hybrids and availability of irrigation water due to adoption of different water harvesting techniques, area under cotton in the Saurashtra region of Gujarat is increasing day by day. The low yield of irrigated cotton yield is due to severe weed infestation. Initial slow growth, wide row spacing, high dose of chemical fertilizers combined with prostate nature of its growth permit early and severe crop-weed competition resulting in loss of yield to the tune of 45-85% (Das 2008). At present, manual weeding has become costly due to scarcity of laborers and hence it has become extremely difficult to keep the crop weed free. Effective and economical weed control in irrigated cotton is possible through integrating pre- and post-emergence herbicides along with hand weeding and interculturing. Effectiveness of newly developed post-emergence herbicides *viz.* quizalofop, oxadiargyl, imazethapyr and glyphosate needs to be tested for irrigated cotton and hence, an experiment was undertaken to evaluate the efficacy of some pre- and post-emergence herbicides for irrigated Bt cotton.

METHODOLOGY

A field experiment was conducted at Weed Control Research Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat, India) during rainy seasons of 2011-12 to 2013-14. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction (pH 7.8 and EC 0.32 dS/m) as well as low in available nitrogen (219 kg/ha), available phosphorus (22.7 kg/ha) and medium in available potash (243 kg/ha). The experiment comprising of 10 treatments, *viz*. T_1: Pendimethalin 0.9 kg/ha as pre-emergence (PE) *fb* hand weeding (HW) & interculturing (IC) at 30 and 60 DAS, T_2: Oxadiargyl 90 g/ha as PE *fb* HW and IC at 30 and 60 DAS, T_3: Pendimethalin 0.9 kg/ha as PE *fb* Pendimethalin 0.9 kg/ha as herbigation at 45 DAS, T_4: Pendimethalin 0.9 kg/ha as PE*fb* Quizalofop 40 g/ha as post-emergence (PoE) at 45 DAS, T_5: Pendimethalin 0.9 kg/ha as PE *fb* Imazethapyr and 75 g/ha as PoE at 45 DAS, T_6: Pendimethalin 0.9 kg/ha as PE *fb* Oxadiargyl 90 g/ha as PoE at 45 DAS, T_7: Pendimethalin 0.9 kg/ha as PE *fb* Glyphosate 0.96 kg/ha as PoE, directed spray at 75 DAS, T_8: HW & IC at 30, 60 and 90 DAS, T_9: Weed free, and T_{10}: Unweeded check, were laid out in randomized block design with three replications. The Bt cotton hybrid '*Beejdhan 2*' was sown at 120 x 45 cm spacing using seed rate of 1 kg/ha. FYM 15 t/ha was incorporated in soil at the time of preparatory tillage. The crop was fertilized with 160-0-120 kg N-P_2O_5-K_2O/ha. The pre-emergence herbicides were applied to soil on the next day of sowing. The knapsack sprayer fitted with flat fan nozzle was employed for spraying pre- and post-emergence herbicides using spray volume of 500 l/ha. Weed dry weight of weeds was recorded at harvest. Weed index (WI) and weed control efficiency (WCE) were worked out.

Table 1. Effect of weed management practices on weed parameters, seed yield and economic returns

Treatment	Seed yield t/ha	No. of sympodial branches/plant	Weed dry weight (kg/ha)	WI (%)	WCE (%)	Net return (Rs/ha)	B:C ratio
T_1: Pen+HW	2.001	14.35	284	3.06	83.43	60,146	2.47
T_2: Oxa+HW	0.927	13.08	1298	55.11	24.32	5,916	1.14
T_3: Pen+Pen	1.573	13.75	506	23.80	70.49	39,083	1.97
T_4: Pen+Qui	1.964	14.24	380	4.87	77.82	58,734	2.46
T_5: Pen+Ima	1.223	13.40	692	40.77	59.65	21,197	1.52
T_6: Pen+Oxa	0.973	13.36	1220	52.89	28.86	8,501	1.21
T_7: Pen+Gly	1.284	13.12	841	37.83	50.98	24,918	1.62
T_8: HW	2.024	14.53	220	1.96	87.16	57,992	2.31
T_9: WF	2.065	15.21	69	0.00	95.97	57,644	2.24
T_{10}: UWC	0.561	10.41	1715	72.82	0.00	-9,091	0.76
LSD (P=0.05)	0.189	1.01	189				

Pen=Pendimethalin, HW=Hand weeding, Oxa=Oxadiargyl, Qui=Quizalofop, Ima=Imazethapyr, Gly=Glyphosate, WF=Weed free, UWC=Unweeded check, **Market price** (Rs/kg):Pendimethalin: 400, Imazethapyr: 1750, Oxadiargyl: 930, Glyphosate: 270, Quizalofop: 1280, Seed cotton: 50, Cotton stalk: 0.5

RESULTS

The major weed flora observed in the cotton field were *Digera arvensis*, *Eluropus villosus*, *Cyperus rotundus*, *Cynodon dactylon*, *Echinochloa crusgalli*, *Chenopodium album*, *Convolvulus arvensis*, *Trianthema monogyna*, *Amaranthus spinosus*, *Commelina benghalensis* and *Asphodelus tenuifolius*.

The weed free check (T_9) produced significantly higher seed cotton yield, which was on par with HW at 30, 60 and 90 DAS, pendimethalin 0.9 kg/ha as PE *fb* HW at 30 and 60 DAS, and pendimethalin 0.9 kg ha^{-1} as PE*fb* quizalofop 40 g/ha at 45 DAS (Table 1). Higher yield was due to better weed control and consequently higher growth. Unweeded control gave signifcalty lower yield due to severe weed competition.

Application of pendimethalin 0.9 kg/ha as PE *fb* HW at 30 and 60 DAS recorded maximum net returns, closely followed by pendimethalin 0.9 kg/ha as PE *fb* quizalofop 40 g/ha at 45 DAS and HW at 30, 60 and 90 DAS . The maximum B:C ratio was accrued with pendimethalin 0.9 kg/ha as pre-emergence *fb* HW at 30 and 60 DAS (T_1), closely followed by pendimethalin 0.9 kg/ha as pre-emergence *fb* quizalofop 40 g/ha at 45 DAS (T_4) and HW at 30, 60 and 90 DAS (T_8). Higher yield and comparatively less cost with these treatments gave higher returns over the unweeded check.

CONCLUSION

Economical and efficient control of weeds along with higher yield of Bt cotton could be achieved by pre-emergence application of pendimethalin 0.9 kg/ha *fb* HW and IC at 30 and 60 DAS or sequential application of pendimethalin 0.9 kg/ha as pre-emergence *fb* quizalofop 40 g/ha at 45 DAS or HW at 30, 60 and 90 DAS on clayey soils of south Saurashtra agro-climatic zone of Gujarat.

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Effect of weed management strategies on weed flora and yield of *Bt* Cotton

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Cotton (*Gossypium hirsutum* L.) is one of the most important commercial fiber crops of India. In view of severe infestation of annual and perennial weeds in cotton, the potential yield is generally not realized. Crop weed competition period for cotton is between 20-60 days from sowing (Patel *et. el.* 2014). The available herbicide are able to check the emergence and growth of annual weeds in cotton but with reference to new molecules like pyrithiobac-sodiumno any experiment is conducted previously on weed management with integration of cultural and post-emergence herbicides in cotton, hence present investigation was undertaken.

METHODOLOGY

A field experiment was conducted during *kharif* season of year 2014 at *AICRP-Weed Management Farm, Anand Agricultural University, Anand (Gujarat)* for the evaluation of efficient weed management strategies in *Bt* cotton. The experiment was laid out in randomized block design with ten treatments and replicated thrice. Recommended dose of fertilizer (280–0–0 NPK kg/ha) was applied in four equal splits as basal, 30, 60 and 90 DAS with other recommended package of practices in *Bt* cotton variety GCH-8.

RESULTS

Grassy weeds dominated (63%), followed by broad-leaved (37%). *Commelina bengalensis* and *Digera arvensis* were found more dominant weed species among the grassy and broad-leaved weeds respectively. Among the treatments, the lowest weed dry matter at 90 DAS was observed under pendimethalin 1000 g/ha PE *fb* hand weeding at 20 and 50 DAS, followed by pyrithiobac-sodium 62.5 g/ha + quizalofop-p-ethyl 50 g/ha POE *fb* manual weeding at 50 DAS (9.50 g/m^2) and pyrithiobac-sodium 62.5 g/ha + quizalofop-p-ethyl50g/ha POE *fb* directed spray of glyphosate at 2000 g/ha at 60 DAS (11.26 g/ha). The highest weed control efficiency at 90 DAS was observed in pendimethalin at 1000 g/ha PE*fb* HW at 20 and 50 DAS (72%)

Among the weed management practices, pendimethalin at 1000 g/ha PE *fb* HW at 20 and 50 DAS recorded the highest seed cotton yield, which was at par with pyrithiobac-sodium 62.5 g/ha + quizalofop-p-ethyl 50 g/ha POE *fb* directed spray of glyphosate at 2000 g/ha at 60 DAS. The lowest seed cotton yield and stalk yield were recorded under weedy check. The B :C ratio was found maximum with pendimethalin at 1000 g/ha PE *fb* HW at 20 and 50 DAS, followed by pyrithiobac-sodium 62.5 g/ha + quizalofop-p-ethyl 50 g/ha POE *fb* directed spray of glyphosate at 2000 g/ha at 60 DAS.

Table 1. Weed dry matter, seed cotton yield and economics as influenced by integrated weed management practices

Treatment	WDM at 90 DAS (g/m^2)	WCE at 90 DAS (%)	Seed cotton yield (t/ha)	Stalk yield (t/ha)	Cost of cultivation (x10^3 Rs./ha)	B:C ratio
Pendimethalin at 1000 gPE *fb* 2 hand weeding at 20 & 50 DAS	7.0^i (48.8)*	72	3.62^a	5.92^a	56.36	2.57
Pendimethalin at 1000 g PE *fb* pyrithiobac-sodium 62.5 g/ha POE at 20 DAS	22.78^b (518.3)	9	2.16^e	4.62^{cd}	54.53	1.58
Pendimethalin at 1000 g PE *fb* pyrithiobac 62.5 g + quizalofop- p- ethyl 50 g/ha POE at 20 DAS	21.46^c (465.5)	14	2.35^e	5.24^{abc}	56.33	1.67
Pyrithiobac 62.5 g + quizalofop 50 g POE at 20 DAS	22.64^b (562.3)	9	2.09^e	4.18^d	54.10	1.55
Pyrithiobac 62.5 g + quizalofop 50 g POE at 20 DAS *fb* manual weeding at 50 DAS	9.50^h (90.86)	62	2.99^{cd}	4.63^{cd}	55.30	2.16
Pyrithiobac 62.5 g + quizalofop 50 g POE at 20 DAS *fb* directed spray of paraquat at 600 g/ ha at 60 DAS	15.71^e (253.3)	37	3.25^{bc}	5.75^{ab}	56.25	2.31
Pyrithiobac 62.5 g + quizalofop 50 g POE at 20 DAS *fb* directed spray of glyphosate at 2000 g at 60 DAS	11.26^g (131.1)	55	3.51^{ab}	5.92^a	56.85	2.47
Pendimethalin at 1000 g *fb* glyphosate directed spray at 2000 g at 45 DAS	16.44^d (269.9)	34	2.36^e	4.70^{cd}	54.51	1.73
Mechanical weeding at 20, 40 and 60 DAS	12.64^f (159.0)	49	2.75^d	4.93^{bcd}	54.33	2.02
Weedy check	24.90^a (619.2)	-	1.17^f	2.60^e	50.13	0.93
LSD (P=0.05)	Sig.	-	Sig.	Sig.	-	-

* Values in parentheses are original. Data transformed to square root transformation. Treatment means with the letter/lettersin common are not significant by Duncan's New Multiple Range Test at 5 % level of significance.

CONCLUSION

Application of pyrithiobac-sodium 62.5 g/ha + quizalofop-p-ethyl 50 g/ha POE *fb* directed spray of glyphosate at 2000 g/ha at 60 DAS was found equally effective as pendimethalin at 1000 g/ha PE *fb* HW at 20 and 50 DAS for better weed management, yield of *Bt* cotton and returns.

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Phytotoxicity evaluation of quizalofop-ethyl in Cotton

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Cotton (*Gossypium hirsutum* L.) known as 'king of fibre crops' is an important natural fibre of commercial importance, sustains the cotton textile industry in the country. Losses caused by weeds in cotton range from 50-85% depending upon the nature and intensity of weeds (Kakade, 1996). Availability of pre and post emergence herbicides these days, however make weeding an affordable practice. But the information pertaining to the phyto toxicity of many new herbicides available in the market and recommended for cotton is scanty. Hence, the present investigation was conducted.

METHODOLOGY

A field study was conducted to assess the phyotoxicity of quizalofop ethyl -5% EC on the crop safety in relation to unsprayed control during *Kharif 2012*, on black cotton soil of Agronomy field unit, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka. The soil type was deep black soil with an average fertility status of OC of 0.52 %, available P_2O_5 of 29.75 and K_2O of 179.45 kg/ha. Nine weed control treatments (Table 1) were replicated thrice in a randomized complete block design using Cv.MRC 7351 BG II. Pre emergence herbicide was applied on one day after sowing using a spray volume of 750 l of water/ha with flat fan nozzle (WFN 72) attached to the knapsack sprayer, whereas post emergence herbicides were sprayed on 20 days after sowing coinciding with 2-4 leaf stage of weeds using a spray volume of 300 l/ha with flat fan nozzle (WFN 60) attached to the knapsack sprayer. The crop was sown at a common spacing of 90 cm between rows and 60 cm between plants. Uniform fertilizer dose of 150 kg N, 75 kg P_2O_5 and 75 kg K_2O/ha was provided to cotton as per the recommendation. The gross and net plot sizes were 7.2 x 5.4 m and 3.6 x 4.2m, respectively. The phyto-toxicity rating (using 0 to 10 scale, 0= no adverse effect of herbicide on crop, 10 = severe adverse effect of herbicide on cotton) was recorded on symptoms- epinasty, hyponasty, necrosis symptoms, wilting and stunted growth, after 1, 3, 5 and 10 days after spraying (DASp).

RESULTS

Use of quizalofop- ethyl -5% EC at 37.5 to 200 g/ha did not cause phyto-toxicity in terms of epinasty, hyponasty, wilting, necrotic symptoms, vein clearing symptoms and stunted growth indicating its safety in cotton as post emergence, at all stages- 1,3,5 and 10 DASp. Application of quizalofop ethyl 5 % EC at 37.5 to 200 g/ha at 20 DAS recorded significantly higher cotton yields compared to unweeded control. Similarly, pre emergence application of pendimethalin @ 1000 g/ha at 1 DAS followed by quizalofop- ethyl -5% EC – 50 g/ha at 20 DAS and pendimethalin 30 EC alone at 1000 g/ha - 1 DAS recorded significantly higher seed cotton yield as compared to unweeded control (Table 1). Significantly higher seed cotton yield and WCE was recorded in weed free control (3 HW at 15, 30 and 45 DAS).

Table 1. Effect of quizalofop-ethyl in relation to unsprayed control seed yield and weed control efficiency in cotton

Treatment	Seed cotton yield (kg/ha)	Weed control efficiency
T_1 : Quizalofop-ethyl -5% EC at 37.5g at 20 DAS	1370	79.89
T_2 : Quizalofop-ethyl -5% EC at 50g at 20 DAS	1430	81.56
T_3 : Quizalofop-ethyl -5% EC at 100 g at 20 DAS	1450	82.83
T_4 : Quizalofop- ethyl -5% EC at 200 g at 20 DAS	1460	86.96
T_5 : Quizalofop-ethyl -5% EC at50g at 20 DAS	1390	80.52
T_6 : Pendimethalin 30 ECat1000 g at 1 DAS	1320	75.52
T_7:Pendimethalin at 1000 gat 1 DAS *fb* Quizalofop- ethyl -5% EC at 50 g at 20 DAS	1510	88.47
T_8 : Weed free control (3 HW at 15, 30 and 45 DAS)	1640	97.22
$T_{9::}$Unweeded control	610	-
LSD (P=0.05)	160.22	NA

CONCLUSION

In deep black soil, use of quizalofop- ethyl -5% EC at 37.5-200 g/ha did not cause phyto-toxicity symptoms in terms of epinasty, hyponasty, wilting ,necrotic symptoms, vein clearing symptoms and stunted growth at all stages.. Thus, use of quizalofop- ethyl -5% EC at 37.5-200 g/ha as post emergence at 20 DAS, is quite safe to cotton under deep black soil condition at Raichur. Application of quizalofop- ethyl -5% EC at 50 g/ha as post emergence at 20 DAS, was effective against grassy weeds and overall benefits were comparable to that of hand weeding or dual herbicide usage of pendimethalin at 1000 g/ha at 1DAS followed by quizalofop-ethyl -5% EC – 50 g/ha at 20 DAS .

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Bioefficacy of pre-emergence clomazone on weed management in cotton

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Cotton is one of the most important commercial crops of India, playing an important role in the Indian economy. Being a long duration and widely spaced crop, the yield loss of seed cotton in India due to weed competition ranges between 50-85% (Venugopalan *et al.* 2009). Weed management plays very crucial role, since its initial slow growth, wider spacing, continuous rainfall and heavy use of nutrients provide enough room for profuse growth of weeds. Weeds being naturally hardy and competitive, compete well with crop for moisture, nutrients, light and space resulting in poor crop yield and increase the pest incidence thereby increasing cost of cultivation.

METHODOLOGY

A field experiment was conducted at Main Agricultural Research Station, Dharwad, Karnataka, India during *Kharif* seasons of 2013 and 2014. The soils of experimental site was deep black, the experiment consisted of six weed management treatments involving different doses of clomazone which were compared with recommended herbicide i.e. diuron and farmers' practice (Table 1). These treatments were evaluated under randomized block design with four replications. Cotton Bt variety '*RCH-2*' was sown in first week of July at 90 x 30 cm and recommended dose of fertilizers was applied as per package of practices. Herbicides were sprayed on the same day of sowing. Observations on weed density and weed dry weight were recorded in 1 m^2 area at 60 DAS. The yield data was recorded and net returns were worked out based on price prevailed during 2013 and 2014.

RESULTS

Pooled analysis over two years indicated that the weed density and weed dry weight of were significantly reduced with the application of clomazone 400 g/ha which was on par

Table 1. Weed parameters, seed cotton yield and net returns in cotton as influenced by pre emergent herbicides (Pooled over two years 2013-14& 2014-15)

Treatment	Weed density (no./m^2)	Weed control efficiency (%)	Weed dry weight (g/m^2)	Weed control index (%)	Seed cotton yield (kg/ha)	Net return (Rs./ha)
Clomazone 300 g/ha (2 IC + 1 HW)	3.78 (14.00)*	78.68	3.00 (9.41)*	87.94	2529	70538
Clomazone 400 g/ha (2 IC + 1 HW)	2.80 (7.28)	88.91	1.94 (3.31)	95.75	3007	90081
Clomazone 500 g/ha (2 IC + 1 HW)	2.76 (7.17)	89.08	1.91 (3.18)	95.92	2508	69244
Diuron 1kg/ha (RPP) (2 IC + 1 HW)	2.40 (4.83)	92.64	1.69 (2.38)	96.94	2763	77997
FP (2 IC + 2 HW)	2.63 (6.50)	90.10	2.01 (3.66)	95.30	2998	89417
Weedy Check	8.12 (65.67)	-----	8.86 (78.03)	-----	1314	26275
LSD (0.05)	0.46	4.34	0.27	1.40	301	8343

*Values in parentheses are original. Data transformed to square root transformation; IC – Intercultivation; HW – Hand weeding; RPP- Recommended package of practices

with recommended herbicide i.e. diuron and also with farmers' practice. The weed control efficiency and weed control index were significantly higher with diuron, but was on par with clomazone 400 g/ha. Clomazone 500g/ha, even though recorded higher weed control efficiency on par with clomazone 400 g/ha, but caused slight injury on cotton crop. Seed cotton yield was significantly higher with clomazone 400 g/ha, but it was on par with recommended herbicide *i.e.* diuron, whereas net returns per ha was significantly higher with clomazone 400 g/ha over the recommended practice of diuron application.

CONCLUSION

Clomazone at 400 g/ha was most effective to control weeds resulting in higher seed cotton yield and it was on par with that obtained with diuron. Net returns were significantly higher with clomazone 400 g/ha as compared to diuron.

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Growth, yield and weed control efficiency of forage lucerne ((*Medicago sativa* L.) as influenced by integrated weed management

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In India, the area under lucerne is fluctuating and the perennial nature of this crop is not fully exploited by farmers mainly due to weed infestation. Weeds in lucerne including Cuscuta are reported to cause yield losses as high as 95 per cent (Mahadevappa and Bhanu murthy, 2005). Hence, an experiment entitled "Integrated weed management in forage lucerne (*Medicago sativa* L.)" was conducted at Student Farm, College of Agriculture, Rajendranagar, Hyderabad, during *rabi* season, 2009-10.

METHODOLOGY

The soil of the experimental field was sandyloam in texture, slightly alkaline (P^H 8.5) with low organic carbon (0.5%), available nitrogen, phosphorus and potassium (240, 23.5 & 326.5 kg/ha) respectively. Lucerne was sown with seed rate of 15 kg/ha and spacing of 30 cm x solid rows. Total amount of phosphorus (80 kg/ha) and potassium (40 kg/ha) was applied as basal and nitrogen (30 kg/ha) was applied in two splits (½ as basal and ½ at 30 DAS).The twelve treatments as in Table 1 were laid in Randomised block design with three replications. Three cuts of lucerne forage was taken at 68 DAS, 36 days after I cut and 32 days after II cut.

RESULTS

Lower weed index was observed with imazethapyr at 75 g/ ha at 12 DAS and was closely followed by pure seed of lucerne fb hand weeding at 30 DAS after each cut, salt (10%) treatment to seeds + imazethapyr at 75 g/ha at 12 DAS and application of imazethapyr at 100 g/ ha at 12 DAS. Average plant height of lucerne was significantly higher with sowing pure seed of lucerne + farmers practice of hand weeding at 30 DAS and after each cut and was found at par with all herbicide applied treatments and salt (10 %) treatment to lucerne seeds *fb* farmers practice.

Table 1. Growth, yield, weed control efficiency and economics of lucerne as influenced b Integrated weed management practices

Treatment	Plant height (cm)	Weed index (%)	Weed control efficiency (%) based on weed dry weight	Green fodder yield (t/ha)	B:C ratio
T_1 – Salt (10 %) treatment to Lucerne seeds before sowing *fb* farmers practice (T_{10})	68.69	80.16	68.39	18.607	1.67
T_2 – Salt (10 %) treatment to seeds + Imazethapyr at 75 g/ha at 12 DAS	72.71	13.26	71.98	29.575	3.10
T_3 – Salt (10 %) treatment to seeds + Pendimethalin at 0.5 kg/ha at 12 DAS	68.61	29.04	58.79	26.038	2.87
T_4 – Stale seed bed + hand weeding at 30 DAS	49.00	141.57	63.92	13.984	1.52
T_5 – Pendimethalin at 0.5 kg/ha as PE	70.35	71.14	67.74	19.689	2.20
T_6 – Pendimethalin at 0.75 kg/ ha as PE	74.00	45.87	49.47	23.331	2.49
T_7 – Imazethapyr at 75 g/ ha at 12 DAS	76.35	0.0	72.00	33.544	3.56
T_8 – Imazethapyr at 100 g /ha at 12 DAS	74.38	24.68	79.17	27.671	2.82
T_9 – Pure seed of Lucerne fb farmers practice (T_{10})	78.02	10.51	78.00	30.388	2.64
T_{10} – Farmers practice (Hand weeding) at 30 DAS and after each cut)	48.05	178.00	77.68	12.367	1.12
T_{11} – Weedy check	46.13	325.96	0.0	8.569	1.07
T_{12} – Weed free check	53.26	86.16	91.15	17.081	1.42
LSD (P=0.05)	12.51			5.954	

Weed control efficiency was significantly higher with imazethapyr at 100 g/ha at 12 DAS and was on par with pure seed of lucerne fb farmers practice of weed control and farmers practice alone (hand weeding at 30 DAS and after each cut) over the remaining treatments. Pendimethalin at 0.5 and 0.75 kg/ha as PE or in combination with salt (10%) treatment to seeds was found less effective in reducing the dry weight of weeds and registered lower weed control efficiency.Green forage yield of lucerne and benefit cost ratio was significantly higher with application of imazethapyr at 75 g/ha at 12 DAS and was on par with pure seed of lucerne *fb* farmers practice of hand weeding at 30 DAS and after each cut, salt (10%) treatment to seeds + imazethapyr at 75 g/ha at 12 DAS. (Shivdhar Gupta and Das, 2005).

CONCLUSION

Imazethapyr at 75 g/ha at 12 DAS or selection of pure seed (Cuscutta free seed) *fb* farmers practice (hand weeding at 30 DAS and at first cut) was found effective in controlling all types of weeds and produce higher green forage yield of lucerne.

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Evaluation of roundup crop shield (K-salt) SL under intercultural and non intercultural practices in Cotton

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Cotton is the third major crop after wheat and rice in semi-arid sub tropical region of India including Punjab, Haryana and Rajasthan states and retained its unique fame as "king of fibers" because of higher economic value. Cotton hybrids are cultivated under wider spacing and heavily fertilized, which in turn invites heavy weed infestation. Due to increased labour scarcity , manual weeding is not economical and the currently available pre-emergence herbicides have lesser weed control efficiency in controlling major problematic weeds like *Cyperus rotundus L. and Cynodon dactylon Peri*. Under these conditions, directed application of potassium salt of glyphosate (roundup crop shield 460 SL), a non selective herbicide using hood in cotton rows would be an added advantage to the cotton growers by controlling weeds efficiently and thus reducing cost of cultivation (Kaur *et al.*,2014).

MATERIALS AND METHODS

A field experiment was conducted to know the efficiency of directed spraying of potassium salt of glyphosate (Roundup Crop shield SL) 500g of acid equivalent in 1000ml, a non selective herbicide using hood in cotton rows at College farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* 2011-12 with eight treatments and three replications using randomized block design (RBD).Cotton variety 7347(Dr Brent) BG2 was used.

All weed control treatments were imposed after 30DAS except pre-emergence application of pendimethalin 30% EC 1.25kg/ha which has taken care of the early weed competition. Application of different treatments was done at different leaf stages. Observations recorded to see phytotoxicity symptoms on crop at 4,7,14 days after each application of the weed control treatments. weed dry matter, weed control efficiency (%) recorded at 60 and 90 days after application and yield and economics are also reported.

RESULTS AND DISCUSSION

Weed dry matter recorded at 60 and 90 DAS indicated that significantly highest weed dry matter recorded under un weeded control (2327 and 2150 kg/ha) followed by roundup crop shield at lower dose of 1350g /ha (675 and 622 kg/ha). Weed dry matter was lowest with manual weeding (33 and 43 kg/ha). Weed control efficiency (%) reported was highest with T6 (98.5%), T8 (98.4%) and T7 (96.3%) among different doses of roundup crop shield. Two rounds of crop shield @1800 g / ha followed by two intercultural operations resulted in higher weed control efficiency (92%)

Two rounds of roundup crop shield 460 SL @ 1800 g /ha has controlled the weeds effectively when compared to the roundup crop shield @ 1350 g /ha and which was on par with that at 2250 g/ha. Highest seed cotton yield was recorded with the treatment interculture (2) + manual weeding (2) (2405 kg/ha) which was significantly superior to two rounds of directed spraying of roundup at the rate of 1350 g /ha (1865 kg/ha) and un weeded control (320kg/ha) and it was on par with yield recorded from other treatments. As for as economics is concerned, highest BC ratio achieved with two rounds of roundup crop shield @1800 g /ha (1:2.05), @2250 g/ha (1:2.04) and with pre emergence pendimethalin 30% EC followed by two intercultural operation (1:2.03). No Phytotoxicity and carryover effect was observed due to directed spraying of roundup crop shield for weed control in cottonc.

Table: Observations on yield and economics of cotton as influenced by roundup crop shield 460 SL with and without intercultural operations.

S.No	Treatment	Weed density (no/m^2)	Weed dry matter (kg/ha)	Weed control efficiency (%)	Yield (kg/ha)	B:C ratio
T1	Weedy check	141	2327(48.1)	-	320	-ve
T2	Roundup Crop shield 460 SL @1350g /ha	52	845(29.1)	63.7	1865	1.89
T3	Roundup Crop shield460 SL @1880 g /ha	22	675(26.0)	71.0	2135	2.05
T4	Roundup Crop shield 460 SL @ 2250 g /ha	12	623(24.9)	73.2	2160	2.04
T5	Two rounds of Roundup Crop shield 460 SL @ 1800 g /ha	13	185(13.9)	92.0	2285	1.96
T6	Intercultivation (2) + manual weeding (2)	11	25(6.0)	98.5	2405	1.94
T7	Pendimethalin 30%EC @ 1.25kg/ha + intercultivation (2)	35	87(9.3)	96.3	2310	2.03
T8	Manual weeding (20,40,60 DAS)	17	38(6.20)	98.4	2175	1.62
	C.D(0.05)		3.1	-	289	
	C.V(%)		8.7	-	8.10	

The values in paranthesis are transformed values.

CONCLUSIONS

Two rounds of directed spray of roundup crop shield 460 SL @1800 g /ha at 30 and 60 DAS of cotton without intercultural operations is an effective and economic dose for efficient weed control without any phytotoxicity and residual effect. Hence, herbicide application without intercultural operations is economically viable option for weed control.

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Yield of rice as influenced by different crop establishment and weed management practices

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Rice *(Oryza sativa* L.*)* is consumed as a staple food by more than half of the world's population. In Asia, the major rice production method used is manual transplanting of seedlings into puddle soil. Puddling, is a process of cultivating soil in standing water, consumes a large quantity of water. The scarcity of irrigation water, therefore, threatens the sustainability of rice production in irrigated environments (Chauhan *et a*l., 2014). In addition, the migration of rural labor to urban areas, because of industrialization, causes a shortage of labor during the peak season of transplanting in many regions of Asia (Mahajan et al., 2013).There are some aspects of alternative rice establishment that are yet well understood, especially in relation to studies addressing a systematic comparision of weed infestation. Therefore, a study was conducted to evaluate the effect of different rice establishment methods and weed control treatments on weed growth and rice yield.

METHODOLOGY

The experiment was conducted during *kharif* season of 2014 at experimental farm of ICAR-Directorate of Weed Research Jabalpur, Madhya Pradesh, India (23°132 N, 79°582 E, and 390 m above mean sea level). The experiment was laid out in split plot design the main treatments consisted of four rice cultures *viz*. Transplanting(TP), Puddled broadcast sowing with sprouted seed (PBSR), direct seeded rice (DSR) and System of Rice Intensification (SRI) and the sub treatment comprises four weed management practices *i.e.* weedy check, herbicide alone (bispyribac-sod. 25g/ha), herbicide (bispyribac-sod. 25g/ha) + 1 hand weeding (20 DAS DAT/ DAS) and 2 handweeding (HW) (20 & 45 DAS/DAT) .

RESULTS

The dominant weed flora of the field was *Echinochloa colona*, *Cyperus* spp, *Eclipta alba* and *Caesulia axillaris*. Significantly higher population of *Echinochloa colona* was recorded under DSR while lowest population of *Cyperus* spp was observed with DSR. Significantly lower population of *Echinochloa colona* was recorded with SRI, TP and PBSR. Higher population of *Cyperus* spp was observed with PBSR as compared to DSR. PBSR also accounted for higher weed dry weight**.** Under weed management practices bispyribac alone and bispyribac + 1 HW significantly reduced the population of *Echinochloa colona* and *Cyperus* spp. The close perusal of the data revealed that the bispyribac had less impact on *Eclipta alba* and *Caesulia axillaris*. All the weed management practices and 2HW recorded significantly lower weed dry weight as compared to unweeded control (Table 1). Crop establishment methods had significant effect on yield and yield attributing characters. Significantly higher 1000 seed weight, panicle length, plant height and grain yield was recorded under SRI. Higher effective tillers per m^2 were recorded under PBSR and DSR. Among weed management practices significant difference was observed for plant height, effective tillers/m^2 and grain yield. The highest value for these characters was recorded with 2 HW which was at par with bispyribac + 1 HW and bispyribac alone and all were significantly superior over unweeded control.

Table 1: Effect of different crop establishment techniques and weed management on growth and yield of rice

Treatment	Total weed dry wt. (g/m^2)	Plant height (cm)	Panicle length (cm)	1000 seed wt (g)	Effective tillers/m^2	Grain yield t/ha
Crop establishment methods						
DSR	85.8	88.6	20.8	29.9	262	3.81
Transplanting	54.2	89.7	23.8	31.3	223	4.23
SRI	63.8	95.5	25.1	32.1	210	4.86
PBSR	76.7	86.3	22.3	31.0	242	3.98
LSD (P=0.05)	NS	7.81	0.98	1.35	30.8	0.39
Weed management practices						
Weedy Check	136.2	88.0	22.8	31.3	201	3.46
Bispyribac	60.3	88.7	22.5	31.1	228	4.2
Bispyribac + 1 HW	47.7	93.1	22.8	30.9	247	4.48
2 HW	36.3	90.2	23.9	31.0	261	4.74
LSD (P=0.05)	34.6	NS	NS	NS	24.4	0.4

CONCLUSION

Different cropping systems influence significantly the yield of rice and maximum was recorded under SRI. Application of bispyribac followed by one handweeding was found effective for controlling weeds and yielded at par with 2HW

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Studies on control strategies of dodder

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Cuscuta campestris is a parasitic plant that infests many food crops, ornamental native plants and weeds. Mishra *et al.* (2007) reported that niger was the most susceptible crop (85% yield loss), followed by greengram (81.6%), sesame (66.8%), soybean (48%), black gram, pigeonpea (24%) and groundnut (17.8%), whereas the yield of rice and cowpea was not affected. It mainly parasitizes alfalfa, but also attacks some horticultural crops, legumes, and broadleaved weeds, though it is seldom found on woody plants, grasses, or cereals (Muktar *et al.* 2011). With the incidence of the wide spread of *C. campestris* in the Northeast region and in Adamawa State in particular (Gworgwor *et al.* 2001), it has become imperative to undertake a study on feasible control practices of *Cuscuta* on groundnut crop.

METHODOLOGY

Experiment was conducted in the pots at the Screen house of the Teaching and Research farm of Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria during 2009 and 2010. Yola is located in Northern Guinea savanna region of Nigeria between Latitude 9°14'N and Longitude 12° 31'E, at an altitude of 158.5 m above sea level (Kowal and knabe 1972). It has an annual mean minimum temperature of 15.2°C and mean maximum temperature of 39°C. Rainfall ranges from 700-1000 mm/annum with the soil texturally classified as sandy loam.

Groundnut was used and two seeds were planted in the pots and thinned to 1 plant per pot, which was carried out in a pot in the screen house. The six treatments each of common/ table salt- commercial product (0, 0.5, 1.0, 1.5, 2.0 and 2.5 M NaCl), dish washing detergent (Morning Fresh) (0, 15 ml detergent + 85 ml distilled water, 30 ml detergent + 70 ml distilled water, 45 ml detergent + 55 ml distilled water, 60 ml detergent + 40 ml distilled water and 75 ml detergent + 25 ml distilled water) and glyphosate (0, 25, 30, 35, 40 and 45 g/ha) were evaluated in CRD replicated four times.

Post-emergence herbicide was only used on crop infested with *C. campestris* to know its efficacy on control of *C. campestris*. Plastic bucket of 15 cm diameter and 20 cm depth, perforated at the bottom were used. Groundnut crop was raised as per recommendation. Data collected were leaf area, leaf area index, Plant height, *Cuscuta* cover scores and biomass of ground.

RESULTS

Dish washing detergent increased dodder necrosis with less harm to groundnut. Dish washing detergent at 15 and 45 ml produced the tallest groundnut plants at 9 WAS and 12 WAS as compared with the remaining treatment. This showed that 15 ml concentration of dish washing detergent is more effective on *C. campestris* compared with the control treatment. While with the use of common salt, use of 1.5 to 2.0 M resulted in higher leaf area, plant height and biomass if groundnut indicating less ill effect of common salt, which curtailed the growth of *Campestris*. Howeer, these had no effect in reducing Campestris. In the experiment using glyphosate, significant difference on the effect of post emergence control for dodder was obtained. Application of 25 to 30 g/ha of glyphosate produced the tallest groundnut plants and leaf area as compared with the control and 25 g/ha treatment. While 35 g/ha treatment gave the largest LA of 8.41 and LAI of 4.13 throughout the experiment compared with the rest of the treatments.

Table 1. Effect of glyphosate in the control of *Cuscutacampestris* on groundnut biomass in 2009 and 2010 seasons

Treatment	Biomass		
Glyphosate g/ha	2009	2010	Mean
Control	24.56[ab1]	18.68[a]	21.62[a]
25	23.05[ab]	16.10[a]	19.57[a]
30	17.75[b]	19.80[a]	18.77[a]
35	20.81[ab]	20.65[a]	20.73[a]
40	28.58[a]	15.93[a]	22.25[a]
45	20.34[ab]	15.83[a]	18.08[a]

CONCLUSION

Spraying of common salt and dish washing detergent were found ineffective in controlling dodder, while glyphosate at the rate of 35 g/ha was effective in controlling *C. campestris* in groundnut.

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Herbicidal control of multiple weed flora in wheat

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Wheat [*Triticum aestivum* (L.) emend. Fiori & Paol] is widely grown as winter cereal and is the backbone of food security in India. It contributes almost 40 per cent of the total food grain production of India. Due to change in climate and increased biotic and abiotic stresses, maintaining production and productivity up to required level is a big challenge. Among biotic stresses, weeds especially grassy weeds like little canary grass (*Phalaris minor* Retz.) and wild oats [*Avena ludoviciana* (L.) dur.] are posing great threat to the productivity of wheat in central India. Keeping this in view the present investigation was undertaken to assess the efficacy of herbicides and their mixtures on weeds in wheat.

METHODOLOGY

A field experiment was conducted during *Rabi* season of 2011-12 at Indian Agricultural Research Institute, Regional Station, Indore and in 2012-13 at farmers field in *Dudhia* village of Indore district. The soil of experimental site in first year was medium black with pH value 7.23, organic carbon (0.64%), available nitrogen (338.4 kg/ha), phosphorus (18.93 kg/ha) and available potassium (364.3 kg/ha). Soil of farmer's field was medium black with pH value of 7.25, organic carbon (0.36), available N (165.5 kg/ha), available phosphorus (11.5 kg/ha) and available potassium (198.5 kg/ha). Total 14 treatments, *viz.* Metribuzin at 210 g/ha, Clodinafop propargyl at 60 g/ha, Pinoxaden at 40 g/ha, Sulfosulfuron at 25 g/ha, Clodinafop propargyl + Metribuzin at 60 + 210 g/ha, Pinoxaden + Metribuzin at 40 + 210 g/ha, Sulfosulfuron + Metribuzin at 25 + 210 g/ha, Accord Plus (Fenoxaprop + Metribuzin) at 120 + 210 g/ha, Total (Sulfosulfuron + Metsulfuron) at 32 g/ha, Atlantis (Mesosulfuron + Iodosulfuron) at 14.4 g/ha, Vesta (Clodinafop propargyl + Metsulfuron) at 60 + 4 g/ha, Isoproturon + 2, 4-D at 1000 g + 500 ml/ha, weedy check and weed free were tried in a randomized block design with three replications. Wheat variety '*HI 1544*' was used. All recommended package of practices were followed for growing healthy crop.

RESUTS

Data from Table 1 indicated that all herbicides significantly decreased the weeds density and dry weights (both broad and narrow leaved weeds) in both the years compared to weedy check. Application of herbicides, *viz.* clodinafop propargyl + metribuzin and vesta registered highest values of weed control efficiency in the range of 87.1-90.3% in both the years at 60 days after sowing. It was also noted that application of herbicides viz., *Vesta* (-7.7%), *Sulfosulfuron* (-7.3%), *pinoxaden* (-3.0%) and weedy treatment (-2.5%) recorded negative values of weed index in 2011-12, which means higher grain yield under herbicide treated plots as compared to weed free treatment. Whereas, during 2012-13, vesta (0.5%) and atlantis (3.8%) recorded lowest values of weed index. Bharat and Kachroo (2007) also reported similar results. Highest grain (6.46 t/ha) yield was obtained with vesta application followed by sulfosulfuron (6.44 t/ha) in first year, however during second year maximum grain (4.18 t/ha) yields wad observed with weed free treatment which was followed by *vesta* with grain yield of 4.16 t/ha and atlantis with 4.02 t/ha. Although, application of metribuzin at 210 g/ha sole or in as mix with other herbicides *viz*. clodinafop propargyl, sulfosulfuron and pinoxaden or as ready mix herbicide accord plus was found effective in controlling complex weed flora but exerted phytotoxicity in wheat crop and resulted significantly lower grain and biological yields. Chopra and Chopra (2012) also recorded pre mix clodinafop propargyl + metsulfuron (60 + 4), which is same formulation of herbicide vesta, as the most effective herbicide mixture for controlling the complex weed flora in wheat.

Table 1. Weed control efficiency, weed index, phyto-toxicity and grain yield as influenced by treatment variables

Treatment	Doses (g/ha)	Weed control efficiency (%)		Weed Index (%)		Phyto-toxicity*		Grain yield (t/ha)	
		2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Metribuzin	210	75.1	69.2	18.8	24.4	2.67	2.33	4.87	3.16
Clodinafop propargyl	60	83.8	79.8	4.0	7.2	0	0	5.76	3.88
Pinoxaden	40	81.8	77.5	-3.0	26.3	0	0	6.18	3.08
Sulfosulfuron	25	79.5	82.1	-7.3	8.6	0	0	6.44	382
Clod. + Metrib.	60+210	87.1	85.6	5.5	11.0	4.00	3.00	5.67	3.72
Pinox.+ Metrib.	40+210	77.0	67.2	28.2	27.7	6.33	3.67	4.31	3.02
Sulfo. + Metrib.	25+210	74.0	76.9	27.7	24.4	7.33	2.00	4.34	3.16
Accord plus (Fenox.+metrib.)	120+210	76.6	57.9	26.7	27.0	3.00	2.67	4.40	3.05
Total (Sulfo. + Metsul.).	32	87.1	79.8	1.5	13.4	0	0	5.91	3.62
Atlantis (Mesosul.+Iodsul.)	14.4	85.6	86.5	1.2	3.8	0	0	5.93	4.02
Vesta (Clod.. + Metsul.).	60+4	87.1	87.7	-7.7	0.5	0	0	6.46	4.16
Isoproturon+ 2,4-D	1000 + 500	86.1	57.6	7.8	21.0	0	0	5.53	3.30
Weedy	-	0	0	-2.5	26.8	0	0	6.15	3.06
Weed free	-	100	100	0	0	0	0	6.00	4.18
LSD (P=0.05)	-	-	-	-	-	-	-	0.67	0.31

* Phyto-toxicity recorded on 0-10 scale, where 0 means nil toxicity and 10 means full plot population toxicity.

CONCLUSION

Post-emergence application of herbicides vesta or atlantis at 400 g/ha and clodinafop propargyl at 60 g/ha or sulfosulfuron at 25 g/ha sole may be used for efficient control of multiple weed flora in wheat in vertisols of central India.

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Competitive ability of major weeds with wheat in northwest pakistan

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To investigate the major weeds of wheat in Khyber Pakhtunkhwa province, a comprehensive survey was conducted during February to June, 2012. Wheat fields at 8 locations were visited to record density, relative density, frequency, relative frequency, canopy coverage, relative canopy coverage and importance value index. Several fields were visited at each location and the data average was calculated. Data showed that *Aven fatua* is a major weed at all the above mentioned eight locations. While the second major weeds were; *Rumex dentatus, Phalaris minor, Rumex crispus, Phalaris minor, Silybum marianum, Neslia apiculata, Silybum marianum,* and *Rumex crispus* at D.I. Khan, LakkiMarwat, Kohat, Peshawar, Mardan, Swat, Mansehra and Chitral, respectively. The seeds of two major weeds at each location were collected at maturity and thus were used for conducted experiments. Field experiments were conducted during October/November 2012 and repeated in 2013 to determine the competitive index of the above mentioned two major weeds at each location by using ecological designs likeadditive design and replacement series. The competitive ability of two major weeds at each location was determined. Knowing the competitive index enables us to decide application of weed control method in wheat crop. Thus by calculating the yield losses, weed management plan can easily be decided. However, the profitability of the weed management depends on the CI rather than density of a weed. Competitive index of a weed species could be changed due to cultural practices like variety used, fertilizer dose, irrigation levels, time of sowing, seed rate used and climatic conditions.

INTRODUCTION

Weed competition is the only constraint for the wheat yield because insects and diseases are not so significant problems in Pakistan. Weeds deprive the crop plants of the nutrients, moisture, light, CO_2 and space, while many weeds also possess allelopathic effects for crops. Annual weeds compete most effectively with wheat during the seedling stages and early tillering. Various weed management options have been employed in past that address weed management without threshold level of individual weed. The underlining reason is that weed flora in wheat and their competitive abilities differ with changes in environment even at micro-climate level, which is again under the influence of crop canopy (light interception) etc. Thus, it is desired to find the competition indices of major weeds of wheat for different agro-climatic regions of Khyber Pakhtunkhwa. Avena fatua, Phalaris minor, and Convolvulus arvensis have already been declared as the major weeds in the country. However, due to herbicidal application weed shift occurs which change the spectrum of weeds in an area. Reduction in wheat yield is dependent on many factors like weed species, crop stand and environmental factors. Several researchers have reported the importance of crop-weed competition models. Crop weed competition is always dependent on the density of each species (Khan and Marwat 2006). They further added that the weed reduced wheat yield chiefly by the indirect effect of decreasing wheat tillers, the earliest formed yield component. The weed density, which resulted in yield losses varied greatly with density and season. In a similar studies Khan et al. (2009) reported that increasing weed density significantly and linearly decreased the grain yield of wheat while higher seed rate suppressed the weed biomass. Wheat yield was reduced 47% at the highest density of 12 common milkweed (*Asclepias syriaca*) shoots m-2 (Yenish *et al.* 1997). Cereal crop species and varieties differ in competitive ability against weeds mainly as influenced by differences in canopy architecture (Olesen *et al.* 2006). Siddiqui *et al.* (2010) reported that the competitive ability of different weeds was different in a field trial of wheat. Apart from yield reduction of grains it has been reported that wild oat also decrease the protein content in wheat grain (Khan *et al.* 2007).

METHODOLOGY

Additive design

The first experiment was laid out in additive design in which the density of *Avenafatua* was varied (0, 5, 10, 15, 20, 25, 30, 35 and 40 /m^2), while the wheat density was held constant (125 kg/ha). The wheat crop was planted with the help of manual drill on well prepared seedbed during the month of November in 2012 at each location. There were seven treatments (*A. fatua* densities) with three replications. Each plot size was 5 x 2.5 m^2. There were ten rows of wheat in each treatment, 30 cm apart. The seeds of *A. fatua* were planted by mixing the seeds with wheat and broadcasted as well on the same day of sowing wheat as per treatment. Number of wheat seeds were calculated for each row of wheat for uniform stand of wheat crop. To avoid the risk of germination failure, higher number of seeds of *A. fatua* were planted and then the population was adjusted through thinning. All other weeds were removed manually throughout the crop season on weekly basis. The crop was irrigated as per requirement.

REPLACEMENT SERIES EXPERIMENT

The above mentioned experimental protocol was followed for the instant experiment. In replacement series experiments the total density of wheat and *A. fatua* was constant at each location but their individual density occurred in alternately varying proportions ranging from 0-100 (0:1). Each species was grown alone to assess intra-specific competition as well. Such design provides an accurate assessment of crop-weed interference.

RESULTS

Two weeds were declared as major weeds at each location. The seeds were collected for field experiments. The data showed that all the weeds at each location were highly competitive even at lower density. This paper presents the competitive index of major weeds in wheat.

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Weed management in sorghum based intercropping system

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Sorghum is the fifth most important cereal in the world followed by wheat, rice, maize and barley and it is the major staple diet of the people of the semi-arid tropics. Comparing the production potential of sorghum, the low productivity in India is attributed to several reasons. Among them weed competition is major constraint. Presence of weeds during critical period reduced the yield of sorghum to the extent of 15-40% (Mishra 1997). Favourable temperature, light and moisture available to crop also permit rapid multiplication of weeds at the early stages and create competition to sorghum crop. The present thrust in weed research is to reduce the herbicide use and to formulate integrated management practices by combining cultural methods which are efficient, economic and ecofriendly.

METHODOLOGY

Field studies were conducted in summer (February to March) and *Kharif* (June-July) in split plot design with different inter cropping systems in main plots, *viz*. sole sorghum, sorghum + blackgram (1:1) and sorghum + cowpea (1:1) and weed control measures in sub plot*viz.*, unweeded control, hand weeding twice (20 & 40 DAS), alachlor at 1.0 kg/ha and alachlor at 1.0 kg/ha + one hand weeding at 30 DAS.

RESULTS

The major weedflora in experimental fieldswere *Trianthemaportulacastrum, Cyperus rotundus, Cynodondactylon, Phyllanthusniruri and Cleome viscosa.* Among the weed flora, *T. portulacastrum* and *C. rotundus* dominanted and significantly altered by weed control treatments. The experimental results revealed that the intercropping system situation exerted significant influence on reducing the total weed population and total weed biomass. Sorghum + blackgram intercropping system recorded the lowest weed count, weed biomass and nutrients removal by weeds and the highest weed control index (WCI) and weed smothering efficiency (WSE). With respect to weed control practices, pre-emergence application of alachlor at 1.0 kg/ha followed by one hand weeding at 30 DAS recorded the least weed parameters and the highest WCI and WSE and the highest crop growth, yield parameters and yield.

CONCLUSION

The combined effect of sorghum + blackgram intercropping system with the pre- emergence application of alachlor fbone hand weeding gave good control of weeds, recorded the highest sorghum equivalent yield (SEY), land equivalent ratio (LER), income equivalent ratio (IER) and cost benefit ratio (CBR).

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Efficiency of chemical and cultural approaches for weed management in maize

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Maize (*Zea mays* L.) is one of the major grain crops in Pakistan which face huge production losses due to weeds infestation in particularly in northern Pakistan. A field study has evaluated the effect of four herbicides (Primextra gold 720SC, Dual gold 960EC, Stomp 330EC and 72.4 SE) and five planting densities of *Z. mays* (4, 5, 6, 7 and 8 plants /m^2) on weed management in northern Pakistan. A randomized complete block design with split plot arrangement and all treatments being three times replicated was used. A control along all the replicated treatments was maintained for comparison. The herbicides, the planting densities and their interactions have shown significant affects on the weed density and the *Z. mays* yield and yield components. The smallest weed densities (41.4 and 44.0 /m^2), the tallest plants (181 and 180 cm), the greater 1000 kernels weight (254 g) and the greater grain yield (3.68 kg/ha) were all found for Primextra gold and Dual gold. The lowest weed densities (53 and 56 weeds/m^2), the tallest plants (175 and 173 cm), the greater kernels (404 and 395 /cob) and the greater grain yield (4.29 and 4.23 kg/ha) were all found for the 7 and 8 plants m^{-2} *Z. mays* densities, respectively. We conclude that pre-emergence herbicides (*e.g.* Primextra gold and Dual gold) and sowing the crop at 7 and 8 /m^2 densities could be effective for weed management and higher *Z. mays* production in northern Pakistan. Further studies are suggested to investigate herbicides combinations and *Z. mays* cultivars at diverse agro-climatic conditions for weed management.

Post emergence herbicides for weed management in rice fallow black gram relay cropping

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Blackgram (*Vigna mungo* L.) in rice fallow relay cropping system is mainly cultivated in delta districts of Tamil Nadu. Inthis system, seeds are broadcasted in zero till condition which survives entirely on the residual soil moisture and fertility after the harvest of preceding rice crop (Veeraputhiran and Chinnusamy 2008). Severe weed growth deprives rice fallow black gram, its natural resources requirementwhich results in poor growth and yield to an extent of 45-60% (Sasikala *et al*. 2014). Presence of rice stubbles and zero till condition prevents adoption of physical, mechanical and pre-emergence herbicide weed control methods. Hence it warranted, to evolve post-emergence herbicide weed management for rice fallow blackgram relay cropping.

METHODOLOGY

Field experiments were carried out during *rabi*2014 and 2015 at TNAU, Coimbatore with nine treatments comprising of three post-emergence herbicides (25 DAS) and its combination with weed free and weedy check laid out in randomised block design and replicated thrice. Seeds of black gram variety ADT 5 were uniformly broadcasted four days before the harvest of paddy. Observation on weed characters at 40 DAS, yield attributes and yield of black gram were recorded and statistically analysed.

RESULTS

The dominant weed flora observed were *Echinochloa colona, E. crusgalli, Panicum repens, Cynodan dactylon* among grasses, *Cyperus rotundus, Cyperus difformis* among sedges and *Cleome viscosa, Eclipta alba, Sphaeranthus indicus* and *Xanthium strumarium* among BLW. The weed density (46.9 /m^2), dry weight (41.3 kg/ha) registered by quizalofop-ethyl 50 g/ha + imazethapyr 50 g/ha was significantly lower than application of single herbicide and was on par with fenoxaprop-p-ethyl 50 g/ha + imazethapyr 50 g/ha. This result is in accordance with the findings of Sasikala *et al*. (2014). The less weed density, weed dry weight, low weed index (0.12) and high weed control efficiency (73.7%) under combined application of herbicides might be due to effective control of early as well as late flushes of weeds. Quizalofop-ethyl, fenoxaprop-p-ethyl and imazethapyr are systemic herbicides that inhibits aceto-hydroxy acid synthase, amino acid biosynthesis, synthesis of branched chain amino acids and fatty acid synthesis by its higher efficacy and long lasting effects on established weeds of grasses, BLW and sedges which in turn retard biochemical and physiological process of normal cell division and cell multiplication in meristems of targeted weed species.

Table 1. Effect of herbicide on weed, yield attributes and yield of rice fallow black gram (Mean of two years)

Treatment	Weed density* (no./m^2)	Weed dry weight (kg/ha)	WCE (%)	Number of pods/plant	Seed yield (t/ha)	Weed index
Weedy check	13.04 (169.6)	156.9	-	10.4	0.23	0.71
Fenoxaprop-p-ethyl 50 g/ha	9.71 (93.8)	82.6	47.4	19.0	0.44	0.44
Imazethapyr 50 g/ha	10.33 (106.3)	93.3	40.5	16.9	0.43	0.46
Quizalofop-ethyl 50 g/ha	9.24 (84.9)	73.7	52.9	22.2	0.51	0.35
Imazethapyr 75 g/ha	9.55 (88.6)	96.2	53.0	20.6	0.47	0.40
Quizalofop-ethyl 75 g/ha	8.13 (65.6)	58.3	62.8	26.6	0.56	0.28
Fenoxaprop-p-ethyl 50 g/ha + Imazethapyr 50 g/ha (mixture)	7.21 (51.5)	52.9	66.3	28.0	0.67	0.15
Quizalofop-ethyl 50 g/ha + Imazethapyr 50 g/ha (mixture)	6.88 (46.9)	41.3	73.7	31.5	0.69	0.12
Weed free	0.71 (0)	-	100	36.8	0.81	-
LSD (P=0.05)	0.41	14.5	7.9	3.6	0.08	0.10

*-Figures in parenthesis are original values subjected to "√x+0.5 transformation

Application of single herbicide was found inferior to combined application of post emergence herbicides, either quizalofop-ethyl 50g/ha + imazethapyr 50g/ha or fenoxaprop-p-ethyl 50 g/ha + imazethapyr 50 g/ha to obtain more yield attributes and higher yield. Application of quizalofop-ethyl 50 g/ha + imazethapyr 50 g/ha significantly registered more number of pods (31.5 /plant), seeds (6.8 /pod), test weight (4.67-37 g) and grain seed yield (0.69 t/ha) than application of single herbicide at various concentrations. This might be due to reduced weed infestation under broad spectrum herbicide application, which minimise the crop-weed competition at critical period of crop growth and maximise the yield parameters and yield in rice fallow blackgram. Similar results on yield attributes and yield by application of post-emergence herbicides was reported by Veeraputhiran and Chinnusamy (2008).

CONCLUSION

This study proved that, combined application of selective and systemic post- emergence herbicides .either quizalofop-ethyl 50 g/ha + imazethapyr 50 g/ha or fenoxaprop-p-ethyl 50 g/ha + imazethapyr 50 g/ha is effectively control the broad spectrum weeds and enhanced the yield attributes and grain seed yield of rice fallow blackgram.

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Evolving chemical and integrated weed management practices in greengram

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In India, grain legumes are important group of food crops and remains as main source of dietary protein. Whereas, the availability of grain legumes has come down from 61 g/day/person in 1951-52 to 33 g/day/person in recent years. Green gram is one of the important grain legume crops, however its true yield potential has not been achieved owing to several constraints. Weed infestation is considered as important constraints in greengram cultivation and has been found to cause 50-90% yield reduction (Khaliq *et al*. 2002). Due to diversity, weeds are major threat to agriculture and they out-compete crops for natural resources utilisation (Chhodavadia *et al.* 2013). Generally weeds are controlled by hand weeding, but it is expensive under labour crunch condition. It is therefore, imperative to evolve economically viable weed management practices for irrigated green gram.

METHODOLOGY

Field investigations were conducted during *Kharif* 2013 and 2014 at TNAU, Coimbatore with nine treatments comprising of pre-emergence herbicides in combination with post-emergence herbicides, hand weeding and weedy check were arranged in randomised block design and replicated thrice. Seeds of variety CO 8 were sown with spacing of 30 x 10 cm. Fertilizers were applied at 25:50:25:20 kg N:P:K:S /ha respectively. Data on weed density, dry weight and control efficiency at harvest stage, seed yield and economics were studied.

RESULTS

Among the weed species, BLW constitutes majority (78%) followed by grasses (14%) and sedges (8%).Among the weed control, hand weeding twice registered lower weed count (11.2 no./m^2), weed dry weight (29.6 kg/ha)and was on par with pendimethalin+ imazethapyr at 1.0 kg/ha (PE) + hand weeding and pendimethalin at 1.0 kg/ha (PE) + hand weeding and significantly lower than all other treatments. The finding confirms the results of Chhodavadia *et al*. (2013). The minimum weed count, dry weight and maximum weed control efficiency in hand weeding twice (92.5%) and IWM practice (91.1%) were due to better control of weeds during critical period of crop-weed competition.

The highest seed yield (1270 kg/ha) was recorded with hand weeding twice, which was significantly higher by 67.1%, 40.4% and 28.3% than weedy check, pendimethalin 1.0 kg/ha (PE) and pendimethalin + imazethapyr 1.0 kg/ha (PE) respectively and was on par with IWM practices. Higher grain yield under IWM practices may be attributed mainly to the effective control of weeds by application of broad spectrum herbicide at pre-emergence stage, hand weeding at subsequent crop growth stage resulting in reduced weed growth during critical period of green gram (15-40 DAS). This facilitates crop-weed competition free environment thereby higher nutrient uptake and better yield attributes. The results confirmed the benefits of IWM practices in greengram as reported by Khaliq *et al.* (2002).

Table 1. Effect of weed management on weed, yield and economics of green gram (Mean of two years)

Treatment	Weed density* (no./m^2)	Weed dry weight (kg/ha)	WCE (%)	Grain yield (t/ha)	Net return (x 10^3 Rs. /ha)	B:C ratio
T_1-Pendimethalin 1.0 kg/ha(PE)	7.46 (55.1)	158.9	60.0	0.75	15.7	1.71
T_2-Pendimethalin+Imazethapyr 1.0 kg/ha(PE)	6.46 (41.2)	119.8	69.8	0.91	22.5	1.98
T_3-T_1+Quizalofop-ethyl 50 g/ha (POE)	5.81 (33.3)	97.8	75.4	0.94	22.9	1.94
T_4-T_2+Quizalofop-ethyl 50 g/ha (POE)	5.40 (28.7)	72.6	81.7	1.09	29.4	2.17
T_5-T_1+Imazethapyr 40 g/ha (POE)	5.59 (30.7)	80.2	79.8	0.96	24.8	2.07
T_6-T_1+Hand weeding at 25 DAS	3.96 (15.2)	48.7	87.7	1.18	31.9	2.18
T_7-T_2 +Hand weeding at 25 DAS	3.78 (13.8)	35.5	91.1	1.26	35.0	2.25
T_8 -Hand weeding at 20 and 40 DAS	3.42 (11.2)	29.6	92.5	1.27	33.1	2.09
T_9 - Weedy check	12.62(158.7)	396.9	-	0.41	0.58	1.03
LSD (P=0.05)	0.57	34.0	5.0	0.15	7.62	0.29

*-Figures in parenthesis are original values subjected to "¯x+0.5 transformation.

Highernet returns (Rs. 35013 /ha) and B:C ratio (2.25) was obtained in pendimethalin+imazethapyr 1.0 kg/ha (PE) + hand weeding at 25 DAS followed by pendimethalin 1.0 kg/ha (PE) + hand weeding at 25 DAS and pendimethalin + imazethapyr 1.0 kg/ha (PE) + quizalofop-ethyl 50 g/ha (POE), which might be due to less labour requirement for weed management and thereby lower variable cost. This finding manifest the core importance of IWM practices in modern intensive cropping systems under labour scarcity conditions (Chhodavadia *et al*. 2013).

CONCLUSION

Pre-emergence application of pendimethalin + imazethapyr 1.0 kg/ha followed by hand weeding at 25 DAS is the efficient and economically viable weed management practice for irrigated green gram. In acute labour scarcity condition, pendimethalin+imazethapyr 1.0 kg/ha (PE) + quizalofop-ethyl 50 g/ha (POE) could be explored as an alternate weed management practice.

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Efficacy and economics of pre and post-emergence herbicides in rainfed pigeonpea

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Pigeonpea (*Cajanus cajan*(L.) Mill sp.), the second most important pulse crop of India, is widely grown under rainfed condition on marginal land at wider spacing during rainy season. Due to its wider row spacing and initial slow growth, weeds pose a major problem to its productivity which may lead toits yield reduction up to 80% (Talnikar *et al.* 2008). Manual and mechanical methods of weed control are quite effective, but they are costly and time consuming (Ram *et al.* 2011). Thus use of herbicides has become a promising and effective option of managing weed growth. Herbicides like alachlor, metalachlor and pendimethalin provide effective weed control during the initial growth period only (up to 30 days after growing). As pigeonpea is a long duration crop, many flushes of weeds germinate at the later stages which compete with the crop. It is therefore, essential to use the post-emergence herbicides in pigeonpea for the effective control of weeds throughout the crop season. Hence, the present study was taken up.

METHODOLOGY

A field experiment was conducted during 2012-13 at Regional Agricultural Research Station, Warangal, Telangana, India to evaluate the efficacy of pre and post- emergence herbicides and their integration in pigeonpea. The experiment was laid out in randomized complete block design comprising nine treatment combinations viz., Weedy check; pendimethalin 750 g/ha as pre–emergence (PE) + one hand weeding (HW) at 50 DAS; imazethapyr 100 g/ha at 15 DAS + one HW at 50 DAS; quizalofopethyl 100 g/ha at 15 DAS + one HW at 50 DAS; pendimethalin 750 g/ha as PE + imazethapyr 100 g/ha at 15 DAS;pendimethalin 750 g/ha as PE + imazethapyr 100 g/ha at 15 DAS + one HW at 50 DAS; pendimethalin 750 g/ha PE + quizalofop ethyl 100 g/ha at 15 DAS; pendimethalin 750 g/ha as PE + quizalofop ethyl 100 g/ha at 15 DAS + one HW at 50 DAS andweed free plot with three replications. The pigeonpea variety '*WRG 53'* (160-180 days duration) was grown at 90 x 20 cm spacing. A rainfall of 925.2 mm was received during crop growth season over 53 rainy days. The recommended fertilizer dose (20:50:20 kg/ha as N: P_2O_5: K_2O) was applied before sowing through urea, single super phosphate and muriate of potash, respectively. The crop was raised under rainfed condition with recommended package of practices for the zone.

RESULTS

The observations revealed that at 70 DAS, the lowest number of dicot weeds was recorded with pendimethalin + imazethapyr + HW sequence (Table 1). However, all the other treatments registered significantly lower count of dicots compared to weedy check and they were at par with each other. Monocots were reduced significantly in imazethapyr + HW which was at par with quizalofop ethyl + HW and pendimethalin + imazethapyr. The highest monocot population was recorded with pendimehtalin + HW followed by pendimethalin + quizalofop ethyl + HW or without HW and pendimethalin + imazethapyr + HW treatments which were at par with each other and they were superior to weedy check as well. This might be due to the germination of later flushes of monocots due to lack of competition in the treated plots while they might be suppressed by the dicots in weedy check. But the total weed dry matter was significantly reduced in all the treatments compared to weedy check, except the pendimethalin + quizalofop ethyl sequence. The weed control efficiency was higher with imazethapyr + HW or pendimethalin + imazethapyr + HW. Similar results were reported by Talnikar *et al.* (2008).

Table 1. Weed growth, yield and economics of pigeonpea asinfluenced by weed control treatments

Treatment	Weed population at 70 DAS (no./m2)		Weed dry matter at 70 DAS (g/m2)	Weed control efficiency (%) at 70 DAS	Pods/ plant	Seed yield (t/ha)	Net Returns (x 10^3 Rs/ha)
	Broad leaf	Grasses					
Weedy check	10.53(112.3)*	1.27(0.7)*	15.44(245.0)*	--	68	0.26	1.22
Pendimethalin + HW	2.97(8.3)	4.64(20.7)	5.30(27.3)	88.36	184	1.37	31.8
Imazethapyr + HW	5.82(40.3)	1.41(1.3)	4.13(18.0)	92.65	239	1.38	31.6
Quizalofop ethyl + HW	4.16(17.7)	2.63(7.3)	4.67(21.3)	91.31	143	1.46	34.7
Pendimethalin + Imazethapyr	6.14(44.7)	2.33(5.3)	6.76(52.7)	78.49	207	1.16	26.4
Pendimethalin + Imazethapyr + HW	2.66(6.3)	3.83(14)	4.47(19.3)	92.12	169	1.36	29.3
Pendimethalin + Quizalofop ethyl	6.35(43.3)	3.83(18.7)	12.29(152.7)	37.67	146	1.09	24.4
Pendimethalin + Quizalofop ethyl + HW	3.41(13.7)	4.08(16.3)	4.96(24.0)	90.20	191	1.44	32.3
Weed free check	1.00(0)	1.00(0)	1.00(0)	100	266	1.71	30.0
LSD (P=0.05)	3.82	2.11	3.30	-	49.1	0.419	-

*****Values in parenthesis are original. Data transformed to square root transformation.

The number of pods was significantly higher with imazethapyr + HW followed by pendimethalin + imazethapyr combination which were at par with pendimethalin + quizalofop ethyl +HW. However, in other treatments also the number of pods/plant was significantly higher than weedy check. Similar trend was observed with respect to seed yield. All the treatments were at par with each other, even though the highest seed yield was recorded with pendimethalin + quizalofop ethyl + HW. But higher net returns and benefit: cost ratio were recorded with quizalofop ethyl + HW compared to the above treatment due to lower cost involved in the treatment. It was followed by pendimethalin + hand weeding.

CONCLUSION

It was concluded that a single application of pendimethalin aat 750 g/ha or quizalofop ethyl at 100 g/ha or imazethapyr at 100 g/ha along with one hand weeding at 50 days after sowing was most effective for controlling weeds, improving the yield and profitability of pigeonpea crop.

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Management of weeds under the system of rice intensification

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The system of rice intensification (SRI) appears to be a viable rice production technology that not only saves the inputs in terms of less seed, water, chemical fertilizers, and pesticides, but also improves the quality of soil health and rice growing environment. However, it requires certain management practices for plants and soil.Weeding is a serious deterrent to SRI adoption (Satyanarayana *et al.* 2007). The combination of wider spacing and saturated moisture condition in the rice field provides ideal conditions for several flushes of weeds, making frequent weeding anecessity. Hence, appropriate weed management strategies are needed to fully exploit SRI technology. The present study was carried out to evaluate different weed management options under SRI method of rice cultivation.

METHODOLOGY

The field experiment was conducted during dry seasons of 2011 at the Institute Farm in the sandy clay loam soil with pH 5.8, medium in organic content with 0.63%. Six weed control treatments, *viz.* chemical control by bensulfuron methyl + pretilachlor (70 + 700 g/ha) at 10 days after transplanting (DAT), mechanical control by a cono weeder (twice) and a finger weeder (twice), hand weeding (twice) along with weed-free and weedy checks, were evaluated in a randomized complete block design with four replications. Fourteen day old seedlings of test variety "Naveen" (120 days) were transplanted on the well leveled plots with uniformity in water retaining capacity. The crop was fertilized through well rotten FYM at 15 tonnes per hectare (0.62% N, 0.13% P and 0.46% K) during the finalland preparation and the recommended dose of fertilizer was applied at the time of panicle initiation. The data collected on weed density, weed biomass, yield parameters, *etc.* were analyzed using ANOVA.

RESULTS

Cyperus difformis was the most predominant weed species in the weedy plots followed by *Sphenoclea zeylanica.* The sedges constituted 56% of the total weed population in the weedy plots followed by broadleaved weeds (28%), and grassy weeds (16%). Weed free treatment recorded maximum grain yield (4.86 t/ha and 5.21 t/ha) followed by weeding with cono-weeder treated plot (4.79 t/ha). Weedy check recorded lowest yield (2.70 t/ha) which was 44.4%, 43.6%, 42.5%, 41.8% and 36.9% lower than weed free, conoweeder, herbicide, hand weeding and finger weederused plots, respectively. Satyanarayana *et al.* (2007) also reported that one or two weedingsareusually sufficient to control most weeds. Weed infestation was comparatively less in plots where the cono-weeder was operated at 15 and 30 days after transplanting (DAT) and bensulfuron-methyl + pretilachlor was applied at 10 DAT that showed higher weed control efficiency of 91 and 90%, respectively. However, highest B:C ratio (1.93) was recorded in the herbicide-treated plots followed by the use of cono-weeder (1.83). The yield reduction in weedy plots was 45% compared to the weed-free check.

Table 1. Rice grain yield and economics as influenced by weed management practices in SRI

Treatment	Grain Yield (t/ha)	Weed Biomass at 45 DAT (g/m^2)	Weed control efficiency (%)	Cost of cultivation (x 10^3 Rs./ha)	Net income (x 10^3 Rs./ha)	B:C Ratio
Bensulfuron methyl + pretilachlor (70 + 700 g/ha) at 10 DAT	4.70	9.3	89.6	26.3	15.2	1.93
Weed free check	4.86	0.0	100	32.9	10.0	1.44
Hand weeding (15 and 30 DAT)	4.64	10.1	88.7	31.0	10.5	1.50
Conoweeder (15 and 30 DAT)	4.79	8.2	90.8	27.8	14.8	1.83
Finger weeder (15 and 30 DAT)	4.28	14.8	83.4	28.9	10.1	1.53
Weedy	2.70	89.2	0	23.8	5.73	1.42
LSD (P=0.05)	0.74	4.32	-	-	-	-

CONCLUSION

Bensulfuron methyl + pretilachlor, provided broad-spectrum of weed control and was the most economicalmethodfor controlling weeds under SRI method of rice cultivation.

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Weed management research in sunflower in India: way forward

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Sunflower (*Helianthus annuus* L) is an efficient oilseed crop with high quality edible oil. Due to its short duration and wider adoptability, the crop is grown round the year in all seasons and has great potential for diversification of major cropping systems in the country. Among the several yield limiting production factors, weeds were identified as one of the critical yield limiting production factors in sunflower cultivation (Suresh and Reddy 2010). The Indian Institute of Oilseeds Research (IIOR), Hyderabad coordinates and provides leadership in conducting and implementing location-specific sunflower research that includes weed management research through AICRP sunflower centres located in various agro-ecological regions of the country. Front-Line Demonstration (FLDs) data for the past 20 years suggest possibility of 21% increase in productivity of sunflower through timely weed control.

METHODOLOGY

The results of field experiments on weed management conducted during 2007-2014 in IIOR, Hyderabad and AICRP-sunflower centres*viz.*, Bangalore, Raichur, Coimbatore (*Kharif* centre) Latur (*Rabi* centre) and Punjab (*spring*) were reviewed for assessingthe status of integrated weed management research in the country. The research carried out in other developed/developing countries provided an opportunity to evaluate different weed management methods suggest possible way forward for enhancing sunflower productivity in India through efficient weed management methods in the years to come.

RESULTS

The research carried out at IIOR and AICRP (Sunflower) over the years has conclusively proven the advantage of pendimethalin(1.0 kg) as pre-emergence application + inter-culturing at 21 DAS followed by hand weeding at 40 DAS in realizing higher yields and net returns of *Kharif* sunflower (Suresh and Reddy 2010). Among several post-emergence herbicides, imazethapyr (Pursuit 10WP) at 0.15 and 0.2 kg/ha and chlorimuronethyl at 9 g/ha were found phytotoxic to sunflower and hence not recommended. However, the preliminary results have indicated post-emergence spray of quizalofopethyl; propa-quizofop and fenoxyprop-ethyl exerted no detrimental effect on the crop and achieved good control of grasses in most of the AICRP (sunflower) trials. All these herbicides are registered with Central Insecticides Board, India for use in soybean crop. No herbicide is registered yet for use in sunflower crop.

On the other hand, work done abroad on weed management in sunflower focused on gene discovery and trait development for herbicide tolerance (HT), particularly to herbicides, *viz*. imidazolinones (Imazethapyr) and sulfonyl ureas (chlorimuron ethyl) as an active area of research during the past decade to provide non-GMO strategies for weed control in sunflower. These tolerant plants have been discovered in sunflower, which permitted the development and commercialization of several herbicide tolerant (HT) traits such as "IMI-SUN", "SURES" and "CLPlus" (Bulos *et al.* 2013). Crossing these HT-tolerant wild sunflower populations with cultivated sunflower lines gave rise to IMI-tolerant populations and lines which were released as donor materials for developing hybrid varieties that were commercially launched in the USA, Argentina and Turkey during the year 2004.

CONCLUSION

Inview of the foregoing issues, the weed management research in sunflower need to be prioritized considering the following options:

· Incorporating herbicide tolerance traits /genes through marker assisted selection into elite sunflower inbred lines

· Pursuing further research on enlarging the broad spectrum weed control by combining post-emergence herbicides, graminicides viz., quizalofop-ethyl, propaquizofop and fenoxaprop-ethyl with pre-emergence – pendimethalin.

· Ascertaining the reaction of commercially available cultivated genotypes to post-emergence herbicides.

· Testing the reaction of germplasm to post-emergence herbicides and other new molecules.

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Study of critical period of crop-weed competition in *Rabi* castor

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India is the global leader in the production and trade of castor. Weeds are one of the major causes for the poor yield of castor as they compete with the crop for moisture, nutrients, light and space. Therefore, determination of critical period becomes imperative for planning weed management programme and to curtail unwise expenditure towards weed management practices. Meagre scientific information is available for castor in South Gujarat in this matter andhence, this experiment was planned.

METHODOLOGY

A field experiment was conducted during *rabi* season in two consecutive years from 2010-11 to 2011-12 at Instructional Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari. Twelve treatments were evaluated with three replications in a randomized block design (RBD). The sowing of castor var. GCH-7 was done at a spacing of 120 x 60 cm by manual labourers and fertilized as per recommended dose (80-17.5-0 kg NPK/ha). The whole dose of phosphorus in the form of SSP and half dose of nitrogen in the form of urea were applied evenly in furrows before sowing. Remaining half dose of nitrogen was top dressed in two equal splits at 50 and 75 days after sowing. Data on weed growth, castor yield and economics were recorded.

RESULTS

The experimental field was infested by major weed species, *viz. Echinochloa crusgalli* (L.) Beauv, *Digitaria sanguinalis* L., *Eragrostis major* (grasses); *Amaranthus viridis* L., *Alternanthera sessilis*., *Digera arvensis* Forsk., *Convolvulus arvensis* L., *Trianthema portulacastrum* L., *Euphorbia hirta* L., *Physalis minima* L., *Euphorbia maderospatensis* (borad leaf weeds) and *Cyperus rotundus* L. (sedge).

Significantly higher seed yield was recorded in weed free up to harvest which remained statistically at par with the weed free up to 90 DAS and weed free up to 120 DAS. Weedy condition up to 90, 120 DAS and up to harvest caused 42.8, 50.6 and 51.3% yield reduction, respectively, as compared to the treatment weed free up to harvest. Oil content in seed was found unaffected due to different treatments. However, the highest oil yield (1.11 kg/ha) was recorded with treatment weed free up to harvest and remained at par with the treatment weed free up to 90 DAS and 120 DAS.

Treatment weed free up to 120 DAS recorded the lowest weed index (0.73%) followed by the treatment weed free up to 90 DAS. Similarly, the highest weed control efficiency was recorded under the treatment weed free up to harvest (100%), followed by the treatment weed free up to 120 DAS (89.8%), weedy up to 30 DAS (88.3%) and weed free up to 90 DAS (65.0%). The highest net realization (₹46.6 x 10^3/ha) was obtained in treatment of weed free up to 90 DAS with BCR value of 3.02 followed by the treatment weed free up to 120 DAS and weed free up to harvest among different treatments of critical period of crop weed competition in castor.

Table 1. Castorseed yield, quality, economicsand weed control efficiency as influenced by different treatments (Pooled over 2 years)

Treatment	Yield (t/ha)	Oil (%)	Oil yield (t/ha)	Net realization (x10^3 ₹ /ha)	BCR	Weed control efficiency (%)
Weed free up to 30 DAS	1.37	46.7	0.64	24.3	2.31	11.5
Weed free up to 60 DAS	1.84	46.7	0.86	35.4	2.61	37.2
Weed free up to 90 DAS	2.23	46.9	1.04	46.6	3.02	65.0
Weed free up to 120 DAS	2.35	46.9	1.10	46.3	2.72	89.8
Weed free up to harvest	2.37	47.0	1.11	45.4	2.59	100.0
Weedy up to 30 DAS	2.06	46.9	0.97	39.4	2.58	88.3
Weedy up to 60 DAS	1.56	46.8	0.73	26.8	2.22	59.6
Weedy up to 90 DAS	1.24	46.8	0.58	17.8	1.85	35.9
Weedy up to 120 DAS	1.03	46.7	0.48	12.6	1.65	19.0
Weedy up to harvest	1.01	46.0	0.46	15.6	1.97	0.00
Two hand weeding and interculturing at 30 and 60 DAS	2.11	46.9	0.99	43.8	2.99	59.5
Pendimethalin at 1.0 kg/ha (as pre-emergence) + one hand weeding and interculturing at 60 DAS	2.14	46.9	1.00	46.3	3.26	57.3
LSD (P=0.05)	0.29	NS	0.14			

DAS: Days after sowing, NA: Not analyzed, BCR – Benefit:Cost ratio

CONCLUSION

Thus, it can be concluded that to realize the potential economical yield of castor with reduced weed competition, crop should be kept weed free up to initial 90 days after sowing, which is more crucial for crop weed competition.

Bioefficacy of new herbicide molecules in sunflower

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Sunflower is becoming popular because of its wider adaptability to different agro-climatic zones and soil types. Productivity of sunflower has been often deflated due to an array of biotic and abiotic factors. Weed competition is one of the major biotic constraints in realizing higher sunflower productivity due to wider spacing and application of higher dose of fertilizers. So, it was programmed to conduct the experiment on bio-efficacy of new herbicide molecules for betterment of farming community through enhanced production and productivity of the sunflower.

METHODOLOGY

Field experiment was conducted at UAS, GKVK Bengaluru, Karnataka, India, during *Kharif* 2014. The soil of the experimental site was acidic in reaction (pH 5.8) and low in available nitrogen, medium in available phosphorus and available potassium.The treatments consisted of five pre-emergence herbicides (pendimethalin 1000 g/ha, clomazone 600 g/ha, oxyfluorfen 80 g/ha, sulfentrazone 192 g/ha and flurochloridone 625 g/ha sprayed at 3 DAS) and the combination of these pre-emergence herbicides with a post-emergence quizalofop-p-ethyl 37.5 g/ha at 30 DAS. Herbicides were compared with farmer's practice of two hand weedings (20 and 40 DAS) and unweeded control. Thus there were twelve treatments and replicated thrice under RCBD design. Sunflower hybrid KBSH-41 was used for sowing.

RESULTS

Dominant weed species noticed in the experimental field were *Cyperus rotundus*, *Cynodondactylon*, *Digitaria marginata*, *Dactyloctenium aegyptium*, *Ageratum conyzoides*, *Borreria articularis*, *Alternanthera sessilis.* Nutrient uptake by sunflower at harvest was significantly higher in treatments having combination of pre- and post-emergence herbicides and two hand weedings at 20 and 40 DAS (Table 1). These treatments recorded 50-79%, 69-135% and 47-80% increased uptake of N, P and K, respectively, as compared to unweeded control. This was attributed to minimum crop-weed competition as a result of better control of weeds from initial stages resulting in better sunflower growth and development leading to better nutrient uptake. Similar results were reported by Suresh and Reddy (2010). Lower uptake by weeds was recorded in treatments having combination of preand post-emergence herbicides and two hand weedings at 20 and 40 DAS. The unweeded control recorded significantly lower nutrient uptake by crop and higher removal by weeds due to unchecked weed growth. Higher seed yield, gross return and B:C ratio was recorded in pendimethalin(3.14 t/ha, ¹ 66358 /ha and 3.37, respectively) or flurochloridone(3.13 t/ha, ¹ 66413 /ha and 3.40 , respectively) or clomazone (3.10 t/ha, ¹ 65503 /ha and 3.37, respectively) when used in combination with post-emergence application of quizalofop-p-ethyl as compared to unweeded check (1.87 t/ha, ¹ 31803 /ha and 2.31, respectively).

Table 1. Nutrient uptake by crop, nutrient removal by weeds at harvest and economics as influenced by weed management practices in sunflower

Treatment	Nutrient uptake by crop (kg/ha)			Nutrient removal by weeds (kg/ha)			Seed yield (t/ha)	Net return (x 10^3 ?/ha)	B : C ratio
	N	P	K	N	P	K			
Pendimethalin 1000 g/ha	92.5	21.3	101.4	28.2	11.1	39.7	2.41	46.0	2.76
Clomazone 600 g/ha	100.6	24.2	106.5	27.8	9.1	38.7	2.56	51.0	2.97
Oxyfluorfen 80 g/ha	94.8	23.2	104.6	32.0	9.3	43.3	2.50	49.6	2.94
Sulfentrazone 192 g/ha	89.3	21.5	99.7	34.7	11.6	47.4	2.35	44.9	2.75
Flurochloridone 625 g/ha	102.4	25.6	107.8	26.1	7.6	33.3	2.73	55.9	3.15
Pendimethalin 1000 g/ha *fb* quizalofop-p-ethyl 37.5 g/ha	125.0	37.2	136.9	14.8	3.1	16.8	3.14	66.3	3.37
Clomazone 600 g/ha *fb* quizalofop-p-ethyl 37.5 g/ha	115.7	31.7	121.6	18.0	4.2	19.3	3.10	65.5	3.37
Oxyfluorfen 80 g/ha *fb* quizalofop-p-ethyl 37.5 g/ha	113.5	29.5	118.7	21.4	4.6	22.8	3.00	65.6	3.40
Sulfentrazone 192 g/ha *fb* quizalofop-p-ethyl 37.5 g/ha	104.7	26.7	112.3	21.5	6.1	29.1	2.75	55.2	3.01
Flurochloridone 625 g/ha *fb* quizalofop-p-ethyl 37.5 g/ha	121.3	34.2	131.0	16.8	3.7	18.9	3.13	66.4	3.40
Two hand weeding	118.7	32.9	125.8	13.2	2.5	16.1	3.45	71.9	3.25
Unweeded check	69.7	15.8	76.2	83.6	19.8	86.8	1.87	31.8	2.31
LSD (P=0.05)	17.5	5.9	7.6	7.9	2.1	8.4	0.46	NA	NA

Note: N- Nitrogen, P- Phosphorous, K- Potassium, NA- Not analyzed

CONCLUSION

Combination of pre and post-emergence herbicides (pendimethalin, fluchloridone, clomazone, oxyfluorfen with quizalofop-p-ethyl) resulted in higher nutrient uptake by the crop and lower removal by weeds apart from giving higher net returns (65503 to 66358 ¹ /ha) and B:C ratio (3.37-3.40) compared to pre-emergence herbicides alone.

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Evaluation of different post-emergence herbicides in groundnut

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Groundnut (*Arachis hypogaea* L.) occupies predominant position among oil seeds in the world in terms of acreage and total production.Weed menace is one of the major limiting factors in realizing potential productivity of groundnut grown in this season. When grown under assured irrigations, it provides favourable environment for fast growth of weeds which interfere with pegging, pod development and harvesting of groundnut besides competing for essential and scarce resources like moisture, nutrients and light. Several annual grasses and broadleaf weeds invade this crop causing heavy yield losses (17-84%). The pre-emergence herbicides like fluchloralin and pendimethalin were found to be effective in controlling the weeds in groundnut. However, in some situations where pre-emergence herbicides could not be used due to unavoidable conditions, the next alternate method of weed control seems to be inter cultivations and hand weeding only. In such conditions, timely hand weeding may not always be possible due to labour demand at critical stages. To overcome this situation, post-emergence herbicide application or combination of pre and post-emergence herbicide application is necessary for better control of weeds. The present investigation was carried out to evaluate the bio-efficacy of post-emergence herbicides in peanut.

METHODOLOGY

The field experiment was carried out at Agricultural Research Station, Kadiri, Andhra Pradesh (India) during three consecutive *Rabi* seasons of 2012-14 under irrigated conditions. The soil was sandy loam in texture (Typic haplustalfs) and neutral in reaction. The experiment contains eleven treatments with three replications in randomized block design. Peanut seed of Kadiri-6 cultivar was sown during first week of December at 30 x 10 cm spacing. Cultivation practices were employed as per the production recommendations to the domain. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at 20 kg N, 40 kg P_2O_5 and 50 kg K_2O /ha respectively. Data on weed growth, weed drymatter, yield attributes, yield were recorded and weed control efficiency (WCU) was calculated to find out the relative efficacy of different herbicides. Two herbicides, imazethaphyr and quizalofop ethyl were tried at 50, 75 and 100 g/ha as post -emergence (POE) at 20 days after sowing.

RESULTS

The total number of weeds at 45 and 80 DAS was significantly lower with weed free check which was on a par with pre-emergence (PE) application of pendimethalin at 1.0 kg/ha one hand weeding. Weed density due to quizalofop ethyl and imazethaphyr did not differ significantly irrespective of the doses. Significantly the lowest weed dry weight was recorded due to pre -emergence application of pendimethalin + one hand weeding, which was on a par with weed free check at 45 DAS and while, significantly varied at 80 DAS. Weed dry weight did not differ among quizalofop ethyl and imazethaphyr. Among the herbicidal treatments, highest weed control efficiency was recorded with pendimethalin + one hand weeding followed by application of pendimethalin as PE + quizalofop ethyl as POE and pendimethalin as PE + immazethaphyr as POE. Pod yield also higher with pre emergence application of pendimethalin at 1.0 kg/ha + one hand weeding which was significantly superior to all herbicidal treatments followed with above treatments. This inceased yields in this treatment was due to lowest crop weed competition which resulted in more number of pods per plant and hundred pod weight.

Table 1. Weed density, weed dry matter, weed control efficiency and yield of groundnut as influenced by different weed management practices

Treatment	Weed density (no/m^2)		Weed dry matter (g/m^2)		Weed control efficiency (%)	Pod Yield (t/ha)
	45 DAS	80 DAS	45 DAS	80 DAS	80 DAS	
Un weeded control	194 (14.0)	239 (15.5)	161.6 (12.7)	334.8 (18.3)	--	0.31
Weed free check	10 (3.2)	12 (3.5)	4.9 (2.3)	11.1 (3.4)	93.6	2.21
Pendimethalin at 1000 g/ha as pre-emergence + 1 HW	14 (3.8)	27 (5.2)	21.8 (4.7)	36.2 (6.1)	86.0	2.05
Quizalofop Ethyl at 50 g/ha at 20 DAS	52 (7.3)	68 (8.3)	85.6 (9.3)	171.0 (13.1)	66.8	1.50
Quizalofop Ethyl at 75 g/ha at 20 DAS	64 (8.0)	75 (8.7)	95.8 (9.8)	181.2 (13.5)	61.9	1.51
Quizalofop Ethyl at 100 g/ha at 20 DAS	61 (7.8)	76 (8.8)	90.2 (9.5)	166.4 (12.9)	60.2	1.52
Imazethapyr at 50 g/ha at 20 DAS.	75 (8.7)	88 (9.4)	99.2 (10.0)	131.8 (11.5)	65.9	1.592
Imazethapyr at at 75 g/ha at 20 DAS.	68 (8.3)	84 (9.2)	86.9 (9.4)	117.3 (10.9)	65.3	1.63
Imazethapyr at 100 g/ha at 20 DAS.	66 (8.2)	82 (9.1)	75.5 (8.7)	120.2 (11.0)	65.8	1.63
Pendimethalin at 1000 g/ha as pre-emergence + T4	24 (5.0)	34 (5.9)	25.0 (5.1)	35.4 (6.0)	83.6	1.74
Pendimethalin at 1000 g/ha as pre-emergence + T8	27 (5.2)	43 (6.6)	27.3 (5.3)	32.3 (5.7)	82.0	1.77
LSD (P=0.05)	1.6	2.4	2.5	2.4	--	0.20

Figures in parentheses indicate transformed values by square root transformation ("x+0.5)

CONCLUSION

Post -emergence application of either imazethaphyr or quizalofop ethy at 50-75 g/ha applied at 20 DAS was the most economic level for effective weed management in groundnut.

Development and evaluation of tractor drawn interculture implement with slim pneumatic tyres in groundnut

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Weed infestation in dryland crops is always severe. The intercultural operations in dryland crops aim at not only to remove the weeds but also to create soil mulch that would conserve soil moisture by reducing evaporation from the soil surface, improve infiltration of rain or surface water and reduce runoff. In drylands weeding is mostly done by *metlaguntaka* and *dantiguntaka* driven by a pair of bullocks in between rows and manual weeding within the rows in groundnut crop at 30-45 days after sowing in Anantapuram region. This process is time consuming, laborious and expensive also. The field capacity of this *metlaguntaka* is about 4-5 acres per day and also about 8-10 women labour are required for this purpose. The cost of weeding in groundnut comes to Rs. 400-450 per acre. Tractor operated implements can be used for inter-cultivation but these require wider row spacing and leaving of space at head lands for allowing tractor to operate and turn before entering into the rows. In order to overcome these difficulties, reduce the cost of weeding and human drudgery a tractor drawn inter-culture implement with slim pneumatic tyres was introduced at Agricultural Research Station, Anantapuram with an objective to develop suitable inter-culture implement slim pneumatic tyres to run in between rows of groundnut and to evaluate and test the implement in the groundnut field so as to increase the field capacity and perform timely weed control.

METHODOLOGY

The slim pneumatic tyres of 8.3" x 28" size were procured from local market and tractor drawn 8 row rigid tyneintercultivatorwas fabricated in agriculture engineering workshop at Agricultural Research Station, Anantapuram.The width of the slimpneumatic tyres is 22 cm which can be fitted to the rear wheels of the tractor. The tractor with slim pneumatic tyres can run in the groundnut field at a row spacing of 30 cm. Sweeps of V shape with 14 and 10 cm were fitted to the tynes. The implement with slim pneumatic tyreswas tested in groundnut field at 25 and 40 days of sowing using V shape sweeps of 14 and 10 cm respectively.Front tyres of tractor were reversed to get alignment of front and rear wheels of tractor in order to avoid trampling of in rows.

RESULTS

The results on the performance evaluation of tractor drawn intercultural implement with slim pneumatic tyres are given in Table 1. The depth of the operation was 8.0 cm in case of weeding with tractor drawn intercultural implement and it was 4.6 cm in weeding with danthulu. Crop damage was 2.1% in weeding with tractor drawn intercultural implement, while it was 3.4% in weeding with *danthulu*. Fuel required in weeding with danthuluwas through pair of bullocks, while tractor drawn intercultural implementrequired 2.0 liters diesel/hour for weeding operation (AICRPDA Annual Report 2008-09). The field capacity was 0.6 ha/hr in case of tractor drawn intercultural implement and it was 0.2 ha/hr in weeding with danthulu. Cost of the operation with tractor drawn intercultural implement was cheaper (Rs. 812 /ha) than weeding with *danthulu* (Rs. 1452 /ha). Further, tractor drawn implement performed weeding in eight rows with 95.4% weed control, while danthtulu covered weeding operation in 4 rows with 92.6% weed control.

Pod and haulm yield of 0.452 and 1.340 t/ha respectivelywas obtained with tractor drawn intercultural implement compared to weeding with danthulu (0.404 and 1.120 t/ha respectively). Due to high pod and haulm yield of groundnut with tractor drawn intercultural implementresulted in high gross, net returns and cost benefit ratio. Hence an amount of Rs. 640 /ha could be saved on cost of weeding with tractor drawn intercultural implementcompared weeding with danthulu.

Table1. Performance evaluation of tractor drawn intercultural implement with slim pneumatic tyres

Name of the parameter	Tractor drawn intercultural implement	Farmers practice (Weeding with *danthulu*)
Depth of the operation (cm)	8.0	4.6
Crop damage (%)	2.1	3.4
Fuel consumption (lt/hr)	2.0	-
Man power required /ha	0.42	2.8
Field capacity (ha/hr)	0.6	0.2
Cost of the operation (Rs/ha)	812	1452
No. of rows covered	8	4
Percent of weed control	95.4	92.6
Pod yield (t/ha)	0.45	404
Haulm yield (t/ha)	1.34	1120
Cost of cultivation (Rs/ha)	22,372	23,824
Gross Returns (Rs/ha)	25,700	22,660
Net Returns (Rs/ha)	3,328	-1164
C:B ratio (Rs/ha)	1.15	0.95

CONCLUSION

Weeding with tractor drawn intercultural implement with slim pneumatic tyres was effective for controlling weeds, improving pod and haulm yield and reducing cost of weeding in groundnut.

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Efficacy of herbicides alone and in combination with cultural methods on weed flora and yield of soybean

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Soybean is an important pulse as well as oilseed crop of the world and is known for its quality protein and oil. In Maharashtra, this crop is mainly grown in *Kharif* season facing a serious problem of weed growth. Among various factor responsible for low productivity of soybean, weed infestation during early stage of crop growth is one of the major factors which results in a loss to the extent of 79% (Reddy *et al.* 1990). A judicious combination of herbicide and cultural methods of weed control would not only reduce the expenditure on herbicides but also benefit to improve yield, hence the present investigation was taken.

METHODOLOGY

A field experiment was carried out during *Kharif* 2007-08 to 2009-10 at Zonal Agriculture Research Station, Central Vidarbha Zone, Yavatmal, Maharashtra to test the efficacy of different herbicides alone and in combination with cultural methods of weed management in soybean. Ten treatments, *viz*. fluchloralin PPI 1000 g/ha, imazethapyr 75 g/ha POE at 10 DAS, chlorimuron ethyl 10 g/ha POE at 10 DAS, fenoxaprop-p-ethyl at 75 g/ha + chlorimuron–ehtyl at 10 g/ha POE at 10 DAS, fluchloralin PPI 1000 g/ha+ one hoeing at 25 DAS, imazethapyr at 75 g/ha POE at 10 DAS + one hoeing at 25 DAS, chlorimuron-ethyl at 10 g/ha + one hoeing at 25 DAS, fenaxoprop-p-ethyl at 75 g/ha + chlorimuron-ethyl at 10 g/ha POE at 10 DAS + one hoeing at 25 DAS, weed free (2H + 2HW) and weedy check were arranged in a randomized block design with three replications. Soybean variety *'JS-335'* was sown at 45 cm row spacing on 29, 27 and 30 June in 2007, 2008 and 2009, respectively with recommended package of practices. The crop received recommended dose 30 kg N + 75 kg P_2O_5 /ha at sowing and data on weed growth, yield and economics were recorded.

RESULTS

Data pertaining to weed flora, yield and economics of soybean(Table 1) on pooled data (2007-08 to 2009-10) indicated that, the experimental field was infested with various weed species, consisting of broadleaved, grasses and sedges. Among the herbicides lowest weed density (18.6 /m²), dry matter of weeds (30.3 g/m) and highest weed control efficiency (79.7%) was observed under post-emergence application of imazethapyr 75 g/ha at 10 DAS + one hoeing at 25 DAS. Highest seed yield (1.71 t/ha), net monetary return (NMR, Rs. 23241 /ha) and B:C ratio (2.20) were under weed free, followed by integrated treatment, *i.e.* post- emergence application of imazethapyr 75 g/ha at 10 DAS + one hoeing at 25 DAS. These results are in conformity with the finding of Dhane *et al.* (2010).

Table 1. Weed growth, yield and economics of soybean as influenced by different weed control treatments (pooled data of 2001-08 to 2009-10)

Treatment	Weed density (no./m²) at 45 DAS	Weed dry matter (g/m²) 45 DAS	Weed control efficiency (%) 45 DAS	Seed yield (t/ha)	NMR (x 10³ Rs./ha)	B:C ratio
Fluchloralin PPI 1000 g/ha	7.90 (61.00)*	9.77(95.55)*	36.14	0.94	5.91	1.34
Imazethapyr at 75 g/ha POE at 10 DAS	6.07 (36.78)	7.88(58.99)	60.53	1.32	15.3	1.89
Chlorimuron-ethyl 10 g/ha - POE at 10 DAS	7.36 (54.00)	9.08 (85.22)	42.93	1.08	10.2	1.61
Fenaxoprop-P-ethyl 75 g/ha + chlorimuron ethyl 10 g/ha POE at 10 DAS	6.41 (40.77)	8.22(67.44)	54.95	1.269	13.8	1.79
Fluchloralin PPI 1000 g/ha + 1HW at 25 DAS	6.33 (41.89)	7.94 (67.33)	54.98	1.23	13.5	1.74
Imazethapyr 75 g/ha POE at 10 DAS + 1HW at 25 DAS	4.32 (18.59)	5.50 (30.33)	79.71	1.50	19.2	2.07
Chlorimuron-ethyl 10 g/ha + 1 HW at 25 DAS	5.88 (34.44)	7.52 (59.11)	60.52	1.37	16.8	1.98
Fenoxaprop-P-ethyl 75 g/ha + Chlorimuron–ethyl 10 g/ha POE at 10 DAS+ 1 HW at 25 DAS	5.28 (27.62)	7.01 (49.22)	67.10	1.47	17.5	1.97
Weed free (2H+2HW)	0.71 (0.00)	0.71 (0.00)	100	1.71	23.2	2.20
Weedy check	10.13 (102.67)	12.25(149.77)	---	0.60	-0.19	0.13
LSD (P=0.05)	0.87	1.41	---	0.08	2.00	--

*Value in parentheses are original. Data transformed to square root transformation. DAS: Days after sowing; HW: Hand weeding

CONCLUSION

Post-emergence application of imazethapyr 75 g/ha at 10 DAS + one hoeing at 25 DAS was the most effective for controlling weeds, improving yield and profitability of soybean.

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Evaluation of conventional and conservation planting techniques for wheat

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Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend Fiori & Paol.) is the most important cropping system which occupies about 18 M ha in Asia, of which 13.5 M ha are in Indo-Gangetic Plains. In addition, a sizeable rice–wheat system area (1.06 M ha) exists in Kymore Plateau and Satpura hills agro-climatic zone of Madhya Pradesh outside the Indo-Gangetic Plains (Yaduraju and Mishra, 2002). Wheat is the most traded crop of the world and is next to rice as a vital source of calories, has higher protein content than other major cereals. In the last century, wheat production was revolutionized in the world with the introduction of dwarfing gene 'Norin 10'. In India, a noteworthy increase in productivity of wheat has been achieved during Green Revolution Era due to introduction of high yielding short statured varieties, increased use of chemical fertilizers, better irrigation facilities, improved weed and pest control measures, etc. However, of late the total factor productivity is declining and farmers have to apply more inputs to acquire the same yield. These may be due to conventional agriculture practices which involve intensive mining of natural resources and continuous degradation of natural resources. Other key reason for low wheat productivity is late planting. Many farmers grow late-maturing, fine-grained basmati rice varieties and the long turn around time often reflects burning of previous crop residues, traditional crop establishment methods, too wet or too dry soil moisture problems and unavailability of mechanical power for ploughing at the sowing time, causing late planting of wheat. There is an average yield loss of 1.7% per day, when sown beyond 25 November due to high temperature above 30°C at the time of grain filling reduction in duration of grain filling and thus less grain weight due to the restraint of photosynthesis process and by inhibition of starch synthesis in the endosperm. However, weed infestation is a major concern to crop production under conservation agriculture. This prompted to conduct a field study to evaluate the effect of conventional and conservation planting techniques in wheat on cost of cultivation and weed management.

METHODOLOGY

A field study on wheat was carried out in the *Rabi* season of 2014 at Research Farm of ICAR-Directorate of Weed Research, Jabalpur. The soil of the experiment field was vertisol, pH 7.5, organic C 0.46%, available N 239 kg/ha, available P 16.6 kg/ha and available K 340 kg/ha. The study was carried out in large plots of 1 acre each. The treatments included two methods of wheat planting i.e. (i) Conventional Planting (ii) Conservation Planting [Direct seeded rice (ZT+R)-Wheat (ZT+R)-Greengram (ZT+R)]. Fertilizer application of (120 kg N + 60 kg P_2O_5) was done uniformly in all the two treatments. The total cost of inputs applied in all the two methods of planting were analyzed for comparison. Weed density and dry weight was recorded at 60 DAS.

RESULTS

The grain yield of wheat was higher under conservation planting method as compared to conventional method (Table 1). The results of the experiment showed that out of two planting methods, conservation planting method [Direct seeded rice (ZT+R)-Wheat (ZT+R)-Greengram (ZT+R)] was the most economical and resulted in better weed management. Under conservation planting method, saving of Rs. 1900/acre in cost of cultivation, and higher benefit: cost ratio (2.39) was noted in comparison to conventional planting. In respect of weed management also, conservation planting was better than conventional planting method. The total weed density and biomass were 52/m² and 20.7 g/m² under conservation planting method as compared to conventional planting method (76/m² and 36.1/m², respectively).

Table 1. Effect of different planting methods on weed density, weed biomass, yield and economics of wheat

Planting method	Weed density (/m²)	Weed biomass (g/m²)	Grain yield (t/acre)	Cost of cultivation (Rs/acre)	Gross returns	B:C ratio
Conventional	76	36.1	1.6	13505	23360	1.72
Conservation	52	20.7	1.9	11605	27740	2.39

Table 2. Cost of cultivation of different planting methods (Rs. per acre)

Operation	Conventional Planting	Conservation Planting
Grass cutter	600	-
Spreading of straw	-	500
Burning	400	-
Cultivator	1200	-
Rotavator	600	-
Sowing	600	1000
Seed price	1200	1200
Fertilizers	1980	1980
Irrigation	5000	5000
Herbicide	925	925
Harvesting	1000	1000
Total	13505	11605

Table 3. Weed density and weed dry biomass under conventional and conservation planting methods

Wheat planting method	*P. minor*		*Avena sp.*		*Chenopodium album*		*Cichorium intybus*		*Lathyrus sativa*		*Vicia sativa*		Total	
	No./m²	Dry Wt. (g/m²)	No./m²	Dry Wt. (g/m²)	No./m²	Dry Wt. (g/m²)	No./m²	Dry Wt. (g/m²)	No./m²	Dry Wt. (g/m²)	No./m²	Dry Wt. (g/m²)	No./m²	Dry Wt. (g/m²)
Conventional	42	20.2	10	7.0	12	4.5	8	3.2	4	1.2	-	-	76	36.1
Conservation	25	8.5	12	6.2	8	2.1	4	2.8	-	-	3	1.1	52	20.7

CONCLUSION

Conservation planting method (zero tillage with residue retention) appeared to be the most productive and economic planting method for wheat cultivation, and beneficial for weed management.

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Theme 3

Improving weed management in conservation agricultural systems

Productivity and profitability of maize under different tillage and weed management

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Maize is most sensitive to weeds competition during early stage. Several factors like weed flora, weed density and biomass, management practices and weather condition affect yield losses due to weeds in maize. Tillage practice is one of the factors which affect most to weed flora and their intensity in field crops. Generally, higher weed population is observed in zero and reduced tillage than conventional tillage. Therefore, a field study was conducted to see the effect of tillage management and weed control methods on productivity and economics of maize.

METHODOLOGY

A field experiment was conducted at Research Farm of Birsa Agricultural University during rainy season of 2013 and 2014 to find out the effect of tillage and weed control methods on productivity and economics of maize in maize-wheat system. The treatments comprised of five different tillage methods in main plots, *viz.* conventional tillage (CT) in both *kharif* and winter season (CT-CT), CT in *kharif* and zero tillage (ZT) in winter season (CT-ZT), ZT in both *kharif* and winter season (ZT-ZT), ZT in *kharif* and winter season along with crop residue (ZT-ZT+R) and ZT + crop residue in both *kharif* and winter season (ZT+R-ZT+R) and weed control methods in sub-plots viz., recommended herbicide (atrazine 1.0 kg/ha), integrated weed management (IWM) (intercropping of urdbean and pendimethalin 1.0 kg/ha (PE) *fb* manual weeding at 30 DAS) and weedy check. The experimental soil was poor in N (167 kg/ha) and P (19 kg/ha) and medium in K (187 kg/ha).

RESULTS

The field was infested with major weeds like *Cyperus rotundus*, *Stellaria media*, *Digitaria sanguinalis*, *Alternenthera sessils*, *Commelina nudifolia*, *Paspalam distichum*, *Ageratum conzoides* and *Celosia argensia*. CT-CT recorded less density of grassy and sedges weeds in maize at 60 DAS during 2013 while during 2014, least weed density was in ZT+R-ZT+R which was at par with ZT-ZT and ZT-ZT+R. Similar trend was observed in weed dry matter. Among weed control methods, least weed density and weed dry matter were recorded in IWM followed by atrazine. Non-significant difference was observed due to tillage management practices in maize grain and straw yield during 2013. However, during 2014 ZT+R-ZT+R recorded 86.8% higher grain (3.13 t/ha) and 97.0% higher straw (6.67 t/ha) yield compared to CT-CT. During 2013, higher net return (Rs. 29042/ ha) was recorded in CT-CT and during 2014 under ZT+R-ZT+R (Rs. 45652/ha). However, during 2013 B: C ratio was higher in ZT-ZT+R (1.29) and during 2014 in ZT+R-ZT+R (3.19). In case of weed management practices, grain yield was higher in IWM (2609 and 3098 kg/ha during 2013 and 2014, respectively). Similar trend was observed in net return with highest values under IWM (Rs. 31515 and Rs. 38583 per ha during 2013 and 2014, respectively), whereas, B: C ratio was highest in atrazine (1.48 and 2.73 during 2013 and 2014, respectively).

Table 1. Effect of tillage and weed control methods weed density, weed dry weight, yield and economics in maize

Treatment	Weed density (No./m^2)	Weed dry matter (g/m^2)	Grain yield (t/ha)		Net returns (Rs/ha)		B:C ratio	
			2013	2014	2013	2014	2013	2014
Tillage management								
CT-CT	14.0 (214)	9.01 (88.5)	2.41	1.67	29,042	12,943	1.01	0.61
CT-ZT	15.2 (254)	9.76 (104.2)	2.04	1.87	22,260	17,083	0.75	0.83
ZT-ZT	15.6 (281)	10.0 (115.9)	1.84	2.69	22,636	36,893	1.03	2.51
ZT-ZT+R	15.8 (289)	10.2 (119.8)	2.24	2.83	27,842	39,677	1.29	2.81
ZT+R-ZT+R	18.0 (365)	11.5 (148.5)	2.10	3.13	26,936	45,652	1.28	3.19
SEm±	1.4	0.86	0.17	0.43	3,630	7,598	0.16	0.47
LSD (P=0.05)	NS	NS	NS	1.41	NS	24,774	NS	1.52
Weed Control								
Atrazine	12.6 (161)	8.07 (66.1)	2.36	2.67	30,497	36,615	1.48	2.73
IWM	11.6 (135)	7.4 (55.2)	2.60	3.09	31,515	38,583	1.02	1.90
Weedy check	23.1 (546)	14.8 (224.9)	1.41	1.55	15,218	16,150	0.71	1.34
SEm±	0.9	0.8	0.12	0.30	2,591	4,470	0.09	0.26
LSD (P=0.05)	5.6	4.9	0.50	1.17	10,171	17,546	0.35	1.02
Interaction								
SEm±	0.9	0.8	0.12	0.30	2,591	4,470	0.09	0.26
LSD (P=0.05)	NS	NS	NS	NS	10,171	13,400	0.35	0.78

CONCLUSION

It can be concluded that zero tillage + residue and IWM may be followed to obtain higher productivity and profitability in maize under maize-wheat system.

Influence of cropping systems, crop residue incorporation and herbicides on weeds in jute

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Weeds are an integral part of crops and cropping systems. Their behaviour and composition often changes due to a change in selection pressure imposed by different agronomic practices such as tillage, fertilizer application, cropping sequence, etc. Different cropping systems require different management practices, which may help in disturbing the growing cycle of weeds (Locke *et al.* 2002). Jute is a cash crop of eastern India being grown in pre-*kharif* (summer) season followed by rice in a *kharif* (rainy) season and potato, pulses and mustard in *Rabi* (winter). Crop residues management is one of the aspects which improve soil quality and health and simultaneously influence weed seed germination and seedling emergence. The effects of crop residue on weed seed germination and population has been reported to be dynamic (Chauhan *et al.* 2006). Herbicides are widely used to manage weeds in jute; however, herbicides alone cannot provide effective and season long weed control. Thus, an integrated approach may be followed. However, meager of information is available on the activity of soil active herbicides and different crop residue present on the soil on weeds infestation, hence present study was conducted to evaluate the effect of different jute-based cropping systems, herbicides, and crop residue on weed flora in jute.

METHODOLOGY

A experiment was laid out during 2014 at Barrackpore, Kolkata in a split-spilt plot design with four cropping systems *viz.*, jute-rice-wheat, jute-rice-baby corn, jute-rice-garden pea, and jute-rice-mustard-mungbean in main plots; two residue management practices, *viz.* no-residue and residue (wheat 4 t/ha, corn 4 t/ha, garden pea 2 t/ha and mungbean 2 t/ha incorporated in their respective cropping system) in sub-plots; and three herbicide application treatments, *viz.* pretilachlor 1.0 kg/ha, butachlor 1.0 kg/ha and control (no herbicide) in sub-sub plots with three replications. All the crops were grown with recommended package and practices except mustard and mungbean, which were sown in zero tillage after harvest of rice and mustard, respectively. Observation on weeds was carried out at 25 days after sowing of jute using quadrate of size 50 × 50 cm. Weed data were transformed prior to analysis using square root transformation $\sqrt{(x+0.5)}$ to meet the assumptions of parametric analysis. Least significant difference (LSD) was worked out where the variance ratio (F-test) was significant at P d" 0.05.

RESULTS

A total of seven weed species were recorded in the experimental plots, which comprised of one sedge *Cyperus rotundas;* three grass weeds, *viz. Echinochloa colona*, *Eleusine indica*, and *Cynodon dactylon*; and three broad leaved weeds (BLW), *viz. Physalis minima*, *Portulaca oleracea* and *Trianthema portulacastrum.* Broad leaved weeds were predominant weeds (70.8%) followed by grass (22.8%) and *C. rotundus* (7%). Weed density in jute was significantly influenced by different cropping systems, residue management, and herbicides applications (Table 1). The jute-rice-mustard-mungbean system recorded the highest *C. rotundus* but the lowest broad leaved and total weed density. This may be due to zero tillage practiced in mustard and mungbean before the jute. Both jute-rice-babycorn and jute-rice gardenpea systems recorded the highest broad leaved population as well as total weed density, while, the jute-rice wheat system recorded the lowest grass weed density. Residue incorporation did not affect species wise weed density, but the total weed density was significantly lower under residue incorporation. Both, pretilachlor and butachlor were equally effective in controlling grassy weeds, but pretilachlor was found superior in controlling BLW over butachlor. The highest fibre yield (3.17 t/ha) was recorded with the jute-rice-garden pea system and the lowest in the jute-rice-wheat system. Although the residue incorporation did not influence fibre yield significantly, but numerically higher fibre yield was recorded in residue incorporation treatment. Significantly higher fibre yield of jute was recorded in both butachlor and pretilachlor as compared to control.

Table 1. Weed density and fibre yield under different cropping systems, residue incorporation, and herbicides application in jute

Cropping system	Weed density (no/m^2) at 25 d after sowing				Fibre yield (t/ha)
	Cyperus rotundus	Grassy weeds	Broad leaved weed	Total weed density	
Cropping system					
Jute-rice-wheat	2.28 (6.0)	2.36 (9.11)	7.17 (65)	7.57 (74.1)	2.88
Jute-rice-baby corn	2.72 (8.7)	3.24 (23.9)	8.82 (103)	9.56 (127.7)	3.02
Jute-rice-garden pea	1.89 (3.8)	3.22 (23.3)	8.51 (92)	9.24 (115.8)	3.17
Jute-rice-mustard -mung	5.08 (27.8)	3.39 (24.0)	4.90 (26)	6.11 (40.1)	2.94
LSD (P=0.05)	0.82	0.65	0.92	0.72	0.14
Residue management					
No Residue	3.07 (12.11)	3.21 (19.2)	7.74 (81)	8.57 (100.8)	2.91
Residue incorporation	2.91 (11.0)	2.90 (16.0)	6.96 (62.1)	7.67 (78.1)	3.08
LSD (P=0.05)	NS	NS	NS	0.69	NS
Herbicide application					
Pretilachlor @1.0 kg/ha	2.86 (11)	1.21 (2.58)	4.25 (19.3)	4.53 (21.9)	3.18
Butachlor @1.0 kg/ha	2.70 (8)	1.35 (2.60)	5.75 (35.4)	6.01 (38.0)	3.04
Control (no herbicide)	3.42 (14.8)	6.59 (47.6)	12.0 (160.8)	13.8 (208.3)	2.78
LSD (P=0.05)	NS	0.59	0.45	0.46	0.098

CONCLUSION

It is concluded that residue incorporation, application of butachlor / pretilachlor 1.0 kg/ha and following of jute-rice-mustard-mungbean system can effectively control the weeds in jute.

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Efficient weed management through conservation agricultural practices

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It is imperative to keep the crop fields free of weeds for better crop establishment. Manual weeding is increasingly becoming difficult task due to labour shortage and higher wages. Weed control using herbicides though effective and economical, may result in the development of herbicide resistant weeds and adversely affect the environment. Successful implementation of conservation agriculture (CA) depends largely on a good understanding of weed seed bank dynamics in soil and management practices. CA is the adoption of innovative crop rotation in which crops are planted in minimum, no-till, or drastically reduced tillage systems with some crop residue retention on the soil surface to reduce unproductive losses of water through evapo-transpiration and control weeds. Thus, CA is a concept for optimizing crop yields, economic and environmental benefits. CA has developed to a technically viable, sustainable and economic alternative to current crop production practices. It involves integration of minimal soil disturbance, residue retention and sensible/profitable cropping /farming systems.

Weed management through CA-based practices

Reduced or zero-tillage (ZT) creates unsuitable conditions for weed seed germination, so decreases the weed population (Benech-Arnold *et al*., 2000). About 50-60% less germination of weeds has been recorded in CA in rice-wheat systems because the soil is less disturbed than in tilled soils. CA practices like ZT and bed planting has resulted in 50-60% reduction in the population of *P. minor*. ZT can reduce weed problems and make management easier if weeds are managed effectively in the initial 2-3 years. As compared to the conventional tillage (CT) option, lower weed population and higher yields are observed when seeds are sown using zero-till in standing crop residue along with the application of herbicides in a proper combination, sequence, and rotation.

Deep and frequent tillage operations experience higher weed population by exposing old and dormant weed seeds to suitable climate for germination. CA based practices, that is, permanent no-till residue managed beds and double no-till (ZT direct seeded rice (DSR) - ZT wheat) reduced weed infestation in rice-based cropping systems of Eastern Uttar Pradesh (ISWS 2013). However, CT helps in breaking dormancy of weed seeds through O_2 diffusion into the soil, CO_2 removal from the soil, increased temperature, and increased nitrate levels. Whereas, minimum tillage or zero-tillage holds the weed seeds on the soil surface that increases the predation possibility of weed seeds. ZT-DSR with anchored residue was found to be the most effective in minimizing weed density, dry weight, and nutrient depletion by weeds. ZT rice–ZT wheat recorded higher growth, yield attributes, and yield of wheat due to higher weed control efficiency and better crop establishment over CT rice–CT wheat (Ravi Kumar 2014). Residue retention with *Trichoderma* application and residue retention alone was found more effective over the residue removal in minimizing the weed density and total dry weight in ZT wheat (Kumar, 2009).

Appropriate crop rotations and growing of cover crops during a fallow period helps to suppress the weed population by smothering and allelopathic effects. Growing green manures or cover crops planted in the minor season or as a relay crop efficiently suppresses weed growth. *Sesbania* as a cover crop significantly reduced sedges and broadleaved weeds in ZT direct seeded rice. Hobbs (2007) argues that CA reduces the problem of weeds by 50-60% by inhibiting weed germination through mulch or cover crops. However, according to Barberi (2002), physical effects of cover crops are the most important to reduce weed population. Cereals cover crops, like rye (*Secale cereale* L.) and oat (*Avena* sp.) can provide longer weed control throughout the season and also reduce available soil nitrogen. Rye has long been reputed to produce allelopathic compounds.

CONCLUSION

Adopting CA-based practices with minimum soil disturbances, need based residue retention and sensible crop diversification can be an efficient and sustainable weed management option for minimizing weed infestation, enhancing resource-use efficiency, and quality of the environment.

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Weed control efficiency and productivity of soybean-onion cropping system under tillage and weed management practices

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Soybean-onion system is more popular among the farmers in Maharashtra. Weeds are the major problem in most cropping systems and their control is essential for successful crop production. Tillage and herbicides are used for weed control, but the degree of control achieved may vary widely depending upon weed species present, soil type, climatic condition, crop growth, tillage method and cropping system. The present investigation was carried out to find out the effect of tillage and weed management on weed dynamics in soybean-onion system.

METHODOLOGY

An experiment was conducted at Mahatma Phule Krishi Vidyapeeth Rahuri during 2010-2012 to study the effect of conservation tillage and weed management in soybean-onion cropping system. The soils of the experimental field was clay loam in texture with low in available nitrogen (218.5 kg/ha), medium in available phosphorous (17.1 kg/ha) and high in potassium (493.6 kg/ha). The experiment was laid out in split plot design. All the treatments were same for *kharif* soybean and *rabi* onion. Main-plot treatments comprised of two tillage practices, *viz.* conventional tillage (one mould bold ploughing followed by two harrowing) and minimum tillage (rotavator once) and in sub-plot six weed management practices *viz*., weedy check, weed free, pendimethalin (PE/PPI) 1 kg/ha, quizalofop-ethyl (POE) 0.05 kg/ha (20 DAS/DAT), pendimethalin (PE/PPI) 1 kg/ha *fb* quizalofop-ethyl (PE/POE) 0.05 kg/ha (20 DAS/DAT), pendimethalin (PE/PPI) 1 kg/ha *fb* hand weeding (20 DAS/DAT). All other cultural practices followed in both soybean and onions were as per recommendation for this region.

RESULTS

Major weeds in the experimental site were: *Cyperus rotundus*, *Eragrostis major*, *Cynodon dactylon*, *Brachiaria cruciformis*, *Lactuca runcinata*, *Parthenium hysterophorus*, *Tridex procumbens*, *Euphorbia thymifolia*, *Digeria arvensis*, *Portulaca oleracea*, *Phyllanthus niruri*, *Euphorbia geniculata, Commelina benghalensis*, *Convolvulus arvensis* and *Physalis minima.* Lowest weed population was recorded in weed free and maximum under weedy check. However, among weed control treatment, minimum weed population was recorded in pendimethalin 1 kg/ha + hand weeding (20 DAS/DAT) at all growth stages in both crops and both tillage practices i.e., conventional and minimum tillage. Interaction effect between tillage and weed management practices was found significant at 90 DAS during both years of study. During first year of experiment lowest total weed intensity of 2.33 and 6.22/m^2 at 30 and 90 DAS, respectively was recorded under pendimethalin 1 kg/ha + hand weeding (20 DAS) in conventional tillage and during second year in minimum tillage (2.38 and 5.68/m^2 at 30 and 90 DAS, respectively). Similarly, highest weed control efficiency was recorded in pendimethalin 1 kg/ha *fb* hand weeding (20 DAS) in conventional tillage (95.3%) which was at par with pendimethalin 1 kg/ha *fb* hand weeding (20 DAS) in minimum tillage (92.9%) and pendimethalin 1 kg/ha *fb* quizalofop-ethyl 0.05 kg/ha (20 DAS) in minimum/conventional tillage. The overall reduction in weed population was higher under minimum tillage in comparison to conventional tillage.

Tillage practices could not influenced growth and yield attributes of soybean and onion. Weed management through pendimethalin 1 kg/ha *fb* hand weeding (20 DAS/DAT) recorded significantly higher growth and yield attributes of soybean and onion in comparison to weedy check. Similarly, soybean seed yield and onion bulb yield was not affected due to tillage practices. However, the highest soybean seed yield (2.31 t/ha) and onion bulb yield (303.02 t/ha) was recorded under pendimethalin 1 kg/ha *fb* hand weeding (20 DAS/DAT). Similar findings were also reported by Monsefi *et al*. (2013). Tillage management did not influence gross and net returns of soybean and onion, however, B:C ratio was higher in minimum tillage (1.65 and 3.28 for soybean and onion, respectively). In case of weed management, highest net return (Rs. 23,548 and 1,79,363/ha for soybean and onion, respectively) and B:C ratio (1.77 and 3.55 in soybean and onion, respectively) were recorded in pendimethalin 1 kg/ha *fb* one hand weeding (20 DAS/DAT).

CONCLUSION

Based on two years of experimentation, it could be concluded that following of minimum tillage (rotavator once) and weed management practice of pendimethalin (PE/PPI) 1 kg/ha + one hand weeding (20 DAS/DAT) found to be effective in controlling weeds and enhancing growth attributes, yield and economic returns in soybean-onion cropping sequence.

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Weed control efficiency and yield of rice under different tillage, crop establishment and weed management practices in rice-based conservation agricultural systems

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Development of crop management technologies and irrigation infrastructure in post-independence India has boosted the production of rice crop. For further productivity growth of rice and keeping pace with natural resource base, more emphasis is needed on conservation agriculture. However, weeds are the major biological constraints for the adoption of conservation agriculture (Jat *et al.* 2005). Weed control in conservation agriculture is a greater challenge than in conventional agriculture

. Hence, field experiments were carried out to assess the weed control efficiency and yield of rice under different tillage, crop establishment methods, and weed management in rice-based conservation agricultural systems.

METHODOLOGY

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu during *kharif* and *rabi* seasons of 2012-14. Transplanting after conventional tillage of *kharif* and *rabi* rice (T_1), transplanting after conventional tillage of *kharif* and under zero tillage of *rabi* rice (T_2), transplanting under zero tillage + crop residue for *kharif* and *rabi* rice (T_3), direct sowing after conventional tillage for *kharif* rice and *rabi* rice (T_4), direct sowing after conventional tillage *kharif* and under zero tillage *rabi* rice (T_5), and direct sowing under zero tillage + crop residue for *kharif* and *rabi* rice (T_6) were in main plots with rice-fallow-summer greengram under zero tillage. Recommended herbicides for transplanted rice – pre-emergence (PE) butachlor 1.0 kg/ha for *kharif* , PE pretilachlor 1.0 kg/ha for *rabi* and direct seeded rice - PE pretilachlor (S) 0.45 kg/ha (W_1); integrated weed management (transplanted rice - PE butachlor 1.0 kg/ha for *kharif*, PE pretilachlor 1.0 kg/ha for *rabi* and direct seeded rice - PE pretilachlor (S) 0.45 kg/ha + intercrop with green manure daincha incorporation and mechanical weeding at 35 DAS/T (W_2); and non-weeded check (W_3) were in sub-plots. Rice variety 'ADT (R) 45' for *kharif* 2012 and 2013 and 'CO (R) 50' during *rabi* 2012-13 and 2013-14 were grown. Greengram 'CO 6' was used during 2013 and 2014. The trial was layout in a strip-plot design with three replications.

RESULTS

Transplanted rice under conventional tillage in the CT-CT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* + inter crop with *dhaincha* incorporation and mechanical weeding at 35 DAT resulted in higher weed control efficiency (Table 1) at 30 and 60 DAT, and harvest during both the seasons. This might be due to lower weed emergence, weed density and weed dry weight as earlier reported by Mishra and Singh (2012). PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* and PE pretilachlor (S) 0.45 kg/ha for direct sown rice + intercrop with *dhaincha* incorporation and mechanical weeding at 35 DAS/T resulted in significantly higher grain yield of rice in both *kharif* and *rabi* seasons. This could be attributed to higher number of productive tillers per unit area, filled grains/panicle and 1000 grain weight and ultimately higher yield of rice.

Table 1. Tillage, crop establishment, and weed management methods on weed control efficiency (WCE) and rice grain yield in rice-based conservation agricultural systems

Treatment	Weed control efficiency (%)						Rice yield (t/ha)			
	Means of *Kharif* 2012 and 2013			Means of *Rabi* 2012-13 and 2013-14						
	30 DAS/T	60 DAS/T	At harvest	30 DAS/T	60 DAS/T	At harvest	*Kharif* 2012	*Rabi* 2012-13	*Kharif* 2013	*Rabi* 2013-14
Crop establishment and tillage										
T_1- TR (CT-CT -ZT)	90.9	84.2	84.8	87.3	83.3	83.8	5.10	5.59	5.05	5.43
T_2- TR (CT-ZT -ZT)	87.3	78.3	80.6	83.6	76.6	77.7	4.93	5.19	4.81	5.03
T_3- TR (ZT+CR - ZT+CR-ZT)	80.8	71.7	72.2	80.8	70.8	70.9	4.39	4.53	4.43	4.66
T_4- DSR (CT-CT -ZT)	87.1	78.3	80.0	84.8	80.1	79.0	4.67	4.78	4.73	4.97
T_5- DSR (CT-ZT -ZT)	78.4	65.5	69.4	78.8	68.0	64.2	4.17	4.15	4.13	4.22
T_6- DSR (ZT+CR - ZT+CR-ZT)	77.1	61.0	62.6	70.2	55.7	56.3	3.90	3.10	3.70	3.22
							0.30	0.33	0.28	0.39
Weed management methods										
W_1-(Rec. Herb)	79.1	65.3	67.9	76.2	64.7	63.1	4.93	4.87	4.86	5.02
W_2-(IWM)	88.0	81.0	81.9	85.7	80.2	80.9	5.46	5.78	5.56	5.82
W_3-(UW)	-	-	-	-	-	-	3.19	3.02	3.01	2.93
							0.33	0.39	0.31	0.44

CONCLUSION

In the present study, transplanted rice under conventional tillage in the CT-CT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* + inter crop with *Sesbania* incorporation and mechanical weeding at 35 DAT recorded higher weed control efficiency, higher growth attributes and remobilization of photosynthates from vegetative organs to reproductive parts (grains), ultimately enhancing the grain yield.

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Weed management in high density planting system of cotton

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Cotton (*Gossypium hirsutum* L.) is an important commercial crop of India. Since it is a crop of rainy season, weeds are major limiting factor in its production. Losses caused by weeds in cotton ranges from 50-85%, depending upon the nature and intensity of weeds. Weeds primarily compete for nutrients, moisture, and sunlight during the early crop growth period. In high density planting weed control during initial period is needed to suppress weeds in later stages of plant growth. For successful weed management requires advance planting and timely execution. Any delay in an application may reduce weed control, and increase herbicide use rates and herbicide costs. Hence, the study was carried out to find out suitable herbicides alone and in combination with cultural practices for proper and timely control of weeds under high density planting of cotton.

METHODOLOGY

A field investigation was conducted at Rainfed Cotton Research Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during 2013-14 to study the efficacy of pre- and post- emergence weedicides on weed control efficiency and seed cotton yield under high density planting system (HDPS) of cotton. The experiment was laid out in a randomised complete block design with eight treatments replicated three times. Cotton seed variety 'AKH 081' was sown at a spacing of 60 x 10 cm (1,66,000 plants/ha) on broad bed and furrow system with RDF 60:30:30 NPK kg/ha. Seasonal rainfall was 560 mm. The dry spell occurred after 9th September 2014 onwards.

RESULTS

In the field *Commelina benghalensis*, *Cynodon dactylon*, *Cyperus rotundus*, *Digera arvensis*, *Parthenium hysterophorus* and *Celosiaargentea* were dominated weeds. The results showed lowest count of grassy and broad leaved weeds, and weed dry weight under directed spraying of glyphosate at 40-45 DAS. The highest population of weeds and dry weight was in the weedy check. The weed control efficiency was maximum in hoeing at 20-25 DAS *fb* glyphosate 1.50 kg/ha at 45 DAS (90.8%) followed by hoeing at 20-25 DAS *fb* glyphosate 1.25 kg/ha at 45 DAS (90.4%). Significantly highest seed cotton yield was recorded in weed free check (1750 kg/ha) followed by pendimethalin 38.7 CS at 1.25 kg/ha *fb* hoeing at 30 DAS and one hand weeding at 45 DAS (1627 kg/ha). Similar results were also reported by Pawar *et al.* (2000). Gross and net returns were significantly higher in weed free check, whereas B: C ratio in pendimethalin 1.25 kg/ha *fb* hoeing at 30 DAS and one hand weeding at 45 DAS (2.27).

Table 1. Weed density, weed dry weight, weed control efficiency (WCE), seed cotton yield (SCY) and economics as influenced by weed management under HDPS of cotton

Treatment	Grassy weeds density (no./m^2)	Broad leaved weeds density (no./m^2)	Total density (no./m^2)	Dry weight of weeds (g/m)	Weed control efficiency (%)	SCY (t/ha)	Net returns (Rs/ha)	B:C Ratio
Pendimethalin 1.25 kg/ ha *fb* hoeing at 30 DAS and one hand weeding at 45 DAS	13.0	3.6	16.3	24.3	83.9	1.62	36,804	2.27
Quizalofop ethyl 0.075 kg /ha at 20-25 DAS *fb* hoeing at 45 DAS	24.7	8.0	32.7	52.6	65.3	1.29	25,656	1.96
Pyrithiobac sodium 0.075 kg/ ha at 20-25 DAS *fb* hoeing at 45 DAS	18.3	12.0	30.3	51.0	66.3	1.17	20,643	1.77
Hoeing at 20-25 DAS *fb* glyphosate 1.50 kg/ha at 45 DAS	8.0	2.7	10.7	13.9	90.8	1.56	28,615	1.83
Hoeing at 20-25 DAS *fb* glyphosate 1.25 kg/ha at 45 DAS	6.7	4.3	11.0	14.6	90.4	1.55	28,954	1.85
Hoeing at 20-25 DAS *fb* glyphosate 1 kg/ha at 45 DAS	7.0	4.7	11.7	16.2	89.3	1.45	25,075	1.75
Weed free check	11.3	3.3	14.7	22.0	85.5	1.75	39,410	2.25
Weedy check	54.7	33.3	86.0	151.4	-	0.25	-5,618	0.65
CD (P=0.05)	5.1	4.7	7.5	10.8	-	0.25	-	-

CONCLUSIONS

It can be concluded that pre-emergence application of pendimethalin 1.25 kg/ ha *fb* hoeing at 30 DAS and one hand weeding at 45 DAS can be used for effective weed management and higher return in high density planting of cotton.

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Effects of wheat residue and cultivation systems on weed population in sugarbeet in rotation with wheat

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In the recent two decades, conservation agriculture (CA) has been playing an important role in sustainability of crop production and has become a fast growing production system. The total area under CA in 2015 is estimated to be 157 million hectares (FAO, 2015). Minimum soil disturbance, crop rotation and retention of crop residue on the soil surface are three basic factors in CA; however, the main barriers to the global adoption of CA practices continue to be: knowledge on how to do it (Friedrich *et al*. 2012) and what are the effects of these changes on different components (for example, weeds) of agricultural systems. In addition, research is limited on effective weed management programs in conservation tillage systems for sugar beet. Weed population changes in wheat-sugar beet rotation with different crop residue amounts in two CA and conventional agricultural systems was the objective of this experiment.

METHODOLOGY

A two-year experiment was conducted in a field of Iranian Research Institute of Plant Protection, Tehran, Iran in 2012 and 2013. The study was arranged in a split-plot experiment based randomized complete block design with four replications. Treatments were tillage system viz., zero tillage (ZT) and conventional tillage (CT) in main-plots and wheat residue levels viz., 0, 1, 3 and 5 t/ha in sub-plots. Wheat was planted in autumn of during 1st year and weeds in the crop was controlled by mesosulfuron + iodosulfuron (400 g/ha, WG 6%). In the second year, harvested field divided in two sections (for ZT and CT systems in main-plots) and different amounts of wheat residues retained on the soil surface of 60 m^2 plots and then, sugar beet ('Rasul' with 100,000 plants/ha) was planted directly in old wheat ridges or indirectly in ploughed plots and new ridges. Weeds were controlled chemically (glyphosate 5 l/ha, SL 41%) in conservation treatments before sugar beet planting and again at 2-4 sugar beet leaf stages in all treatments with phenmedipham + desmedipham + ethofumesat (3 l/ha, EC 18%) and haloxyfop-R- methyl ester (1.5 l/ha, EC 10.8%) for control of broad and narrow leaf weeds, respectively. Weed population (including weed density and biomass at 30 days after herbicide application) and sugar beet root yield (in the end of season) evaluated in different plots. Data were analyzed by SAS and means were compared by Duncan's new multiple range test.

RESULTS

Results indicated lower weed pressure in the first-year in moldboard and chisel plough systems compared with the no-till system. Comparison of two agricultural systems (CA and conventional agriculture) indicated that weed density and biomass were more in CA (Fig 1). Higher weed pressure in the no-till system resulted from no mechanical preparation of experimental field before sugar beet planting. Sugar beet root yield was significantly affected by tillage (*P* d" 0.05) when

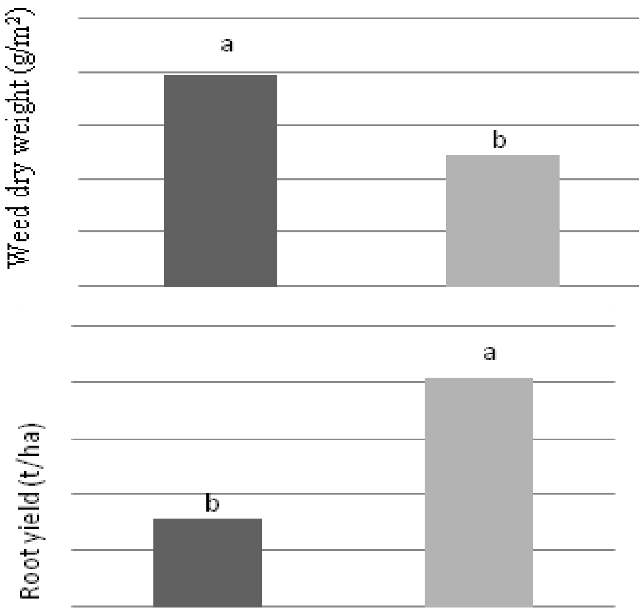

Fig 1. Weeds dry weight and sugarbeet root yield in conservation (CA) and conventional (CO) systems (pd"0.05)

averaged across weed management treatments (Fig 1). Weak sugar beet germination and growth in the first year of CA, its structural canopy and potential to compete with weeds were reasons of low root yield of sugar beet in CA. Our study indicated that weeds dry matter decreased with increasing of wheat residue on the soil surface. Crop residue has effect on seed germination by changing of soil temperature, water and nutrition. In addition, it will build a mechanical layer in top of the soil and weed seedling cannot emerge.

Weed management and conservation practices in rice-wheat cropping System

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Due to growing resource degradation problems worldwide, conservation agriculture (CA) has emerged as an alternative strategy to sustain agricultural productivity. The principles of CA in the rice-wheat cropping system may include reduced or no tillage with residue recycling and green manuring, etc. The practice of direct seeding of rice and wheat by zero till along with residue retention have emerged as the two cardinal principles of CA. The rice-wheat rotation is one of the most important cropping systems for food self-security in the world. The productivity of the system is decreasing due to pathogens, multi nutrient deficiencies, and weed flora besides increasing soil health problems. The use of green manuring crops having bio-herbicidal characteristics or weed smothering capability would have the additional benefits of adding biomass to soil. *Sesbania*, which is known to fix a large amount of atmospheric nitrogen, has been tried as pre rice legume as a source of N (Ladha *et al*. 2000). The present experiment was underway to see the effect of CA based cropping systems on rice and wheat along with weed management practices on yield of rice and wheat and weeds growth.

METHODOLOGY

A field experiment was conducted during *Rabi* 2013 and *Kharif* 2014 to develop an appropriate establishment method in the rice-wheat cropping system along with weed management practices under an irrigated ecosystem. The experiment was laid out in a strip-plot design comprising five establishment methods in main-plots and three weed control methods in sub-plots (Table 1). Wheat variety 'UP 2572' was sown on November 8, 2013 while rice variety 'Pant Dhan 12' was sown on June 20, 2014 in DSR and ZTR plots, wherever transplanting was carried out on July 12, 2014. Post-emergence herbicide clodinafop 15% + MSM (1%) was applied on December 16, 2013 in wheat while in rice, bispyribac-Na was sprayed on July 7, 2014 as early post-emergence in DSR and ZTR and on August 4, 2014 in transplanted rice.

RESULTS

CA had significant impact on weed dry matter as well as grain yield of rice and wheat crop. The results revealed that among the different establishment methods highest grain yield of wheat was recorded with DSR (ZT) + R - wheat (ZT) + R-*Sesbania* (ZT) while the yield of rice was higher under the conventional method. During *rabi*, maximum wheat yield was recorded zero tillage with residue retention in both rice and wheat crop and *Sesbania* brown manuring. Significantly less density and dry matter accumulation of weeds and maximum grain yield of both the crops was obtained in IWM. Highest net returns and B:C ratio in wheat was recorded in TPR (CT) - Wheat (ZT) - *Sesbania* (ZT) whereas in rice it was recorded in TPR (CT) -Wheat (CT). IWM (herbicide + one HW) practice recorded the highest net return and benefit cost ratio in both the crops.

Table 1. Effect of rice establishment methods and weed management on yield and economics of rice and wheat in rice-wheat cropping system

Treatment	Wheat			Rice		
	Grain yield (t/ha)	Net returns (Rs/ha)	B:C ratio	Grain yield (t/ha)	Net returns	B:C ratio
Establishment System						
TPR(CT)-Wheat (CT)	4.2	53,850	2.8	4.6	30,060	1.9
TPR(CT)-Wheat (ZT)-Sesbania (ZT)	4.1	59,000	3.2	4.5	28,700	1.9
DSR(CT)-Wheat (CT)- Sesbania (ZT)	4.0	51,450	2.7	2.4	51,400	1.2
DSR(ZT)-Wheat (ZT)- *Sesbania* (ZT)	3.8	49,600	2.8	1.7	-1,880	0.9
DSR(ZT)+R-Wheat (ZT)+R -*Sesbania* (ZT)	4.7	39,000	2.5	2.4	7,640	1.3
LSD (P=0.05)	3.5	-	-	0.4	-	-
Weed Management						
Clodinafop (15 %) + MSM (1%) @ 60+4 g/ha	4.5	60,650	3.1	3.1	11,785	1.4
IWM (Herbicide + one hand Weeding)	4.8	65,250	3.1	4.3	25,605	1.8
Unweeded	3.2	39,300	2.4	1.9	-2,660	0.9
LSD (P=0.05)	0.4	-	-	0.1	-	-

TPR- transplanted rice, CT- conventional tillage, ZT- zero tillage, DSR- direct seeded rice, R- residue retention, IWM- integrated weed management, MSM- metsulfuron-methyl

CONCLUSION

Among the different establishment methods in the rice-wheat cropping system, the highest grain yield of wheat was recorded under DSR (ZT) + R- Wheat (ZT)+ R- Sesbania (ZT) while in rice it was with TPR (CT)-wheat (CT). Among the weed management practices, IWM was found superior over the other treatments.

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Tillage and weed management practices in the maize-sunflower cropping system

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Weed control can become a limiting factor in crop production when tillage is decreased. Changes in tillage method can affect weed population dynamics, including weed seed distribution in the soil. Managing weeds in reduced-tillage is a challenge for crop growers. Once no-till is established, herbicide costs generally decreased and become competitive with conventional systems. Crop rotation can also provide an opportunity to manage weeds effectively. The optimum tillage methods combined with effective weed control method is to be identified for efficient weed management. Hence, a field experiment was conducted to develop information on weed population dynamics under tillage and weed management methods.

METHODOLOGY

An experiment was laid out in a split-plot design during *kharif* 2013 and *rabi* 2013-14 where main plot treatments consisted of four tillage methods [zero tillage - zero tillage (ZT-ZT), zero tillage - conventional tillage (ZT-CT), conventional tillage- zero tillage (CT-ZT), conventional tillage-conventional tillage (CT–CT)] and two weed management practices for maize (atrazine 0.5 kg/ha + hand weeding at 45 DAS) and for sunflower (Pendimethalin 1.0 kg/ha + hand weeding at 45 DAS) in sub-plots.

RESULTS

The weed flora of the experimental field was grouped into grasses, sedges and broad leaved weeds. In maize crop, major broad leaved were: *Trianthema portulacastrum*, *Digera arvensis*, *Amaranthus viridis*, *Cleome gynandra*, *Parthenium hysterophorus* and *Datura metal*, and grassy weeds were *Dactyloctenium aegyptium*, *Echinochloa colona*, *Setaria verticillata* and *Dinebra retroflexa*. In sunflower crop, the major broad leaved weeds were *Trianthema portulacastrum*, *Digera arvensis*, *Amaranthus viridis*, *Portulaca oleracea*, *Corchorus olitorius* and *Parthenium hysterophorus*, and grassy weeds were *Dactyloctenium aegyptium* and *Echinochloa colona*. *Cyperus rotundus* was the only predominant sedge weed observed in both the crops.

In maize, yield attributes like cob length, cob girth, cob weight, number of rows/cob,

no. of grains/row and 100 grain weight, grain yield (5.03 t/ha) and B: C ratio (2.31); and in sunflower, yield attributes like capitulum weight, number of seeds per capitulum, yield (2.15 t/ha) and B: C ratio (2.07) were significantly higher in conventional tillage - conventional tillage (CT-CT). Among weed management practices, highest maize grain yield (5.29 t/ha) and B: C ratio (2.41) was recorded in preemergene application of atrazine at 0.5 kg/ha + HW at 45 DAS. Similarly in sunflower, highest seed yield (1.99 t/ha) and B: C ratio (1.75) was recorded in pendimethalin 1.0 kg/ha + HW on 45 DAS.

Table 1. Weed growth, yield and economics of maize and sunflower as influenced by tillage and weed management practices

Treatment	Maize (*kharif* 2013)					Sunflower (*rabi* 2013-14)				
	Weed density (No/m^2)	Weed dry weight (g/ m^2)	WCE (%)	Yield (t/ha)	B:C ratio	Weed density (No/m^2)	Weed dry weight (g/ m^2)	WCE (%)	Yield (t/ha)	B:C ratio
Tillage methods										
ZT-ZT	5.7 (32.6)	4.2 (16.0)	68.4	4. 26	2.13	8.2 (65.7)	5.8 (31.3)	46.0	2.76	1.75
ZT-CT	5.0 (25.3)	4.9 (22.0)	56.5	4.06	2.03	6.5 (40.3)	4.5 (18.6)	67.9	2.97	1.88
CT-ZT	5.3 (29.1)	4.7 (19.9)	60.9	4.74	2.17	7.2 (49.7)	4.8 (20.8)	64.1	2.41	1.85
CT-CT	4.2 (18.0)	3.7 (12.0)	76.3	5.03	2.31	5.6 (29.0)	4.1 (14.9)	74.3	3.06	2.07
CD (P=0.05)	0.42	0.32	-	0.53		1.07	0.38	-	0.25	
Weed management practices										
Hand weeding twice at 25 & 45 DAS	5.0 (25.0)	5.1 (23.7)	53.3	5.04	1.91	7.4 (52.3)	4.3 (16.9)	70.85	3.43	1.45
Herbicide + 45 DAS	4.3 (19.0)	4.5 (18.5)	64.4	5.29	2.41	5.0 (22.7)	3.8 (12.5)	78.40	3.53	1.75
Weedy check	5.9 (34.7)	7.3 (50.6)	-	3.01	1.48	14.1 (196.0)	7.7 (57.9)	-	2.618	1.05
CD (P=0.05)	0.3	0.4	-	0.51		0.7	0.4	-	0.28	

Weed data subjected to square root transformation and figures in parenthesis are means of original values

CONCLUSION

It is concluded that conventional tillage with integrated weed management practices was most effective in controlling weeds, and achieving higher yield and profitability in the maize-sunflower cropping system.

Impact of tillage and weed management on weed control efficiency and yield of summer cowpea

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Cowpea (*Vigna unguiculata* L.) is one of the important legumes in Maharashtra with an area of 11,800 ha and an average productivity of 390 kg/ha (Anonymous 2009). In summer seasons, cowpea is infested by a number of weed species that compete with the crop right from emergence to harvest for growth resources and thus affecting crop yield adversely. Therefore, a good weed management practices involving locally methods and good cultural practices can be used for effective control of weeds. Summer cowpea is grown as a catch crop in Konkan region irrigated areas. Similarly, tillage practices also affect weeds infestation in summer cowpea. Therefore, present study was conducted to see the effect of tillage management and weed control methods in summer cowpea.

METHODOLOGY

An experiment was conducted on coastal lateritic soil of Konkan during the summer season of 2011 at Agronomy Farm of College of Agriculture, Dapoli, Ratnagiri. The experiment was laid out in a split plot design with three replications. The main plot treatments consisted of tillage systems, *viz.* zero tillage, strip tillage, minimum tillage, conventional tillage and the sub-plots weed management viz., weedy check, weed-free check [hand weeding at 15, 30, and 45 days after sowing (DAS)], one hand weeding at 25 DAS, pre-emergence (PE) application of pendimethalin 1.0 kg/ha, pendimethalin 1.0 kg/ ha + hand weeding at 25 DAS, and integrated weed management (IWM) i.e., pendimethalin 1.0 kg/ha *fb* hoeing at 20 DAS + hand weeding at 25 DAS. Cowpea variety '*Konkan Sadabahar'* was used in the experimental. Tillage and weed management practices were followed as per the treatment. Fertilizers were applied uniformly through urea and single superphosphate at 25 kg N, and 50 kg P_2O_5/ha. Data on weed growth, yield performance, and economics were recorded.

RESULTS

In summer cowpea, the major weeds observed during the study were: *Ludwigia octovalvis*, *Mimosa pudica*, *Cyperus iria*, *Alternanthera sessilis*, *Ageratum conyzoides*, *Silosia argentia and Portulaca oleraceae*. Tillage treatments significantly influenced the population and dry matter of weeds. Among the different tillage systems, conventional tillage recorded significantly lower weed density and dry matter of weeds over rest of tillage systems; however minimum tillage was at par. The highest weed control efficiency was recorded in conventional tillage followed by minimum and strip tillage. The lowest weed index value was recorded in conventional tillage followed by minimum and strip tillage. This is obviously due to efficient control of weeds under conventional and minimum tillage systems that provided better soil physical environment in rhizosphere. Similar results were also reported by Ikuenobe *et al.* (1994). Among tillage, maximum B: C ratio (1.46) was found in minimum tillage followed by conventional tillage (1.40).

Table 1. Weed growth, yield and economics of summer cowpea as influenced by different practices

Treatment	Weed density (0.25 m^2)	Weed dry matter (g/0.25m^2)	Weed control efficiency	Weed index	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	B:C ratio
Tillage systems								
Zero tillage	18.6 (4.0)	19.8 (4.2)	28.5	35.0	720	1459	25,137	1.20
Strip tillage	17.0 (3.8)	17.3 (3.9)	37.3	30.8	766	1674	25,439	1.27
Minimum tillage	13.1 (3.3)	12.2 (3.3)	55.8	26.7	812	1906	23,559	1.46
Conventional tillage	12.0 (3.1)	11.3 (3.2)	59.0	25.8	822	1971	24,843	1.40
CD (P=0.05)	- (0.2)	- (0.2)	-	-	44	208	-	-
Weed management								
Weedy check	41.8 (6.5)	27.4 (5.2)	-	67.8	356	840	18,389	0.82
Weed-free check	0.7 (1.0)	0.8 (1.1)	100	-	1110	2551	30,376	1.54
Hand weeding at 25 DAS	13.8 (3.7)	16.5 (4.0)	39.6	39.7	668	1487	23,961	1.18
Pendimethalin 1.0 kg/ha	14.9 (3.8)	19.6 (4.4)	28.5	55.2	496	1145	20,093	1.04
Pendimethalin 1.0 kg/ha + hand weeding at 25 DAS	10.40 (3.2)	13.8 (3.7)	49.5	14.0	952	2071	26,623	1.51
IWM (Pendimethalin 1.0 kg/ha *fb* hoeing at 20 DAS + hand weeding at 25 DAS)	9.6 (3.1)	12.8 (3.6)	83.2	0.5	1100	2421	29,026	1.60
CD (P=0.05)	- (0.2)	- (0.2)	-	-	40	137	-	-

Figures in the parentheses are square root transformations

Similarly, weed management treatments significantly influenced the density and dry matter production of weeds. Among weed management treatments, the lowest weed density (1.02/m^2) was observed under the weed-free check (hand weeding at 15, 30, and 45 DAS) followed by IWM (pendimenthalin 1.0 kg/ha *fb* hoeing at 20 DAS + hand weeding at 25 DAS). Similar trend was recorded in weed dry weight. These results are in conformity with the findings of Hussaini and Lado (2010). Maximum weed index (67.8%) was recorded in the non-weeded control and lowest in IWM (14.0%). The highest grain yield (1110 kg/ha) was recorded in weed-free and which was at par with IWM (1100 kg/ha) and lowest yield (356 kg/ha) in weedy check. The maximum stover yield (2551 kg/ha) was recorded in the weed-free and lowest in weedy check (840 kg/ha). The maximum B: C ratio (1.60) was observed with IWM followed by weed-free check (1.54).

Planting techniques on weeds dynamics and productivity of maize-wheat cropping system

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Maize (*Zea mays* L.)-wheat (*Triticum aestivum* (L.) emend. Fiori & Paol.) is the most dominant cropping system in the State of Himachal Pradesh. The productivity of this existing cropping system in small, undulating and marginal farmer's field is very low besides low fertility status of the soil. Weeds that grow with crops deplete considerable amount of nutrients, soil moisture and compete for other resources thereby resulting poor crop growth and production. Crop losses due to weed competition throughout the world as a whole, are greater than those resulting from combined effect of insect-pests and diseases (Hassan *et al.* 2005). Tillage practices play a vital role on crop establishment, growth and development and can have a major impact on the distribution of the weed flora and weed seeds in soil, because soil disturbance regimes are related to seed distribution and viability (Lutman *et al.* 2002).Keeping in view the above facts and needs of the farmers, the present study was undertaken.

METHODOLOGY

The fixed layout experiment was carried out at the research farm of the CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur ($32^0 6'$ N latitude and $76^0 3'$ E longitude) during *kharif* 2009–*rabi* 2011 to elucidate the effect of different planting techniques on weed dynamics and productivity of maize-wheat cropping system. The experiment was laid out in strip plot design with 16 treatment combinations. Maize planting techniques was laid out in main-plots viz., sowing by power tiller operated zero till-drill, power tiller operated multi-crop planter, manually operated seed drill and conventional method (sowing behind the hand plough). Similar planting techniques were used in wheat in sub-plots during *rabi* season.

RESULTS

Major weeds in maize were: *Azeratum conyzoides*, *Commmelina benghalensis* and *Polygonumalatum (broad-leaved)*, and *Echinochloa colona*, *Penicum dichotomiflorum*, *Eleusine indica* and *Digitaria sanguinalis (grassy weeds); and in wheat Vicia sativa* and *Anagallis arvensis (broad leaved)*, and *Lolium temulatum*, *Phalaris minor* and*Avena ludoviciana (grassy weeds)*.

The results revealed that planting techniques in *kharif* and *rabi* season didn't influence the weed population, weed dry weight and green cob yield of maize. While, multi crop planter, manual seed drill and conventional techniques in *rabi* season resulted in significantly lower weed count and weed dry weight of broad leaved weeds as compared to zero till seed drill in wheat crop. However, higher weed population under zero till seed drill did not showed any significant decrease in the yield of wheat. Comparable yields of maize and wheat crop were recorded in zero till seed drill and other planting techniques.

Table 1. Effect of planting techniques on weed count and weed dry weight in maize and wheat (2 years pooled data)

Treatment	Maize					Wheat				
	Weed count (No./m^2)		Weed dry weight (g/m^2)		Green cob yield (t/ha)	Weed count (No./m^2)		Weed dry weight (g/m^2)		Grain yield (t/ha)
	Broad leaved	Grassy	Broad leaved	Grassy		Broad leaved	Grassy	Broad leaved	Grassy	
In kharif (rice)										
Zero till seed drill	19.0 (362.0)*	7.4 (57.0)	8.2 (67.2)	4.9 (25.0)	6.49	5.7 (34.8)	6.3 (40.2)	2.5 (7.2)	4.9 (23.8)	3.58
Multi-crop planter	20.3 (415.7)	7.7 (61.7)	8.0 (66.2)	4.4 (20.3)	7.40	6.2 (41.3)	7.1 (52.0)	2.6 (7.2)	5.0 (25.9)	3.54
Manual seed drill	18.7 (350.7)	8.8 (80.0)	6.8 (45.8)	5.0 (25.9)	8.06	5.9 (41.0)	7.1 (53.3)	2.4 (6.6)	4.7 (22.4)	3.58
Conventional tillage	19.4 (377.0)	7.0 (50.0)	8.0 (64.7)	4.4 (19.8)	7.39	6.5 (48.8)	6.4 (43.8)	2.7 (8.4)	4.7 (23.7)	3.67
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
In rabi (wheat)										
Zero tillage	19.1 (368.3)	7.8 (64.3)	7.5 (56.0)	4.8 (24.5)	7.20	9.4 (91.0)	6.8 (46.8)	4.2 (18.7)	4.8 (24.2)	3.30
Multi-crop planter	19.6 (388.0)	8.0 (66.7)	8.0 (64.9)	4.7 (23.2)	7.41	4.9 (24.3)	6.6 (45.5)	2.0 (3.8)	4.5 (21.5)	3.88
Manual seed drill	19.4 (377.7)	7.3 (54.3)	7.9 (64.8)	4.1 (17.7)	7.66	4.9 (24.2)	7.4 (56.5)	1.9 (3.3)	5.0 (24.8)	3.56
Conventional tillage	19.2 (371.3)	7.9 (63.3)	7.5 (58.2)	5.0 (25.6)	7.07	5.1 (26.5)	6.2 (40.5)	2.0 (3.6)	5.0 (25.3)	3.63
CD (P=0.05)	NS	NS	NS	NS	NS	2.3	NS	1.1	NS	NS

*Values in parentheses are the averages of original values; Data transformed to square root transformation of "x+0.5

CONCLUSION

It was concluded that all planting techniques resulted in comparable yield of maize and wheat. Thus, planting technique can be followed as per the availability of resources at farm level.

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Influence of tillage and weed management in direct-seeded rice-wheat cropping system

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Tillage influences weed infestation as under zero tillage seeds of most of the seasonal weeds remain on the soil surface while under conventional tillage the weed seeds are turned down by plough and buried beneath the soil. Thus, under zero tillage the infestation of weeds is more. Sowing of crop under zero tillage situation produces more yield and is more profitable due to conserved organic matter in the soil provided weeds are managed by application of herbicides (Sharma and Singh 2012). Presence of crop residues on soil surface in zero tillage suppresses weeds and also affects the soil fertility and microbial activity.

METHODOLOGY

Present investigation was undertaken under Birsa Agricultural University, Ranchi during 2013-14. The soil was medium in organic carbon (0.52%), having soil pH 5.3. The treatments comprised of four tillage sequences in main plot namely zero–zero (Z-Z), zero–conventional (Z-C), conventional–zero (C-Z) and conventional–conventional (C-C) tillage performed during *Kharif* and *Rabi* seasons respectively and weed control methods viz., recommended herbicides butachlor 1.0 kg/ha as pre-emergence + 2,4-D 0.5 kg/ha as post-emergence in rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha as post-emergence in wheat, weed free (three hand weeding at 20, 40 and 60 DAS in rice and at 25, 50 and 75 DAS in wheat) and weedy check under sub-plots, replicated four times**.** The experiment was designed in split-plot. The variety for rice and wheat were 'Lalat' and 'K 9107', respectively. The crop was fertilized with recommended 100 kg N + 25.8 kg P + 33.2 kg K in rice and wheat.

RESULTS

Different tillage sequences did not influence wheat grain yield however, conventional–conventional (C-C) tillage sequence recorded maximum grain (4.83 t/ha) and straw yield (8.08 t/ha) followed by zero–conventional (Z-C), conventional–zero (C-Z) and zero–zero (Z-Z). Among weed control methods, hand weeding at 25 and 40 days after sowing being similar to application of recommended herbicides in wheat isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha as post-emergence recorded 25.2% higher grain (4.81 t/ha),18.8% straw yield (7.87 t/ha). Punia *et al.* (2006) has also reported improved grain yield of wheat with application of recommended herbicides.

Table 1. Effect of tillage and weed control methods on yield and soil fertility after harvest of wheat (2013-14)

Treatment	Yield (t/ha)		pH	OC (g/kg soil)	SMBC (ppm)	Dehydrogenase (ppm TPF/hr)	Azotobacter $x10^3$cfu	Total Bacterial Population $x10^5$cfu
Tillage methods	Grain	Straw						
Z –Z	4.08	6.66	5.38	5.48	220.5	10.34	4.00	61.9
Z – C	4.50	7.62	5.27	5.49	198.7	9.35	3.00	61.3
C – Z	4.37	7.41	5.27	5.49	183.7	8.20	2.83	61.0
C – C	4.83	8.08	5.22	5.33	186.2	6.67	2.92	61.2
LSD (P=0.05)	NS	NS	NS	NS	12.2	1.04	NS	NS
Weed control methods								
RH – RH	4.68	7.84	5.22	5.31	204.0	7.35	2.44	60.9
HW – HW	4.81	7.87	5.37	5.44	190.9	9.19	3.63	60.5
WC – WC	3.84	6.62	5.26	5.59	196.8	9.38	3.50	62.6
LSD (P=0.05)	0.62	1.05	0.06	0.15	NS	0.83	0.73	1.8

*ND= Not determined

Zero-zero tillage sequences followed in rainy and winter seasons recorded higher soil microbial biomass carbon (220.53ppm), Dehydrogenase (10.34 ppm TPF/hr), whereas, pH, organic C, *Azotobactor* and total bacterial population were not influenced by different tillage methods. Among weed control methods, hand weeding increased pH marginally from 5.3 to 5.37. Similarly hand weeding recorded higher *Azotobacter* count (3.63 $x10^3$ cfu) being similar to weedy check. However weedy check recorded higher organic carbon (5.59 g/kg soil) and Dehydrogenase activity (9.38 ppm TPF/hr) and similar to hand weeding. But bacterial population (62.69 x 10^5cfu) was significantly higher compared to hand weeding. Similar findings were also reported by Pal *et al.* (2013).

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Effect of tillage on weed incidence and fodder cereal production in rice fallow

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Agronomic practices such as tillage have implications on weed incidence and hence on crop management strategies to be followed. Tillage greatly influence weed population and competition to crops depending on the degree to which it is carried out. Conventional tillage though highly effective for weed control is nowadays not much preferred due to gaining importance of conservation tillage.

METHODOLOGY

An experiment was conducted during December 2009 to February 2010 at College of Horticulture, Thrissur, Kerala to study the effect on tillage practices on weed incidence in fodder cereal production in summer rice fallows. The experiment was laid out in split plot design with four replications. The treatments consisted of four tillage practices in main plots, *viz*. zero tillage with and without herbicide application, minimum tillage and conventional tillage and in sub-plots three fodder cereals as maize, sorghum and bajra. After imposing treatments, cereal seeds were dibbled at a spacing of 30x15 cm. All other practices were followed as per recommendation for this region. Observation on weed flora, density and weed dry matter production were taken at 30 and 60 DAS and forage yield were recorded at 60 DAS from a single cut.

RESULTS

The data on weed count revealed that broad leaved weeds constituted major weed flora followed by grasses and sedges. The major weeds were: *Ludwigia parvifloa, Melochia corchorifolia, Mollugo pentaphylla, Spheranthus indicus* (broad-leaved), *Digitaria ciliaris, Ischaemun indicum, Isachne miliaceae, Echinochloa spp.* (grasses), *Fimbystilis spp. and Cyperus haspan* (sedges). Significant variation in weed population could be observed due to tillage, whereas no difference between the fodder cereals probably due to their similar growth habit. The highest density of grasses was observed in zero tillage followed by minimum tillage and herbicide based zero tillage. The population of dicot weeds showed a decreasing trend in zero and minimum tillage from 30 DAS to harvest stage. But the population of dicot weeds in conventional tillage plots showed a considerable increase 4.2 no/m^2 from 30 DAS to harvest stage (60 DAS). Weed density was highest in zero tilled plots of all three fodder cereals. Similarly, highest weed dry weight of 1.54 t/ha was in zero tillage compared to the conventional tillage at 30 DAS (193 kg/ha). Weed dry weight at harvest in zero tillage with herbicide increased by 100% and in conventional tillage by 200% of 30 DAS. At par yield of all three fodder cereals were recorded under zero tillage and minimum tillage. Analysis of benefit - cost ratio revealed highest value under fodder maize in zero tillage.

CONCLUSION

The study revealed that fodder cereals can be economically grown under zero or minimum tillage.

Nutrient uptake in drum-seeded rice as influenced by different weed management practices

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Rice (*Oryza sativa* L.) is the principal source of food for more than half of the world population. In recent years, direct seeding with drum seeder has become popular due to its advantages like cost reduction, faster growth and establishment, easiness in inter-culture, lesser seed rate and higher yield. However, profuse weed growth is the major problem due to simultaneous germination of weeds and rice seeds. The nutrient loss due to heavy weed infestation in drum seeded rice under puddled condition is about 21.5, 16.5 and 10.8% of N, P and K, respectively (Sangeetha *et al.* 2011**)** and reduction in grain yield is 53% (Hussain *et al.* 2008). There is a need to evaluate the combination of pre- and post-emergence herbicides for suppressing the grasses, annual sedges and broadleaved weeds. In cognizance of the above, the present study was undertaken.

METHODOLOGY

A field investigation was carried out during *kharif* 2012 at of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh to know the performance of pre- and post- emergence herbicides in drum seeded rice. The soil of the experiment field was sandy loam in texture. The soils are low in organic carbon, available nitrogen and phosphorus and medium in potassium. The field experiment was laid out in Randomized Block Design consisted of ten weed management practices with pre- and post- emergence herbicides and mechanical weeding with power weeder (Table 1). A sprouted seed of rice variety 'NLR-33358' was sown with the help of drum seeder in the field with recommended packages of practices. A uniform fertilizer dose of 120:60:60 N, P_2O_5 and K_2O kg/ha was applied as per recommendation.

RESULTS

The predominant weed species observed in the experimental field were the sedges (71%), grasses (18.5%) and broadleaved weeds (10.5%). Among the weed management practices, the lowest uptake of nutrients *viz.*, nitrogen, phosphorus and potassium by weeds was recorded with two hand weeding at 20 and 40 DAS, which was comparable with pre-emergence application of oxadiargyl 75 g/ha *fb* azimsulfuron 30 g/ha at 40 DAS. The nutrients uptake by weeds associated with drum seeded rice was 49.5, 11.14 and 65.75 kg/ha of N, P and K, respectively in unweeded check. The highest uptake of nitrogen, phosphorus and potassium by crop was recorded with pre-emergence application of oxadiargyl 75 g/ha *fb* azimsulfuron 30 g/ha applied at 40 DAS, which was however, comparable with two hand weedings at 20 and 40 DAS and both of them were significantly higher than rest of the weed management practices. This can be ascribed due to effective control of all the categories of weed resulted in increased dry matter production of crop. The highest uptake of N, P and K was 130, 24.3 and 259.4 kg/ha due to effective control of weeds throughout the crop growth period. These findings are in accordance with those of Mukherjee and Maity (2002). The highest grain yield was recorded with pre-emergence application of oxadairgyl 75 g/ha *fb* post-emergence azimsulfuron 30 g/ha, which was 51% higher than the unweeded check.

Table 1. Effect of weed management practices on nutrient uptake by weeds and crop in drum-seeded rice

Treatment	Dose (g/ha)	Weed dry weight (g/m)	Nutrient uptake by weeds (kg/ha)			Dry matter production (t/ha)	Nutrient uptake by Crop (kg/ha)			Grain yield (t/ha)
			N	P	K		N	P	K	
Pretilachlor	500	7.5 (56.2)	12.4	4.8	19.7	9.24	82.7	13.7	153.3	3.81
Oxadiargyl	75	7.4 (53.9)	11.9	4.6	18.9	9.41	85.3	14.0	159.1	3.93
Pretilachlor + power weeder	500	5.6 (30.5)	6.7	2.6	10.7	10.10	96.0	16.0	197.1	4.59
Oxadiargyl + power weeder	75	5.5 (29.6)	6.5	2.5	10.4	10.29	99.1	16.4	205.8	4.60
Pretilachlor + azimsulfuron	500 + 30	4.6 (20.7)	4.5	1.8	7.3	10.61	109.7	19.4	229.2	5.18
Oxadiargyl + azimsulfuron	75+30	4.4 (18.8)	3.4	1.4	5.1	11.63	130.0	24.3	259.4	5.75
Pretilachlor + bispyribac-sodium	500 + 30	4.6 (20.9)	4.6	1.8	7.3	10.53	106.2	19.3	226.5	5.10
Oxadiargyl + bispyribac-sodium	75 + 30	4.4 (19.1)	4.3	1.7	6.7	10.72	110.0	19.6	232.1	5.20
HW twice	-	3.5 (12.0)	2.6	1.3	4.2	11.51	127.0	23.7	254.4	5.71
Unweeded check	-	15.0 (225.0)	49.5	11.1	65.8	8.67	72.8	11.9	121.4	2.82
LSD (P=0.05)		0.2	0.8	0.1	1.3	0.20	4.0	0.9	9.9	0.14

Note: Figures in parentheses are original values. Weed Data transformed to $\sqrt{X+0.5}$

CONCLUSION

It was concluded that preemergence application of oxadairgyl 75 g/ha *fb* post-emergence application of azimsulfuron 30 g/ha resulted in the broad spectrum weed control coupled with the highest nutrient uptake and grain yield in drum seeded rice. Uncontrolled weed growth in drum seeded rice drains 49.5, 11.1 and 65.8 kg N, P and K/ha, respectively.

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Resource conservation technologies: an alternate for weed management

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The greatest challenge of 21st century is to meet the rising food demands of the geometrically increasing population while sustaining the natural resources. Weeds are the major issues to be solved the resource conservation technologies like zero tillage and bed planting in wheat. The reports registered about 30% less germination of weeds particularly *P. minor* in wheat sown under no tillage conditions in rice-wheat system. After combine harvesting of rice the left over residues create hindrances in sowing operations under no-tillage conditions. The farmers used to burn the combine harvested rice residues followed by sowing of wheat with zero tillage machines. To avoid the residue burning and sustaining the natural resources the sowing of wheat with '*Happy Seeder*' was promoted. The loose straw lying in the field proved beneficial in two ways i.e., it acts as mulch for conserving soil moisture and impeded sunlight restricting the germination of weed seeds lying in the undisturbed soil. There was more than 50% less germination of weed seeds beneath the rice mulch and the growth of emerged weeds was also slow which could not compete with the wheat crop (Lathwal, 2010)

METHODOLOGY

The primary aim of this study to accelerates the adoption of resource conservation technologies, *viz*. 'Happy Seeder'. Ten on-farm demonstrations were conducted at farmer's field in the adopted village Badoushhi Kalan of Fatehgarh Sahib district during *rabi* 2013-14. The soil type of the village was loamy sand. The sowing of wheat with Happy Seeder and conventional tillage was compared. The Happy Seeder machine was provided to the selected farmer as incentive. The observation on weed count/m^2 at 40 days after sowing (DAS), plant height, effective tillers/m^2 and grain yield at the time of harvest of wheat crop was recorded. The data was analysed on average basis.

RESULTS

The results revealed that sowing of wheat with happy seeder had direct advantage over zero tillage without residue. The paddy straw acts as mulch which moderate soil temperature and conserves moisture and thus resulted in higher wheat yield than conventional tillage. Weed seed germination reduced by 52.1% due to zero tillage with straw mulch (Happy Seeder) as compared to zero till drill sown wheat. The same results were recorded by Singh *et al.* (2013). Straw mulch raised soil temperature during cooler part of the year and lowered in the hotter part and thus enhancing crop growth (Vincent and Quirke 2002). Similarly, 4.3% higher grain yield was recorded in 'Happy Seeder' plots as compared to conventional plots. The highest net returns of Rs. 47,200/ha and B : C ratio (3.2) was obtained in sowing with 'Happy Seeder' than conventional tillage.

Table 1. Effect of different sowing method on growth, yield parameters and economics of wheat crop

Sowing method	Weed count (no./m^2) at 40 DAS	Plant height at harvest (cm)	Effective tillers/m^2	No. of grains/ ear	Grain yield (t/ha)	Net returns (Rs./ha)	B: C ratio
Happy Seeder	11.4	80.5	372	78.3	4.8	47.200	3.2
Zero till-drill	23.8	79.3	306	61.5	4.6	42.701	2.8

CONCLUSION

It can be concluded that 'Happy Seeder' sown wheat has less weed population and higher yield. Therefore, it can be promoted for higher adoption for sowing of wheat under rice-wheat cropping system.

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Weed management in maize through application of tank-mix herbicide

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Maize (*Zea mays* L.) is the third most important cereal crop in India after rice and wheat. It is cultivated on 9.4 million (M) ha with a production of 24.2 MT and an average yield of 2.67 t/ha (DMR 2014). Maize is cultivated mainly as rainy season crop which are infested with weeds occurring in different flushes. It is widely spaced and grows at a slow rate initially, which allows weeds to emerge in large number and compete with maize. Weeds reduce yield through competition for moisture, nutrient, space and light during the growing season and interfere with harvest (Kumar *et al*. 2012). Research work has hardly been undertaken to understand the selectivity of herbicides, imazethapyr and chlorimuron-p-ethyl in maize. Their bioefficacy against the composite weeds, including *Cyperus rotundus* in combination with other herbicides as tank-mix or sequential application has hardly been studied in India or elsewhere.

METHODOLOGY

A field experiment was conducted during 2010 and 2011 to evaluate the bio-efficacy of pre-emergence tank-mix and sequential application pre-emergence followed by (*fb*) post-emergence of herbicides on weeds particularly *Cyperus rotundus* L. in maize (*Zea mays* L.) at Indian Agricultural Research Institute, New Delhi. Twelve treatments consisting of tank mix and sequential applications of imazethapyr and chlorimuron along with pendimethalin and KNO_3, atrazine with hand weeding and mustard residue application and brown manuring with *Sesbania* were arranged in a randomized block design with three replications. Maize hybrid 'HQPM 1' was used in the study with a seed rate of 25 kg/ha in rows spacing of 60 cm. Half of the recommended dose of N was applied basally through broadcasting and mixed with soil before sowing of maize along with full dose of P_2O_5 and K_2O. The remaining N was top-dressed as hill placement close to the maize plants at 35 days after sowing. Data on weed growth, yield performance and economics were recorded.

RESULTS

Seven major weed species comprising of three grassy weeds (*Achrachne racemosa*, *Dactyloctenium aegyptium* and *Setaria glauca*), one sedge (*Cyperus rotundus*) and three broad-leaved weeds (*Trianthema portulacastrum*, *Commelina benghalensis* and *Digera arvensis*) were present in maize field. It was observed that the tank-mix pre-emergence application of pendimethalin 0.75 kg/ha + imazethapyr 0.05 kg/ha with or without KNO_3 (6%) and pendimethalin 0.75 kg/ha + chlorimuron-p-ethyl 0.006 kg/ha resulted in significant suppression of *Cyperus rotundus*, broad leaved and grassy weeds, and caused a significant reduction in total weed population and dry weight (Kumar *et al*. 2012). These tank-mixes were superior to other weed control treatments and resulted in higher weed control efficiency and weed control index. However, the pre-emergence tank-mix application of pendimethalin 0.75 kg/ha + imazethapyr 0.05 kg/ha resulted in comparable maize yield with weed-free check in both years, but the yields in this treatment were higher than in other weed control treatments. This treatment, excluding weed-free check, resulted in the highest net returns and benefit : cost ratio. Atrazine 1.0 kg/ha + mustard residue mulch at 5 t/ha was the next best treatment, resulting in higher maize yield through concurrent reduction in weed competition.

Table 1. Weed growth, yield and economics of maize as influenced by different weed control treatments (mean of two years)

Treatment	WCE (%)	WCI (%)	Grain yield (t/ha)	Stover yield (t/ha)	Cost of cultivation (× 10^3 Rs/ha)	B:C
Weedy check	0.0	0.0	2.53	6.44	16.7	0.91
Atrazine 0.75 kg /ha + pendimethalin 0.75 kg/ha (tank-mix PE)	69.6	74.4	3.65	8.55	18.7	1.24
Atrazine 1.0 kg/ha + hand weeding at 30 DAS	78.4	87.0	3.53	8.23	20.8	0.95
Atrazine 1.0 kg/ha + mustard residue mulch @ 5 t/ha	66.4	74.8	3.76	8.48	20.8	1.17
Pendimethalin 0.75 kg/ha + imazethapyr 0.05 kg/ha (tank-mix PE)	90.6	90.9	3.95	8.85	19.0	1.50
*KNO_3 (6%) + pendimethalin 0.75 kg/ha + imazethapyr 0.050 kg/ha (tank-mix PE)	89.2	87.3	3.63	8.20	28.0	0.53
Pendimethalin 0.75 kg/ha + chlorimuron 0.006 kg/ha (tank-mix PE)	85.6	85.3	2.75	6.59	18.2	0.76
Pendimethalin 0.75 kg/ha PE *fb* imazethapyr 0.050 kg/ha POE with sand	78.1	76.8	2.91	7.62	19.5	0.73
Pendimethalin 0.75 kg/ha PE *fb* chlorimuron 0.006 kg/ha POE with sand	75.5	74.0	2.78	7.35	18.7	0.90
Brown manuring (*Sesbania* @ 5 kg/ha+ 2,4-D 0.75 kg/ha at 25 DAS)	59.8	60.3	3.13	7.85	18.0	1.18
Brown manuring (*Sesbania* @ 10 kg/ha+ 2,4-D 0.75 kg/ha at 25 DAS)	64.6	67.7	3.29	8.20	18.0	1.22
Weed-free check	100.0	100.0	4.12	8.96	25.7	0.91
LSD (P=0.05)			0.68	0.80		

KNO_3 was applied separately; PE –pre-emergence; POE – post-emergence

CONCLUSION

It was concluded that pre-emergence tank-mix application of pendimethalin 0.75 kg/ha + imazethapyr 0.050 kg/ ha was most effective for controlling weeds including *C. rotundus*, improving grain yield and profitability of maize (*Zea mays*) in western Indo-Gangetic Plains.

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Performance of wheat under different planting methods with varied row spacing and weed management practices

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Wheat (*Triticum aestivum*) is one of the most extensively grown crops in the world, and is the second most important source of staple food in India after rice. In India, it is grown in 31.34 mha with production of 95.91 mt and productivity of 3.06 tonnes/ha (Anonymous, 2014). It plays an important role in the food and nutritional security i.e., up to 40% of total foodgrain production of the country. A number of factors are responsible for stagnation of wheat production and productivity like weeds, excessive tillage and soil degradation. As there is hardly any scope for expansion of area under wheat, the main emphasis would be on increasing the productivity of wheat by adopting the improved cultivation practices including weed management.

METHODOLOGY

A field experiment was carried out during *Rabi* season of 2013-14 at CCS Haryana Agricultural University, Hisar, Haryana to study the performance of wheat under different planting methods with varied row spacing and weed management practices. Experiment was laid out in split-plot design replicated thrice, having six planting methods in main-plots *viz*. bed planting with two and three rows, drill sowing at 18 and 20 cm (conventional tillage), drill sowing at 18 and 20 cm (zero tillage) and five weed control practices in sub-plots *viz*. pinoxaden 50 g/ha, carfentrazone + metsulfuron (RM) 25 g/ha, pinoxaden + [carfentrazone + metsulfuron (RM)] 50 + 25 g/ha, weed free and weedy check. Wheat variety 'HD 2967' was sown on 3rd December 2013 as per package of practices recommended by CCS Haryana Agricultural University, Hisar. Herbicides were applied as per treatment at 35 DAS using 500 l/ha water by knapsack sprayer fitted with flat-fan nozzle.

RESULTS

Straw and grain yields were significantly affected by various planting methods. The highest grain yield was recorded under zero tillage at 18cm row spacing and was found to be at par with all other planting methods except under bed planting with 2 rows. Grain yield under zero tillage at 18cm row spacing was 16.3 and 2.8% higher as compared to bed planting with two rows and drill sowing at 20 cm row spacing (conventional tillage), respectively. Maximum straw yield was recorded under drill sowing at 18cm row spacing (conventional tillage) which was significantly higher (11.0%) as compared to bed planting with two rows but was at par with all other planting methods. Significantly higher grain yields were recorded in all herbicide treatments than weedy check. The highest grain yield was observed under weed free treatment which was at par with the application of pinoxaden + [carfentrazone + metsulfuron (RM)] and was 45.2 and 41.7% higher, respectively over weedy check. Similar trend was also observed for straw yield of wheat.

Significantly highest weed dry weight was recorded in bed planting with 2 rows of wheat and the minimum weed dry weight was observed under zero tillage with 18cm row spacing. However, significantly lower dry weight of weeds was recorded in all weed management treatments over weedy check and the lowest weed dry weight was recorded under application of pinoxaden + [carfentrazone + metsulfuron (RM)] (95.9% lower than weedy check). Weed control efficiency was significantly influenced by various planting methods and was highest under zero tillage at 18cm row spacing for both grassy and broad leaf weeds (63.3 and 60.2%, respectively). Among herbicide treatments, weed control efficiency for both grassy and broad leaf weeds was highest under application of pinoxaden + [carfentrazone + metsulfuron (RM)].

CONCLUSION

Sowing of wheat at 18 cm row spacing (both under zero and conventional tillage) and application of pinoxaden + [carfentrazone + metsulfuron (RM)] (50 + 25 g/ha) at 35 DAS can be used for effective weed control and higher wheat productivity.

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Influence of bio-compost on weed density and yield of rice under sodic soil

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Rice (*Oryza sativa* L.) is being cultivated as a major crop and it currently one half of the world population (Wu *et* al. 2004) and its native is in tropical and subtropical south eastern Asia and Africa. Rice is the principal source of food from more than one third of world population. Uttar Pradesh is second largest rice growing state after West Bengal in the country. For sustained crop production and economy of costly fertilizer input, adaptation of environment friendly organic based (biocompost) alternative / integrated nutrient in modern cropping system. Sodic soil is one of the most important biotic stress, which directly reduce the plant growth and development. It is widely distributed in irrigated and non irrigated areas.

METHODOLOGY

A field experiment was conducted during *kharif* season of 2012 at main experimental station, Narendra Deva University of Agriculture & Technology Kumarganj, Faizabad. The experiment was laid out in randomized block design with three replications. Treatments comprised of two rice varieties, *viz.* 'Narendra Usar Dham 3' and 'NDR 359' and three doses of bio-compost, viz. 2, 4 and 6 t/ha. Bio-compost was applied 15 days before transplanting of rice and mixed properly with upper soil layer (0-15cm soil depth). Soil of experimental field was silty loam with pH 9.2, EC (dS/m^2) 3.5 and ESP (27.3) having low organic C 0.21%.

RESULTS

Maximum plant high was recorded with application of 6 t/ha bio-compost, which might be due to good impact of pressmud in sodic soil because of pressmud contain higher amount of organic matter content, nitrogen content and other nutrients. The variety 'Narendra Usar Dhan 3' also showed higher plant height. The maximum number of tillers per hill was counted with the application of higher dose of bio-compost (6 t/ha). This increase may be due to better soil environment, maximum nutrient availability and its uptake reducing the pH around the root environment. The present result is in close conformity to result of Srivastava and Singh (1971). Significantly higher grain yield (27.85 g/hill) and grain yield (5.54 t/ha) were found with the application higher level of 6 t/ha bio-compost than other treatment, whereas test weight was found non-significant. The higher grain yield per hill and yield achieved with application of 6 t/ha pressmud might be due better impact of pressmud by virtue of its NPK and Ca content.The maximum number of weeds density dry weight were observed in control plot whereas, minimum were recorded in 6 t/ha of rice field.

Table 1. Influence of Bio-compost on weed density and yield attributing traits of rice under sodic soil.

Treatment	Weed density at 60 DAT (no/m^2		Weed dry weight 60 DAT (g/m^2)		Grain yield (t/ha)		
	V_1	V_2	V_1	V_2	V_1	V_2	Mean
Control	10.7(110.8)	10.6 (110.4)	12.30(140.8)	12.1 (139.9)	3.45	3.87	3.66
2 t/ha	8.60(100.4)	8.4 (99.9)	11.7 (138.4)	11.5(137.8)	4.73	5.24	4.99
4 t/ha	3.7 (13.4)	3.7 (12.9)	5.31(24.0)	5.28(23.6)	4.88	5.73	5.31
6 t/ha	2.61(5.95)	2.5 (5.8)	2.6 (6.3)	2.6 (6.2)	5.11	5.97	5.54
LSD (P=0.05)							
V	0.32		0.32		0.24		
T	0.32		0.33		0.34		
V x T	0.32		0.33				

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Irrigation and tillage practices on the occurrence of weeds in fodder maize

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Reduced tillage has greater significance in conservation agriculture because of its role in soil and moisture conservation and cutting costs. Most primary tillage operations influence distribution of weed seeds in different soil layers (Fray and Olson, 1978). However, secondary tillage practice such as harrowing has less influence on seed bank (Ball and Miller 1990). Irrigation can also influence weed germination and growth and thus have implications for weed management. These assume significance when crops like fodder maize are grown utilizing residual moisture left by previous crops.

METHODOLOGY

A field experiment was conducted during 2012-13 at Thrissur, Kerala to evaluate different irrigation schedules and tillage practices on the incidence of weeds in fodder maize in summer rice fallows. The experiment was laid out in split plot with four main plot treatments (irrigation level) and three sub plot treatments (tillage) replicated thrice. The treatments comprised of four levels of irrigation at IW/CPE ratios 1.0, 0.7 and 0.4 and no irrigation and three tillage practices as herbicide based zero tillage, minimum tillage and conventional tillage. Seeds were sown at a spacing of 30 x 15 cm and observations on weeds number and dry matter production were recorded at 30 days after sowing and at harvest (64 days after sowing).

RESULTS

Broadleaf weeds dominated the experimental field followed by grasses and sedges. However, there was no significant difference in weeds number due irrigation and tillage practices at both stages of observation. The major weeds were: *Melochia corchorifolia, Mollugo trifolia, Coldenia procumbens, Oldenlandia corymbosa, Ageratum conyzoides, Glinus oppositifolius,* (broadleaf), *Digitaria ciliaris, Cynodon dactylon, Ischaemum indicum, Isachne miliacea, Echinochloa* spp. (grassy weeds), and *Fimbristylis miliacea* and *Cyperus haspan* (sedges). Number of weeds was lower at harvest than 30 DAS probably due to smothering of weeds by crops and drying up of some weeds.

Dry matter production of weeds gives better indication of weed competition than weed population. In the present experiment, dry matter production of weeds varied significantly due to irrigation level with highest value in IW/CPE ratio of 0.4 followed by 0.7 at both stages of observation and the lowest in no-irrigation (M1). In M_3 and M_4, crops grew luxuriously due to adequate soil moisture and thus inhibiting weed growth. Dry matter production of weeds differed because of tillage methods too. The highest weed biomass was noticed in minimum tillage followed by conventional tillage and the lowest was in herbicide based zero tillage. Because of the application of glyphosate complete weed control was achieved at the time of sowing and therefore, less weed growth was observed in herbicide based zero tillage plots. Interaction between irrigation levels and tillage was also significant. Irrigation at IW/CPE 0.4 with minimum tillage showed the maximum weed biomass at both stages followed by irrigation at IW/CPE 0.7 with minimum tillage.

CONCLUSION

In fodder maize, weed population was unaffected by irrigation and tillage practices. Herbicide based zero tillage was efficiently educed weed biomass in comparison to minimum or conventional tillage.

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Efficacy of different herbicides on three problematic weed species of winter season

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Weeds are the most underestimated crop pests in tropical agriculture although they cause maximum reduction in the yield of crops than other pests and diseases (Yaduraju 2006). They compete with crop for space, light, moisture and nutrients, and reduce the crop yield by 17-25% (Shehzad *et al.* 2011). Herbicides are an effective and efficient tool of weed management and their selective use will not only provide economic yields, but also help to avoid weed resistance (Om *et al.* 2004). Some weeds are better controlled by soil-applied herbicides, while oth-ers are more susceptible to post-emergence herbicides. Hence the present study was carried out to evaluate the efficacy of different herbicides on three problematic weed species of winter season.

METHODOLOGY

The field experiment was carried out during the winter season of 2014-15, at the Norman E. Borlaug Crop Research Centre, GB Pant university of Agriculture and Technology. Seven treatments of different herbicides, including control were used (Table 1). Out of them two were pre-emergence (trifluralin 1.0 kg/ha and pendimathalin 1.0 kg/ha) and four pos-temergence herbicides (clodinofop 60 g/ha, clodinofop + metsulfuron-methyl (60 g+ 4 g/ha), Sulfosulfuran 25 g/ha and metribuzein 250 g/ha). The trial was conducted to study the efficacy of pre and post-emergence application of herbicides on *P. minor, M. denticulata* and *A. arvensis.*

RESULTS

The mean data on weed biomass under different treatments is presented in Table 1. The biomass of weed species was recorded at 40 DAS and at harvest. At 40 DAS, all the treatments were found effective to control *P. minor* except sulfosulfuron but at maturity stage, *P. minor* recovered in some treatments. The biomass of *P. minor* was recorded 841.3 g/m^2 under metribuzin and 687.3 g/m^2 under pendimethalin at harvest. *M. denticulata* was successfully controlled by clodinofop-propargyl + metsulfuron-methyl, sulfosulfuron and metribuzin. The biomass was found maximum under trifluralin (154.6 g/m^2) at 40 DAS and clodinofop-propargyl (892 g/m^2) at harvest. The pre-emergnce herbicides pendimethalin and trifluralin effectively controlled the germination of *P. minor* and *A. arvensis*. Clodinofop-propargyl + metsulfuron-methyl, sulfosulfuron and metribuzin were control *A. arvensis* effectively.

Table 1. Effect of herbicides on biomass of weed species (g/m^2) at 40 days after spraying and at harvest

Treatments	*P. minor*		*M. denticulata*		*A. arvensis*	
	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest
Trifluralin 1kg/ha	0	0	154.6	630.6	0	0
Pendimethalin 1.0 kg/ha	0	687.3	147.1	505.3	0	0
Clodinofop-propargyl 60g/ha	0	0	93.7	892.0	4.96	118.6
Clodinofop-propargyl + Metsulfuron methyl 60+4g/ha	0	0	0	0	0	0
Sulfosulfuron 25g/ha	94.6	310.0	0	0	0	0
Metribuzin 250g/ha	0	841.3	0	0	0	0
Control	386.6	1085.3	129.3	694.0	15.8	73.3
SEm±	5.28	26.8	15.5	11.6	2.24	3.28
CD (P=0.05)	16.4	82.8	47.4	36	6.96	10

CONCLUSION

Among the herbicides tested in the present study, the pre-emergence herbicides pendimethalin and trifluralin effectively controlled the germination of *P. minor* and *A. arvensis*. Among post emergence herbicides, ready-mix of clodinafop + metsulfuron-methyl successfully controlled all the three weeds. Application of clodinafop alone seems to be effective against only *P. minor* whereas, sulfosulfuron and metribuzin were effective against the broad-leaved weeds.

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Effect of planting and weed control methods on system productivity in maize-wheat cropping system

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As maize has wide adaptability and compatibility under diverse soil and climatic conditions, hence it is cultivated in sequence with different crops under various agro-ecologies of India. Maize-wheat is the 3rd most important cropping systems after rice-wheat and rice-rice that contributes about 3% in the national food basket. A number of factors are responsible for stagnation of production and productivity of maize-wheat cropping system like weeds, excessive tillage and soil degradation that limit the system productivity. As there is hardly any scope for expansion of area under crops, the main emphasis would be on increasing the productivity of the system by adopting the improved cultivation practices and weed management practices. Haryana state has an ample scope to increase acreage and productivity of maize-wheat cropping system as maize can be a strong candidate in the drive of crop diversification to displace puddled transplanted rice. Adaptation of new resource conservation technologies (RCTs) like zero-tillage and furrow irrigated raised bed system (FIRBS), coupled with effective weed management and crop diversification by including maize in place of rice may be a viable solution.

METHODOLOGY

A field experiment was carried out during *kharif* season of 2013 and *rabi* season of 2013-14 at CCS Haryana Agricultural University, Hisar, Haryana to study the performance of maize-wheat cropping system under different planting methods and weed management practices. Experiment was laid out in split-plot design with four replications having three planting methods in main-plots, *viz*. conventional tillage (CT), zero tillage (ZT) and furrow irrigated raised bed system (FIRBS) and four weed control practices in sub-plots, *viz*. atrazine (50% WP) 750 g/ha (pre-emergence) in maize and pinoxaden 50 g/ha + premix of metsulfuron and carfentrazone (Ally Express 50% DF) 25g/ha + 0.2% NIS post-emergence in wheat; tembotrione (Laudis 42% SC) 120 g/ha + S 1000 ml/ha (10-15 DAS *i.e.* 2-4 leaf stage) in maize and clodinafop-propargyl 60 g/ha *fb* metsulfuron 4 g/ha (sequential application) as post-emergence in wheat; two hand weeding (HW) both in maize (20 and 40 DAS) and wheat (30 and 50 DAS); and weedy check in maize and wheat. Hybrid maize 'HQPM 1' was sown during *kharif* 2013 and wheat variety 'HD 2967' was sown (without disturbing the layout) during *rabi* 2013-14 as per recommended package of practices. Herbicides were applied using 500 l/ha water by knapsack sprayer fitted with flat-fan nozzle.

RESULTS

The grain yields of maize and wheat were not significantly affected by various planting methods however higher crop yields were observed under FIRB planting. Various herbicidal treatments recorded significantly higher grain yield than weedy check. Tembotrione (Laudis 42% SC) 120 g/ha + S 1000 ml/ha (2-4 leaf stage) being superior to atrazine and hand weeding which provided more than 85% control of weeds including sedges in maize. In wheat, pinoxaden 50 g/ha + premix of metsulfuron and carfentrazone (Ally Express 50% DF) 25 g/ha + 0.2% NIS post-emergence and clodinafop 60 g/ha *fb* metsulfuron 4 g/ha effectively controlled the weeds and provided more than 90% control of weeds in wheat. Sheoran *et al*. (2013) also observed effective weed control in wheat with various herbicide mixtures. Unchecked weeds drastically reduced the grain yield of both the crops. Sharma and Gautam (2003) recorded the highest values for yield and all the growth parameters with the weed free treatments followed by HW twice or 1.0 kg atrazine/ha compared to the untreated control in maize.

CONCLUSION

It may be concluded that the system productivity of maize-wheat cropping system was comparative under various planting methods but higher crop yields were obtained with FIRBS. Application of atrazine 750 g/ha (pre-emergence) in maize and pinoxaden 50 g/ha + premix of metsulfuron and carfentrazone (Ally Express 50% DF) 25 g/ha + 0.2% NIS post-emergence in wheat; and tembotrione 120 g/ha + S 1000 ml/ha (2-4 leaf stage) in maize and clodinafop 60 g/ha *fb* metsulfuron 4 g/ha as post-emergence in wheat effectively controlled all kinds of weeds.

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Impact of weed management practices on weed population dynamics in maize

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Maize (*Zea mays* L.) is the third most important food crop in world with highest in production i.e., 872.8 mt during 2012 (FAOSTAT, 2014). India ranks fourth in production with 22.5 mt including 5.50 mt in *rabi* 2012-13 with productivity of 2.55 t/ha (IndiaStat 2014). Maize plants are very susceptible to weed competition and yield losses are estimated at 35% to complete crop failure (Sharma *et al.* 1998). The intensive use of a limited number of herbicides creates a situation where herbicide resistance is more likely to develop. Presently, there are 58 weed species in corn are resistant to herbicides, which is second highest after wheat. Maximum 66 weed species are resistant to herbicide atrazine (Heap 2014). Apart from this, long life of herbicides in soil and environment is great threat to the sustainability of the lives on the earth. So, present study was conducted to identify the suitable weed management practices in maize.

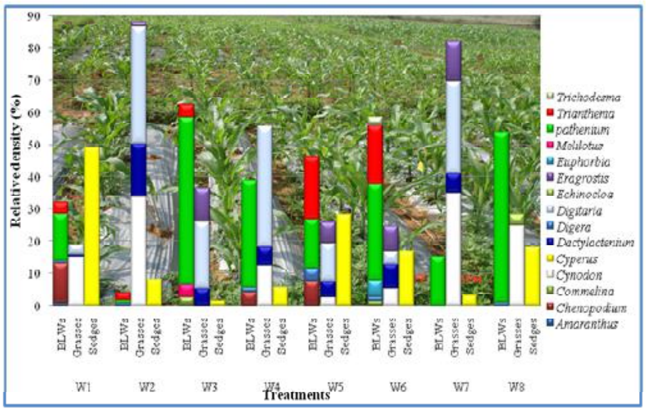

Fig. 1. Effect of weed management practices on relative density of weeds at 90 DAS in maize during rabi 2014-15

RESULTS

At 90 DAS, higher relative density of sedges followed by broad leaf weeds and grasses was observed in W_1, whereas, higher relative density of grasses was observed in W_2 and W_7 and sedges in W_3, W_5, W_6 and W_8 treatments. The highest relative dominance of grasses was observed in W_7 followed by W_2, W_3, W_4, W_5, W_1 and W_8 treatments. The increased dominance of grasses in W_2 and W_7 was might be due to non selective and reduced efficacy of applied herbicides. However, relative frequency of broad leaf weeds was in order of $W_3 > W_2 > W_1 > W_6 > W_5 > W_8 > W_7$ and sedges in weedy check (W_8) > farmers practice (W_1). Ecological dominance of grassy weeds was higher in brown manuring > $W_7 > W_2$. Among the broad leaf weeds, ecological dominance of *Parthenium hysterophorus* and *Trianthema portulacastrum* was in order of $W_8 > W_3 > W_4 > W_6 > W_5 > W_1$ and *Trianthema portulacastrum* in W_5 and W_6 treatments.

METHODOLOGY

An experiment was carried out during *rabi* season of 2014-15 at PJTSAU, Hyderabad with eight treatments *viz.*, hand weeding at 20 and 40 DAS (W_1), pre-emergence application of atrazine 1.0 kg/ha *fb* 2, 4-D sodium salt 1.0 kg/ha at 30 DAS (W_2), cowpea live mulch (W_3), cowpea brown manuring (W_4), black polythene mulch (W_5), white polythene mulch (W_6), high density planting i.e., planting on either side of the ridge + halosulfuron-methyl 67.5 g/ha at 20 DAS (W_7) and weedy check (W_8), replicated thrice. Maize hybrid 'Dekalb Super 900M' was sown on 28 October 2014 in planting geometry of 60cm x 20cm. Recommended dose of P (60 kg P_2O_5/ha) and K (40 kg K_2O/ha) entirely applied as basal and N (180 kg/ha) was applied in three equal splits at basal, knee height and tasselling stage (RDF: 180-60-40 Kg N, P_2O_5 and K_2O).

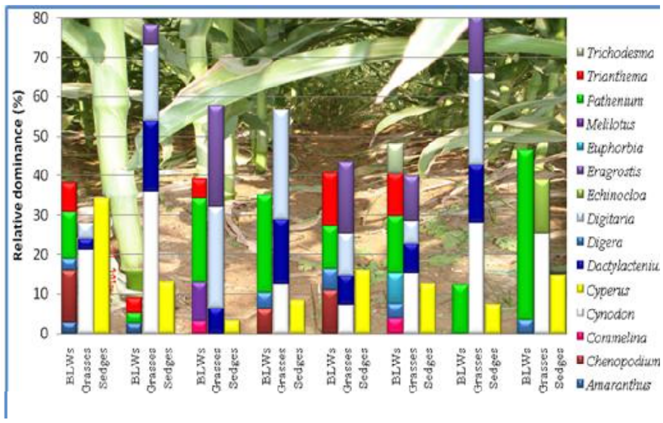

Fig.2. Effect of weed management practices on relative dominance of weeds at 90 DAS in maize during rabi 2014-15

CONCLUSION

Weed population of different types of weed species varied with different treatments. Broad leave weeds were dominant in weedy check, hand weeding, lives mulch and polythene mulches and grasses and sedges in herbicides treatments.

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Effect of tillage and weed management on weed dynamics and system productivity of rice-wheat-greengram cropping system

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Traditionally, rice is grown in puddle field with transplanting and subsequently wheat under conventional tillage. It requires heavy amount of water, energy and labour and also adversely affects the soil health. Over the past few years in many countries, there has been increasing trend towards conservation agriculture (CA). Globally, CA occupies about 125 mha area. The major CA practicing countries are USA, Canada, Brazil, Argentina and Australia. However, in India CA is practiced in about 43 mha area (Jat *et al*. 2011). Weed control in CA is a greater challenge than in conventional agriculture because there is no or minimum tillage operations and pre-plant incorporated herbicides cannot be incorporated in soil which resulted in reduced efficacy of herbicides (Chauhan and Johnson 2009). Under zero tillage weed seeds remain on the soil surface and enrich the weed seed bank. This seed bank remains the main source of annual weed infestation and constitutes a weed seed reservoir in agricultural production systems. Therefore, the present investigation was undertaken to see the impact of tillage and weed management on weed dynamics and system productivity of rice-wheat cropping system.

METHODOLOGY

A field experiment was conducted during 2012 to 2014 at the ICAR Directorate of Weed Research, Jabalpur, Madhya Pradesh. The soil of experimental site was clay loam in texture (Typic chromusterts) at 0–15 cm surface layer and clay beyond 15 cm soil depth with 7.3 pH, 0.22 dS/m EC, 0.54% OC, 238 kg/ha N, 16.5 kg/ha P and 342 kg /ha K. The field experiment was consisted of 15 treatments, comprising of five tillage as main-plot treatments (T_1- conventional tillage in rice + sesbania - conventional tillage in wheat - zero tillage in greengram, T_2- conventional tillage in rice + sesbania + previous crop residues – conventional tillage + rice residues in wheat - zero tillage in greengram, T_3- zero tillage in rice + sesbania - zero tillage in wheat - zero tillage in greengram, T_4- zero tillage in rice + sesbania + previous crop residues - zero tillage + rice residue in wheat-zero tillage in greengram, T_5- transplanted rice - conventional tillage in wheat); and three weed control methods as sub-plot treatments (W_1- weedy check, W_2- continuous use of bispyribac in rice and tank mix of clodinafop and sulfosulfuron in wheat, W_3-herbicide rotation in both crops), were laid out in split-plot design with three replications. Direct seeding of rice cultivar 'IR 64' was done in the 3rd week of June with 80 kg/ha seed rate. Whereas, wheat cultivar 'GW 273' was seeded at 120 kg/ha during 3rd week of November each year with recommended dose of fertilizers *viz.*,120: 60: 40 kg N, P_2O_5 and K_2O/ha to rice and wheat. Greengram variety 'Samart' was sown in the last week of March with recommended dose of fertilizers (20: 60: 40 kg N, P_2O_5 and K_2O/ha) under zero tillage. The data on weed density and dry weight were recorded at 60 DAS in each crop. Whereas, weed seed bank studies were done at 0-5, 5-10 and 10-15 cm soil depth after harvesting of greengram in each year.

RESULTS

Tillage and weed management practices significantly influenced the weed density and dry weight. The weed density and dry weight were minimum (21.3/m^2 and 10.87 g/m^2, respectively) under T_2 in rice-wheat-greengram cropping system in both years followed by T_5 (22.1/m^2 and 11.79 g/m^2, respectively). Among weed management practices, lowest weed density including dry weight were found under W_2 (20.9/m^2 and 11.67 g/m^2). Weed seed bank was more at 0-5 cm soil depth compared to 5-10 and 10-15 cm depth. Significantly lowest weed seeds were observed under T_5 (4.41 and 3.39) in *kharif* and (7.43 and 5.77) in *rabi* season at 0-5 and 5-10 cm soil depth, respectively. Similarly, lower weed seeds (2.3 and 4.13

Table 1. Effect of tillage and weed management practices on weed dynamics, weed seed bank and system productivity of rice–wheat–greengram cropping system (mean of 2012-13 and 2013-2014)

Treatment		Weed density (no./m^2)	Weed dry weight (g/m^2)	Weed seed bank (Nos.)						System Productivity (t/ha)
				Kharif			Rabi			
				0-5 cm	5-10 cm	10-15 cm	0-5 cm	5-10 cm	10-15 cm	
Tillage treatment										
T_1-	CT (DSR)+S-CT(Wheat)-ZT (Greengram)	23.9 (574.0)*	11.9 (139.7)	4.5 (20.1)	4.8 (22.6)	2.4 (5.2)	8.2 (67.4)	6.7 (44.9)	4.4 (18.6)	14.69
T_2-	CT (DSR) +R+S-CT+R(Wheat)-ZT (Greengram)	21.3 (453.1)	10.9 (117.6)	5.0 (25.2)	4.6 (20.6)	3.1 (8.9)	9.3 (85.4)	6.9 (47.6)	4.4 (18.6)	15.97
T_3-	ZT (DSR)+S-ZT(Wheat)-ZT (Greengram)	26.4 (698.5)	18.8 353.1)	5.4 (28.9)	4.9 (23.9)	2.3 (4.8)	9.39 (77.7)	7.1 (49.5)	4.1 (16.5)	10.14
T_4-	ZT (DSR) +R+S-ZT+R(Wheat)-ZT (Greengram)+R	25.6 (656.9)	16.6 (276.7)	4.4 (18.9)	4.2 (17.3)	2.9 (8.1)	8.0 (63.5)	6.42 (40.7)	4.2 (16.9)	15.03
T_5-	CT(TPR)-CT(Wheat)	22.1 (486.6)	11.8 (69.5)	4.4 (18.9)	3.4 (11.0)	2.5 (6.1)	7.4 (54.7)	5.7 (32.8)	4.9 (23.7)	8.62
	CD (P= 0.05)	1.1	2.7	1.1	1.2	0.5	0.2	1.9	0.1	1.18
Weed control										
W_1-	Weedy check	28.3 (801.2)	17.3 (299.1)	7.1 (49.5)	7.3 (52.6)	3.6 (12.6)	10.9 (118.5)	8.4 (71.1)	5.1 (25.0)	13.16
W_2-	Continuous use of bispyribac-Na in rice and tank mix of clodinofop and sulfosulfuron in wheat	20.8 (435.0)	11.6 (135.7)	3.6 (12.5)	3.1 (8.9)	2.2 (4.1)	7.8 (61.6)	6.2 (38.1)	4.1 (16.1)	16.81
W_3-	Herbicide rotation	21.2 (447.9)	12.9 (167.9)	3.8 (13.7)	2.9 (8.2)	2.2 (4.3)	7.8 (61.1)	5.5 (29.9)	3.6 (11.8)	15.69
LSD (P=0.05)		1.4	1.2	0.9	0.9	0.6	0.6	1.1	0.1	1.7

*Figures in parentheses are mean of original values; Data subjected to square root transformation; CT- conventional tillage, R- previous crop residues, S- sesbania, ZT- zero tillage in *kharif* and rabi, respectively) were found in zero tillage in rice-wheat-greengram cropping system compared to other tillage practices. The lowest weed seed bank was recorded in W3 which was at par with W2 and significantly higher over W1 (weedy check). The system productivity was highest in case of T_2 (15.97 t/ha) followed by T_4 (15.03 t/ha) and in W2 (16.81 t/ha) due to lower crop- weed competition.

CONCLUSION

It can be concluded that adoption of zero tillage + *Sesbania* + previous crop residue in rice with - zero tillage + rice residue in wheat - zero tillage + residue in greengram along with weed control by bispyribac-Na in rice and tank-mix of clodinafop and sulfosulfuron in wheat was found effective in controlling weeds and enhancing system productivity in rice-wheat-mungbean cropping.

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Tillage and crop rotation influence the weed seed bank composition of wheat fields in the Eastern Gangentic Plains of India

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Weeds represent a major constraint to production of wheat in the Eastern Indo-Gangetic Plains (EIGP) of northern India. However, relatively little information is available on which species are dominant in the region, and how weed communities vary based on management history and ecology. The objectives of this study were to estimate the density and composition of the weed seed bank from 84 farmer fields differing in historic tillage (conventional tillage [CT] versus zero tillage [ZT]) and crop rotation practices (rice-wheat vs rice-maize/potato-rice-wheat) across three regions in Bihar and Eastern Uttar Pradesh: Samastipur-Vaishali-Muzaffarpur (SVM), Ara-Buxar (AB) and Maharajgunj-Kushinagar (MK).

METHODOLOGY

Within each region, fields under ZT management in wheat for at least three previous seasons were compared to adjacent fields in which wheat was grown under continuous CT. Eight to ten pairs of ZT and CT fields were surveyed from each region. In addition, fields with rice-wheat rotations were compared to adjacent fields with rice - maize/potato rotations in the upland ecologies of the SVM region. Soil samples were collected to a depth of 15 cm from each field following rice harvest but before wheat planting. Soils were brought to a common greenhouse, spread in a thin layer in flats, and evaluated for germinable seed bank through exhaustive germination under well watered conditions for 3 months.

RESULTS

In the AB and SVM regions, ZT was associated with 71 and 81% lower seed bank densities of *Chenopodium album* compared to CT. In the MK region, ZT was associated with lower seed bank densities of *Phalaris minor* and higher seed bank densities of many other several weeds including *Soliva anthemifolia* in MK and *Mazus pumilus* in SVM. In the SVM region, more diverse crop rotations involving maize/potato intercropping, were associated with lower seed bank densities of *P. minor*, but higher densities of *Cannabis sativa* and *Digitaria ciliaris*.

CONCLUSION

Our results suggest that ZT and crop diversification are useful strategies for reducing economically important weed species of wheat including *C. album* and *P. minor*, but may result in shifts in weed communities towards other potentially competitive species. Future research evaluating the economic importance of these species, and identifying pro-active strategies for managing them should be helpful for improving the productivity and sustainability of rice-wheat cropping systems in the region.

Evaluation of sequential application of herbicides in zero-till maize

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Maize (*Zea mays* L.) is emerging as one of the most important *Rabi* crop particularly in rice-fallow conditions covers an area of 0.25 mha in coastal Andhra Pradesh with yield potential of 7.2 to 8.8 t/ha (Anonymous 2009). In rice-maize system wider spacing, slow initial growth and maintenance of high soil moisture regimes in maize and removal of apical dominance due to rice harvest stimulates rice stubbles to rejuvenate and more weeds to germinate, and hence resulted in more weed problems in maize during initial growth stage (Kumar and Sundari, 2002). The crop weed competition in maize during initial 40 DAS is very critical and hence, effective weed control through pre-emergence or early post-emergence herbicides is important to achieve higher maize yield. Therefore, present study was taken to see the effectiveness of different herbicides in maize under rice fallow zero till condition.

METHODOLOGY

The experiment was carried out during 2011-12 and 2012-13 at Maize Research Centre, Hyderabad on sandy clay loam soils to evaluate the efficacy of sequential application of herbicides against weeds in zero-till maize. Eight treatments along with hand weeding twice at 25 and 45 DAS and weedy check were used in randomized block design with three replications. During *Kharif* season, rice variety 'MTU 1010' was transplanted and the weeds were controlled by spraying bispyribac-sodium 250 ml/ ha at 20 days after transplanting. Maize hybrid 'DHM 117' was dibbled under zero-till conditions and adopted all the recommended package of practices. As per the treatments, glyphosate was applied before 2 days of maize sowing, and atrazine and metribuzine after sowing maize (same day) were applied uniformly by knapsack sprayer with discharge rate of 500 l/ ha. Data on weed growth, yield and economics were recorded as per standard procedure.

RESULTS

At experimental site, grassy weeds were predominant (60%) than broad leaved (28%) and sedges. All the weed management practices significantly reduced the density and dry weight of weeds over weedy check. Among the herbicides treatments, significantly higher grain yield (7.51 t/ha) was recorded in glyphosate 1.0 kg/ha as pre-plant application followed by 2,4-D sodium salt 0.4 kg/ha at 25 DAS. Weed control efficiency (59.5%) was also higher under these treatments. Among different weed management practices, atrazine *fb* atrazine and metribuzine *fb* atrazine treatments could not control grassy weed effectively as compared to glyphosate. These results are in close conformity with Reddy *et al.* (2012) in zero-till maize. Herbicide treatments resulted in considerably lower cost of cultivation compared to hand weeding. Thus, net returns (Rs 59,385/ha) and B: C ratio (3.56) was found maximum with glyphosate1.0 kg/ha followed by 2,4-D sodium salt 0.4 kg /ha.

Table 1. Influence of weed management practices on weed growth, grain yield and economics of zero-till maize

Treatment	Weed count/m^2		Weed dry natter (g/m^2)	WCE (%)	WI	Grain yield (t/ha)	Net returns (Rs /ha)	B:C ratio
	Grasses	BLW						
	50 DAS	50 DAS	50 DAS	50 DAS				
Atrazine1.0 kg/ha *fb* atrazine 0.75 kg/ha 25 DAS	6.53 (41.7)	2.71 (6.3)	6.32 (39.8)	29.7	33.0	5.07	21,072	1.89
Atrazine 1.0 kg/ha*fb* 2,4-D sodium salt 0.4 kg/ha 25 DAS	4.93 (23.3)	2.52 (5.3)	5.41 (30.2)	49.1	31.2	5.56	24,654	2.06
Glyphosate 1.0 kg/ha (pre plant) *fb a*trazine 0.75 kg/ha at 25 DAS	6.02 (35.3)	4.26 (17.3)	5.16 (24.5)	51.4	14.6	6.21	44,082	2.84
Glyphosate 1.0 kg/ha*fb* 2,4D sodium salt 0.4 kg /ha 25 DAS	5.94 (34.3)	3.69 (13.3)	5.06 (24.4)	59.5	6.93	7.51	59,385	3.56
Metribuzin 0.25 kg/ha *fb* atrazine 0.75 kg/ha at 25 DAS	9.99 (99.0)	4.65 (20.7)	7.05 (49.0)	11.8	33.7	4.81	25,696	2.09
Atrazine 1.0 kg/ha *fb* topremezone 25.2 g/ ha	5.26 (26.7)	3.0 (8.0)	5.62 (31.2)	44.2	20.7	5.12	32,063	2.31
Weedy check (unweeded check)	10.47 (109)	5.03 (24.3)	7.53 (55.3)	-	-	3.94	17,388	1.78
Weed free (HW at 25 and 45 DAS)	3.73 (13.0)	2.16 (3.7)	3.65 (13.0)	76.4	45.6	7.26	54,499	3.24
LSD (P=0.05)	0.21	0.42	0.28	--	--	0. 97		

*Values in parentheses are original; weed data transformed to square root transformation

CONCLUSION

It was concluded that pre-plant application of gyphosate1.0 kg/ha followed by 2,4-D Sodium salt 0.4 kg/ha as post-emergence at 25 DAS was most effective in controlling weeds, improving grain yield and profitability of zero-till maize.

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Adoption of conservation agriculture-based technologies in the Jabalpur region of central India: Success story

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Jabalpur is located in the central plateau region of India. Crop production in this region is dominated by rice, soybean, maize and sugarcane in kharif, followed by wheat, chickpea, lentil, peas and mustard in the rabi season. Soils are deep black cotton in most areas belonging to vertisols. Farmers follow conventional practices like intensive ploughing of the land, clean cultivation (removal or burning of all crop residues and stubbles), fixed crop rotations, and little use of organic manures and moderate use of chemical fertilizers, and other pesticides including herbicides. Combine harvesting of major crops is followed predominantly and the crop residues are invariably burnt in most areas (Singh et al., 2015). There is only small area under greengram and other vegetable crops during summer due to social problems like open cattle grazing. Due to the rising costs of cultivation, the profitability margins are generally low (Rs. 10000 to 20,000 per ha per annum). There is need for promotion and adoption of resource conservation technologies to reduce the cost of cultivation and improve soil health, besides other environmental benefits.

METHODOLOGY

On-farm research trials were undertaken from 2012 onwards in six localities about 50-100 km from Jabalpur. In each locality, 2-3 villages were selected, and 5-8 farmers were identified in each village based on the interest shown by them and suitability of the land. Resource conservation technologies such as direct-seeding of rice, brown manuring with *Sesbania*, zero-till sowing of crops, residue retention on soil surface, summer legumes like greengram or *Sesbania*, and integrated weed management were demonstrated in diversified cropping systems. Nearly 100 such on-form research trails were conducted during 2012-15.The locations, villages, crops, and the major interventions are mentioned in Table 1.

Locality	Villages	Crops / cropping system	Major interventions
Jabalpur			
Majholi	Pola, Dhora, Hinota, Gathora	Soybean - chickpea	Line /zero till sowing, recommended seed rate and fertilizer, improved weed management
Bankhedi	Amna, Dhanwahi	Rice-wheat	Line /zero till sowing in wheat, recommended seed rate and fertilizer, improved weed management
Panagar	Mahagawa, Kariwah, Chanti, Beher, Bharda, Padaria	Rice-wheat-greengram	Resource conservation technologies, improved weed management, recommended seed rate
Shahpura	Bhamki, Kisrod, Magarmuha, Noni	Rice-wheat/chickpea	Resource conservation technologies, improved weed and fertilizer management, recommended seed rate
Gosalpur	Podi-nindora, Bhadam, Khajari	Rice-wheat	Resource conservation technologies, improved weed and fertilizer management, recommended seed rate
Kundam	Khukham, Padariya, Ranipur, Kalyanpur	Maize-wheat	Line sowing, recommended seed rate and fertilizer, improved weed management
Other districts			
Katni	KVK	Wheat	Resource conservation technologies, improved weed and fertilizer management, recommended seed rate
Narsinghpur	KVK	Wheat, summer greengram	Resource conservation technologies, improved weed and fertilizer management, recommended seed rate
Damoh	KVK	Wheat	Resource conservation technologies, improved weed and fertilizer management, recommended seed rate

An area of 1 acre was selected for the on-farm trial, in which 3-4 suitable inventions as per requirement were introduced. Data on weed growth, yield, economics and response of the farmers was collected. A Kisan Gosthi involving 75-100 farmers was organized at each locality during *kharif* and/or *rabi* season to discuss the findings and receive feedback from the farmers. Visits of the key officials were arranged and the events were covered widely in the print and electronic media.

RESULTS

Based on the findings of the last 3 years, the following observations were made:

·Direct-seeding of rice by mid-June is the most suitable option to replace transplanting so as to get an assured crop, reduced the cost of cultivation (by ₹ 2500 /ha) and higher income (by 15-20%).

·Weed in direct-seeded rice can be effectively controlled through a sequential application of pre-emergence herbicides (pendimethalin/pretilachlor) followed by post-emergence herbicides (bispyribac-Na/Fenoxaprop *fb* 2, 4-D /metsulfuron + chlorimuron). A light manual weeding may be requested in specific situations for ensuring perfect weed-free conditions.

·Zero-till sowing of wheat in the residues of previous rice crop with a happy seeder showed outstanding performance and yielded 15-20% more at much reduced cost (₹ 4500/ ha). The zero-till sown crop did not lodge under adverse weather conditions. Successful weed control was achieved with a single post-emergence application of available herbicides like sulfosulfuron, clodinafop, or herbicide mixtures like sulfosulfuron +metsulfuron , mesosulfuron + iodosulfuron and clodinafop+metsulfuron.

·Sowing of greengram by mid-April immediately after the harvest and in the residues of wheat gave an yield of 1.3-1.5 t/ ha in 65 days. Weed control in greengram was achieved by a single application of post emergence herbicide like quizalofop/imazethapyr at 25 DAS.

·Growing of zero-till greengram or *Sesbania* in summer

Weed management in rice-based cropping systems under conservation agriculture

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Weed problems have increased with high-input agriculture. These necessitate continuous monitoring and up-scaling of weed management strategies on a long-term basis. Conservation agriculture is being talked of as a new paradigm in resource management research but weeds are a serious problem in such a system. Diversification and continuous cropping have largely changed the weed communities and, in some cases, these become resistant to commonly used herbicides. Therefore, use of the herbicides has to be investigated in a system perspective. Weed population density and biomass production may be markedly reduced by using crop rotation (temporal diversification) and intercropping (spatial diversification) strategies. In recent years, several low-dose high-potency herbicide molecules have become available, for which, spraying machines and techniques need to be standardized. Hence, an experiment was initiated to address these issues and develop sustainable weed management practices in rice-based cropping system.

METHODOLOGY

A long-term experiment on the effect of crop establishment techniques and weed control measures under conservation agriculture system was conducted at experimental farm of ICAR-Directorate of Weed Research Jabalpur, Madhya Pradesh, India (23°132 N, 79°582 E, and 390 m above mean sea level) during *kharif* 2013 and *rabi* 2013-14 to monitor weed dynamics and crop productivity under rice-based and non-rice-based cropping systems. The soil of experimental field was clay loam in texture, neutral (7.2) in reaction, medium in organic C (0.79%), available N (312 kg N / ha) and P (18 kg P_2O_5 / ha) but high in available K (291 kg K_2O/ ha). Total fifteen treatments consisting of five crop establishment methods, viz. (i) CT(DSR) -CT (mustard / pea / winter maize - ZT (greengram), (ii) CT (DSR) + GR -ZT + RR (mustard / pea / winter maize) -ZT + MsR, PR, MR (greengram), (iii) ZT (DSR) - CT (mustard / pea / winter maize) -ZT (greengram), (iv) ZT (DSR) + GR - ZT + RR (mustard / pea / winter maize) - ZT + MsR, PR, MR (greengram), and (v) CT (TPR) - CT (mustard / pea / winter maize), as main plots; three cropping systems, viz. DSR-mustard, DSR-pea and DSR-winter maize as sub-plot treatments; and three weed control measures, viz. recommended herbicides, integrated weed management (herbicide + mechanical / manual weeding) and unweeded (control) as sub-sub plots were laid out in split-split plot design with three replications.

RESULTS

Predominant weed species in rice were: *Echinochloa colona* and *Dinebra retroflexa* among grasses; *Caesulia axillaris* and *Alternanthera sessilis* among broadleaved weeds; and *Cyperus iria* among sedges. There was significant effect on weed flora distribution, total weed population and weed dry matter production due to different crop establishment techniques. Significantly lowest *E. colona* and *D. retroflexa* was recorded with transplanted rice. Adoption of zero tillage for direct-seeded rice + retention of previous season crop residues recorded lower population of *C. iria* and *Physalis minima* compared to conventional tillage for transplanting. Significantly lowest weed growth (density and dry biomass) and highest grain yield of rice were recorded with adoption of conventional tillage for transplanting, which was at par with the adoption of ZT (DSR). In direct-seeded rice, adoption of zero tillage produced higher grain yield than conventional tillage. Different cropping systems also significantly influenced the weed distribution, weed dry matter production and grain yield of rice. Significantly lowest population of *E. colona* and *C. iria* was noticed with DSR-winter maize cropping system. Similarly, lowest weed biomass and highest grain yield of rice were recorded under DSR-winter maize and DSR - mustard, respectively. Amongst weed control treatments, post-emergence application bisphyribac-sodium @ 25 g/ha recorded the lowest weed growth and highest grain yield of rice, which was statistically at par with application of recommended herbicide followed by 1 HW at 40 DAS.

Table: Weed growth and grain yield of rice as influenced by different crop establishment and weed management under rice-based cropping systems (2013-14)

Treatment	Weed density (no./m^2)		Weed dry weight (g/m^2)		Grain yield (t/ha)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	Rice	Rice equivalent
Tillage and crop establishment						
CT(DSR)+S – CT - ZT	6.3 (39.1)	13.3 (171.9)	8.18 (66.4)	8.3 (68.2)	2.92	3.88
CT(DRS)+S+R – CT + R -ZT	6.6 (42.8)	14.2 (200.0)	7.4 (54.7)	8.4 (69.5)	3.17	4.07
ZT(DRS)+S -ZT-ZT	6.7 (44.0)	15.5 (241.0)	9.6 (90.7)	10.0 (98.9)	3.14	4.06
ZT(DRS)+S +R –ZT+R -ZT	5.5 (29.9)	14.4 (206.0)	7.6 (60.3)	8.9 (78.2)	3.46	4.08
CT (TPR) - CT	4.2 (17.5)	12.9 (165.4)	4.5 (19.6)	7.5 (55.9)	3.65	3.57
LSD (P= 0.05)	1.0	0.8	1.5	1.1	0.09	0.10
Cropping system						
DRS- pea	6.2 (38.1)	15.2 (229.0)	7.5 (55.3)	8.5 (71.8)	3.05	3.05
DRS- mustard	6.6 (43.1)	17.5 (305.8)	7.7 (58.6)	8.5 (71.4)	3.61	3.19
DRS- winter maize	4.8 (22.3)	9.5 (89.8)	7.2 (50.9)	8.8 (77.3)	3.15	5.56
LSD (P=0.05)	0.9	0.6	0.9	0.7	0.06	0.14
Weed control						
Weedy check	12.3 (150.1)	19.4 (374.7)	16.2 (263.2)	12.8 (162.8)	2.42	3.02
Herbicide	2.4 (5.1)	12.8 (162.8)	2.4 (5.0)	7.8 (60.0)	3.77	4.04
Herbicide + HW	3.0 (8.5)	10.0 (99.9)	3.7 (13.4)	5.3 (27.2)	3.62	4.67
LSD (P=0.05)	0.7	0.7	0.9	0.6	0.06	0.09

DSR - direct-seeded rice, TPR - transplanted rice, S - *Sesbania* brown manuring, CT - conventional tillage; ZT - zero tillage, R - residue,

*Data subjected to "x+0.5 transformation. Figures in parentheses are original values.

Dominant weed flora in pea, mustard and winter maize were: *Phalaris minor* and *Avena ludoviciana* among grasses, and *Medicago hispida, Lathyrus sativa* and *Chenopodium album* among broadleaved weeds. Significantly lowest population of *C. album, L. sativa* and *P. minor* were recorded with adopting conventional tillage for sowing of *rabi* crops without previous season crop residues. However, adoption of conventional tillage for transplanting recorded lower population of *A. ludoviciana* and *M. hispida*.

Significantly highest rice equivalent yield (4.1 t/ha) was obtained with adoption of conventional/zero tillage ± of previous season crop residues over CT (TPR)-CT crop establishment techniques. Amongst cropping systems, the lowest population of *M. denticulata*, *P. minor*, and *L. aphaca* was recorded under DSR - winter maize cropping system. However, the lowest population of *A. ludoviciana* and *C. album* was under DSR - mustard system.

CONCLUSION

Different cropping systems did not influence significantly the total weed dry biomass production. The rice equivalent yield was highest under DSR - winter maize

Tillage systems affect the performance of herbicides in direct seeded rice

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Decreased availability of labour or water and their increased costs, has triggered the adoption of dry-seeded rice (DSR) in Asian countries. DSR can be sown under zero-till (ZT) conditions or after tillage in a well-prepared seedbed. In addition to reducing labour and fuel costs, ZT systems may improve soil physical and chemical properties, conserve soil moisture, and reduce soil erosion. Weeds, however, are the main constraint to the production of DSR. Tillage systems greatly influence the composition of weed communities through their effects on the vertical distribution of weed seeds in soil, the relative time of emergence, the abundance of a particular weed species, and weed seed survival.Changing tillage practices may also change herbicide performance, particularly for pre-emergence (PRE) soil-active herbicides (Chauhan *et al.* 2006).

METHODOLOGY

A field study was conducted during 2012 and 2013 at Punjab Agricultural University, Ludhiana, India, with two tillage systems: conventional tillage (CONT) and zero tillage (ZT) in the main plots, and six weed control treatments-pendimethalin (750 g/ha) as PRE, *fb* bispyribac-sodium (25 g/ha) as post-emergence (POST), oxadiargyl (90g/ha) as PRE *fb* bispyribac-sodium (25 g/ha) as POST, oxadiargyl (90 g/ha) as PRE *fb* fenoxaprop-p-ethyl (70 g/ha) as POST and oxadiargyl (90 g/ha) as PRE *fb* fenoxaprop-p-ethyl (70 g/ha) as POST *fb* ethoxysulfuron (20 g/ha) as POST along with non-sprayed check in the subplots.. The experiment was laid out in a split-plot design with three replications. Rice (variety PR 115) was sown at a seed rate of 25 kg/ha. The field was surface-irrigated immediately after sowing and kept moist throughout the season. Biomass of different weeds was recorded at crop maturity and data were square-root-transformed before performing ANOVA. For interpretation of tillage effects at each weed control treatment, the effect of herbicides was sliced out from the interaction effect of tillage and herbicides in SAS 9.3. For clear presentation of weed data, the original values are used for calculating per cent change in weed biomass.

RESULTS

There was no difference in the biomass of weeds for all the weed categories in the weedy check for different tillage systems, during both the years. Pendimethalin *fb* bispyribac when applied to ZT-DSR, resulted in 338-446% increase in grass weed biomass and 171-333% increase in broadleaf weed biomass as compared to CONT-DSR, whereas sedges did not show any differences for tillage systems. Similarly, grass weed biomass was increased by 74-86% in ZT-DSR over CONT-DSR when oxadiargyl *fb* bispyribacwere applied. Shifts in weed species have been reported with the adoption of ZT and dry seeding (Tuong *et al.* 2005). Oxadiargyl fbfenoxaprop resulted in an increase in sedge and broadleafweedbiomass under ZT-DSR by 101 and 76%, respectively, during the year 2013 only. The biomass of grass weeds was decreased by 65-69% under ZT-DSR over the CONT-DSR system when oxadiargyl *fb* fenoxaprop *fb* ethoxysulfuronwereapplied. Dominance of grass weeds resulted in a similar response of the total weed biomass to tillage systems. Total weed biomass was higher in ZT-DSR as compared to CONT-DSR, under pendimethalinfbbispyribac (279-377%) and oxadiargyl *fb* bispyribac (77-89%) during both the years. However, oxadiargyl *fb* fenoxaprop *fb* ethoxysulfuron resulted in lesser total weed biomass by 54-57% in ZT-DSR when compared with the CONT-DSR system.

CONCLUSION

Herbicide efficacy decreases under the ZT-DSR system when compared with CONT, especially for PRE herbicides. For ZT systems, the weeds escaped from PRE herbicides could be tackled through more POST herbicide applications.

Table 1. Change in weed biomass (%) under different weed control treatments in ZT-DSR over CONT-DSR system)

Weed control	Grass weeds	Sedges	Broadleaf weeds	Total weeds
2012				
Weedy check	Ns	ns	ns	ns
Pendimethalin PRE *fb* Bispyribac POST	+446.1*	ns	+333.3*	+377.3*
Oxadiargyl PRE *fb* Bispyribac POST	+85.8*	ns	ns	+89.2*
Oxadiargyl PRE *fb* Fenoxaprop POST	Ns	ns	ns	ns
Oxadiargyl PRE *fb* Fenoxaprop POST fb Ethoxysulfuron POST	-68.7*	ns	ns	-53.9*
2013				
Weedy check	Ns	ns	ns	ns
Pendimethalin PRE *fb* Bispyribac POST	+337.8*	ns	+170.8*	+278.5*
Oxadiargyl PRE *fb* Bispyribac POST	+74.1*	ns	ns	+76.9*
Oxadiargyl PRE *fb* Fenoxaprop POST	Ns	+101.7*	+76.2*	ns
Oxadiargyl PRE *fb* Fenoxaprop POST *fb* Ethoxysulfuron POST	-65.1*	ns	ns	-56.8*

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Weed dynamics and weed-seed stratification in soybean under conservation tillage practices in Vertisols

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Conservation agriculture (CA) has been an approach to manage agro ecosystems for improved and sustained productivity. It has three pronged principles i.e. continuous minimum mechanical soil disturbance, permanent organic soil cover and crop rotation. However, weed management is one of the main concerns of conservation tillage. Keeping this in view, conservation tillage systems have a major influence on weed flora, density and weed-seed stratification. Moreover, availability of non-residual herbicides has made possible to adopt conservation tillage techniques such as reduced tillage and no-tillage. It is evident that weed control in the no-till plots is a major problem. However, to arrive at a suitable control measure, it is necessary to understand the effects of tillage on weeds, their densities and community distribution (species wise). Thus, the present study was undertaken to study the basic changes that occurred due to tillage treatments that were imposed over a long-period of time

METHODOLOGY

A field experiment was conducted on soybean during Kharif 2009-2012 at the research farm of Indian Institute of Soil Science (ICAR), Bhopal (23^o 18'N latitude and 77^o 24'E longitude). The soybean cv JS-335 was sown at 30 x 7.5 cm with the seed rate of 75 kg/ha. In the on-going long-term tillage experiment, observations on weeds were recorded periodically. In the *Kharif* season, observations on weed density/m^2 and species diversity were recorded from four tillage treatments (CT- conventional tillage; MB- mould board ploughing; RT- reduced tillage; and NT- no tillage). Estimated diversity indices i.e. Simpson diversity index and Shannon-Weiner diversity index based on the weed species-wise data. The data on grain yield and attributes was statistically analysed with a split plot design. Weed index was determined to calculate the loss in yield due to weeds.

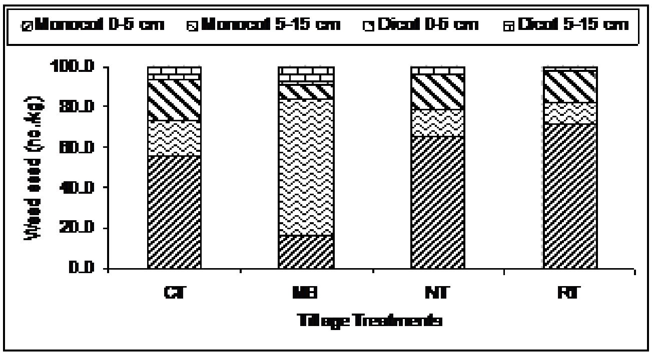

Fig. 1. The vertical distribution of grasses and broadleaf weed seeds (%) in the soil profile

(0-5 and 5-15 cm) in different tillage treatments

RESULTS

Weeds namely *Echinochloa colona*, *Cyperus rotundus*, *Saccharum spontaneum*, *Cynodon dactylon*, *Euphorbia hirta*, *Digera arvensis*, and *Tridex procumbens* were predominant in soybean. However, during previous year *Alternanthera sessilis* and *Trianthema portulacastrum* were the dominant weeds in tilled plots. Since tillage operations influence weed seed species survival, weed seed distribution in the soil is affected. Weed seed bank was determined using the germination assays at ambient conditions. Different tillage systems disturb the vertical distribution of weed seeds in the soil in different ways (Fig. 1).

Studies have found that mould board plough (MB) buries most weed seeds in the tillage layer, whereas CT, NT and RT keep most of the weeds closer to the soil surface. Similarly in RT and NT system around 82 – 88% of the weed seeds were located in the top 5 cm of the soil. Swanton *et al.* (2000) also reported similar pattern. Further, conservation tillage (RT and ZT) do not bring weed seeds from deeper in the soil profile up to the soil surface. The weed seed stratification could be due to two reasons i.e. physical protection and dormancy. Thus, study indicated that prominence of grasses weeds are more associated with conservation tillage methods like NT and RT in surface depth. Shifts in weed population from annuals to perennials have been observed in conservation tillage system. Simpson Diversity Index as well as Shannon Weiner Index values were higher in CT and MB compared to NT and RT. Thus, diversity of weed species was more in treatments where tillage intensity was higher i.e. CT and MB. Thus, tillage operation carries weed seeds from one place to another which resulted in more diversity in tillage treatment. On the contrary, NT and RT have recorded lower weed diversity as there is no/less tillage intervention. Additionally, soybean yield attributes and grain yield were also monitored. Data indicates a significant effect of tillage systems, however, among tillage systems, the CT system had the least grain yields and was significantly lower than the MB, RT and NT treatments.

CONCLUSION

Weed density showed the trend as MB< RT = NT < CT as use of pre-emergence herbicide suppressed the weeds in NT and RT compared to the treatment CT. No-tillage systems retained weed seeds in the surface soil and showed lower weed diversity.

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Weed control, yield and economics of maize under various tillage and weed management

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Among the crop production factors, tillage contributes up to 20% of the yield. The use of minimum tillage in maize cultivation is increasing for reduction in time, fuel and labour requirements. Zero tillage is superior to conventional tillage for higher moisture retention and more income. Greater growth and yield of maize has been reported in zero till method with use of herbicides (Chopra and Angiras, 2008). The experiment was designed to find the best combination of tillage and weed management practices to achieve the maximum productivity and profitability.

METHODOLOGY

The experiment was conducted at Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India. The textural class of the 0-15 cm soil layer was sandy loam (sand 71.6 %, silt 19.1% and clay 10.3 %). The treatments comprised two factors, *viz*. tillage methods with 3 levels *i.e.* CT: conventional tillage, MT: minimum tillage, ZT: glyphosate + zero tillage and weed management practices with 6 levels *i.e.* W_1 : atrazine at 1.25 kg/ha, W_2 : 2,4 - D ammonium salt at 0.5 kg/ha, W_3 : atrazine at 1.25 kg/ha + 2,4 D ammonium salt at 0.5 kg/ha , W_4 : atrazine at 1.25 kg/ha + one hand weeding at 30 DAS and W_5 : two hand weedings at 15 and 30 DAS, W_6 :weedy check . The treatments were tried in split plot design with three replications. Maize hybrid 'Nilesh (NHM-51)' was used for experimentation. . The sowing was done on 21 January 2014 in glyphosate + zero till plots and on 5 February 2014 in conventional and minimum till plots with recommended seed rate of 20 kg/ha and spacing of 60 x 25 cm. Glyphosate 1.0 kg/ha was sprayed on weeds and ratoon rice 10 days before sowing.

RESULTS

Atrazine + one hand weeding under zero tillage (ZT) recorded the minimum weed dry weight of 10.01 g/m^2 (Table 1). The same weed management under minimum tillage and two hand weedings under zero tillage were at par with this treatment. All other treatment combinations recorded significantly higher dry weight of weeds than atrazine + one hand weeding. Atrazine + one hand weeding under zero tillage + glyphosate recorded the maximum grain yield of 8.08 t/ha. Atrazine + 2,4-D and two hand weeding at 15 and 30 DAS under zero tillage, atrazine + 2,4-D, atrazine + one hand weeding and two hand weeding at 15 and 30 DAS under minimum tillage, atrazine + 2,4-D and atrazine + one hand weeding under conventional tillage were at par with it for grain yield. All other treatment combinations proved significantly inferior to it.Atrazine+ one hand weeding under zero tillage gave the maximum net return of ₹88392/ha. Atrazine + 2, 4-D under zero tillage and conventional tillage and atrazine + one hand weeding under minimum tillage remained at par with it.

Table 1. Dry weight of weed atharvest, yield and net return in maize under various tillage and weed management

Treatment	Atrazine	2,4-D	Atrazine +2,4-D	Atrazine +1HW	2HW	Weedy check	Mean
Dry weight of weeds at harvest (g/m^2)							
Conventional tillage	6.02* (35.29) **	5.64 (30.78)	4.60 (20.13)	4.06 (15.47)	4.40 (18.43)	9.66 (92.28)	5.73 (35.40)
Minimum tillage	5.75 (32.14)	5.39 (27.99)	4.38 (18.13)	3.75 (13.09)	4.18(16.50)	9.03 (81.58)	5.41 (31.57)
Zero tillage	5.26 (26.70)	4.92 (23.30)	3.98 (14.88)	3.32 (10.01)	3.84 (13.71)	7.99 (62.85)	4.89 (25.24)
Mean	5.68 (31.26)	5.32 (45.96)	4.32 (17.66)	3.71 (12.76)	4.14 (16.14)	8.89 (78.03)	5.34 (27.52)
LSD (P=0.05)	T = 0.26, W = 0.17, T×W = 0.52, W×T = 0.29						
Grain yield (t/ha)							
Conventional tillage	5.92	4.78	7.11	7.21	6.67	3.74	5.91
Minimum tillage	6.32	5.13	7.33	7.57	7.23	4.61	6.37
Zero tillage	7.08	5.76	7.65	8.08	7.16	4.65	6.73
Mean	6.44	5.22	7.36	7.62	7.02	4.33	6.33
LSD (P=0.05)	T = 0.59, W = 0.22, T×W = 0.96, W×T = 0.38						
Net returns(₹/ha)							
Conventional tillage	54617	38883	71497	70880	60692	24314	53481
Minimum tillage	62619	46316	76813	78631	71275	39070	62454
Zero tillage	75434	57173	83168	88392	72922	41038	69688
Mean	64223	47458	77159	79301	68297	34807	61874
LSD (P=0.05)	T =8994 W =3093 T×W =14338 W×T = 5358						

** Original values in parentheses and * " (x+1) transformed ones before parentheses

CONCLUSION

Atrazine+ one hand weeding under zero tillage proved the best with the minimum dry weight of weeds, themaximum grain yield and net returns.

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Effect of conservation tillage and nutrient management practices on weed dynamics in finger millet under rainfed conditions

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Finger millet (*Eleusine coracana*) is an important millet crop of southern Karnataka under rainfed conditions with its well-known nutritional qualities made the crop very popular. Now a day, conservation tillage practices are becoming very popular due to its various benefits such as reduced cost of cultivation, improved soil health etc., where the soil was least disturbed. Under such conditions, weeds are the major causes for yield reduction as these competes with the crop for nutrients, water, sunlight and space where use of herbicides to manage weeds forms an appropriate alternative strategy to manual weeding (Baskaran and Kavimani, 2014).

METHODOLOGY

A field experiment was conducted during *Kharif* 2014 at AICRP on Dry Land Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India on red sandy clay loam soilusing split plot design with 3 main tillage plots and 5 nutrient management sub plots replicated thriceto study the effect of different tillage and nutrient management practices on weed dynamics and yield of finger millet. The horse gram (variety "PHG-9")was sown in May with pre-monsoon rains on respective treatment plots for mulching and harvested at 60 DAS and was mulched in between crop rows.Finger millet variety "GPU-28" was used with a seed rate of 10 kg/ha.

RESULTS

The major weed floras observed in the experimental field were *Cyperus rotundus* among sedges, *Cynodon dactylon*, *Eleusine indica* among grasses and *Borreria hispida* and *Portulaca oleraceae* among broad leaf weeds. Tillage treatments significantly influenced the weed dynamics. Conventional tillage has recorded significantly higher grain yield (3.20 t/ha) due to lower total weed density and dry weight at both 30 and 60 DAS because of suppression and removal of weeds by tillage and intercultivation resulting in better weed control efficiencyapart from creation of favourable conditions for crop growth. Whereas, significantly lower grain yield (2.30 t/ha) with higher weed index (35.49%) wasrecorded in zero tillage due to higher weed growthbecause ofdeposition of weed seeds in the upper layer of the soil as confirmed by Baskaran and Kavimani (2014).The nutrient management treatments have not differed significantly in weed control (Table 1).

Significantly higher grain yield was noticed in 100% recommended NPK + 7.5 t FYM/ha compared to other treatments which was due to integrated nutrient supply which enhanced the nutrient availability apart from improved soil physical, chemical and biological properties followed by other treatments. Whereas, significantly lower grain yield was observed in horse gram residue mulch + 50 % recommended NPK + 25 % N through FYM + *Azotobacter* seed treatment.

Table1. Weed growth and grain yield of finger millet as influenced by tillage and nutrient management practices

Treatment	30 DAS			60 DAS			Grain yield (t/ha)
	*TWD (No/m^2)	*TWDW (g/m^2)	WCE (%)	*TWD (No/m^2)	*TWDW (g/m^2)	WCE (%)	
Tillage							
T_1	1.06 (13.22)	0.92 (8.24)	92.5	1.22 (21.26)	1.00 (9.24)	93.3	3.20
T_2	1.65 (43.26)	1.50 (30.38)	72.5	1.84 (69.77)	1.35 (22.31)	83.8	2.75
T_3	1.95 (93.69)	1.78 (63.42)	42.5	2.24 (185.69)	1.76 (57.46)	58.2	2.30
LSD (p=0.05)	0.28	0.24	NA	0.32	0.15	NA	0.302
Nutrient management							
N_1	1.60 (51.66)	1.44 (34.54)	68.7	1.82 (94.66)	1.42 (30.63)	77.7	2.48
N_2	1.71 (59.99)	1.54 (40.64)	63.2	1.94 (109.34)	1.48 (35.08)	74.5	3.24
N_3	1.45 (41.68)	1.32 (28.64)	74.0	1.65 (77.29)	1.29 (24.82)	82.0	2.79
N_4	1.54 (48.94)	1.39 (33.36)	69.8	1.76 (90.50)	1.37 (29.79)	78.4	2.37
N_5	1.46 (48.01)	1.32 (32.88)	70.2	1.67 (89.40)	1.28 (28.02)	79.6	2.88
LSD (p=0.05)	NS	NS	NA	NS	NS	NA	187

Note: T_1: conventional tillage (2 ploughings + 1 harrowing + 2 intercultivations at 25 and 50 DAS), T_2: minimum tillage (1 ploughing + 1 harrowing + pre emergence -isoproturon at 565 g/ha) - drill sown finger millet and T_3: zero tillage (glyphosate 41 SL at 10 ml/l at 15 days before transplanting) with transplanted finger millet at 25 DAS. ; N_1: 100 % recommended NPK (50:40:25 kg NPK/ha), N_2: 100% recommended NPK + 7.5 t FYM/ha, N_3: horse gram residue mulch + 100 % recommended NPK, N_4: horse gram residue mulch + 50 % recommended NPK + 25 % N through FYM + *Azotobacter* seed treatment and N_5: horse gram residue mulch + fertilizers based on soil test results (100 % P and 130 % N and K).; *Values in parentheses are original. Data transformed to log(x+2) transformation, DAS-Days after sowing, TWD-Total weed density, TWDW-Total weed dry weight, WCE-Weed control efficiency, WI-Weed index, NS-Non-significant, NA-Not analysed; The data on TWDW in control (110.3 g/m^2 at 30 DASand 137.6 g/m^2 at 60 DAS) for calculating WCEand grain yield in weed free conditions (3.56 t/ha) were taken from additional plots.

CONCLUSION

The conventional tillage was most effective for realizing higher yields and application of 100% recommended NPK + 7.5 t FYM/ha will give higher yields due to its additional soil health benefits in finger millet under rainfed conditions.

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Effect of tillage and weed control practices on performance of cotton-wheat cropping system

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Conservation agriculture (CA) technologies are based on 3 main principles (i) minimum soil disturbance, (ii) permanent soil cover through crop residues or cover crops and (iii) crop rotations for achieving higher productivity (Abrol and Sangar, 2006). Conservation agriculture has become a frontline area of focus to address the above problems.Adequate food production in the future can only be achieved through the implementation of sustainable growing practices. For this, conservation agriculture (CA) is recognized as potential way to achieve sustainability by improving the biological functions of the agro-ecosystem with limited mechanical practices and judicious use of chemical inputs (Derpsch *et al.* 2010; Derpsch *et al.* 2011). Main principle of CA is to minimize soil disturbance through ZT or conservation tillage or reduced tillage. But by adopting conservation agriculture weed management becomes a great challenge. This has been the major reasons for poor adoption of CA technology. This is the high time that we should address this challenge in an eco-friendly way so that CA can be easily adopted by farmers. Considering these issues, we conducted a field experiment to know the effect of tillage and weed control practices on performance of cotton-wheat cropping system.

METHODOLOGY

A field experiment was conducted to study the effect of different tillage and crop establishment practices, *viz.* conventional tillage- flat sowing, conventional tillage – bed sowing, zero tillage – flat sowing and zero tillage- bed sowing (permanent beds); and weed control practices, *viz.* unweeded control, weed-free, pendimethalin + hand weeding, and pendimethalin + paraquat spray. Cotton was sown after the harvest of wheat on 30th May at 70 x 50 cm spacing. Pendimethalin was applied at 1.0 kg/ha, hand weeding was done at 35 days and directed spraying of paraquat was done with 0.5% solution at 35 days in the inter-row spaces. No weeds were allowed to grow in the weed-free treatment with repeated hand weeding.

RESULTS

In the first cycle (2007-08), seed cotton yield was significantly higher in raised-bed than flat-sown crop under both conventional and zero tillage conditions. The mean increase in yield was 0.19-0.34 t/ha under raised-bed over flat sowing. Application of pendimethalin along with hand weeding or directed paraquat spray gave equal seed cotton yield, which was at par with weed-free treatment. This was due to effective weed control under these treatments, which led to 43-46% higher yield than unweeded conditions. Wheat crop, which was grown under the same treatments of tillage and crop establishment as applied to cotton, performed better with conventional tillage and under flat sowing than zero tillage conditions. Zero-tilled wheat gave comparatively lower yield than conventional tillage under flat as well as bed-planted conditions. The mean yield was decreased by 0.12 t/ha under zero tillage and by 0.28 t/ha under bed planting conditions. This was in part due to higher weed infestation under zero-tillage conditions. Application of isoproturon and sulfosulfuron gave equal yields, which were on par with weed-free conditions. Both herbicides resulted in near complete elimination of weeds (93-94%), which led to higher productivity.

Although cotton performed equally well under both tillage practices in the first cycle (2007) but the yield was decreased by 19.4% under zero tillage compared with conventional tillage in the second cycle (2008). Cotton sown on raised-bed gave 9.9-12.5% higher yield than on flat surface in both cropping cycles, irrespective of tillage. Pendimethalin + hand weeding or pendimethalin + paraquat spray were equally good as weed-free in increasing seed cotton yield over unweeded control. The problem of perennial weeds like *Cyperus* and *Cynodon*, as well as *Parthenium* increased in the second cropping cycle.

Table 1. Effect of tillage and weed control practices on cotton-wheat cropping system in the first cropping cycle (2007-08)

Treatment	Cotton (2007)		Wheat (2007-08)	
	Weed dry weight (g/m^2)	Seed cotton yield (t/ha)	Weed dry weight (g/m^2)	Grain yield (t/ha)
Tillage and crop establishment				
CT – flat sowing	213	2.01	70	4.43
CT – raised-bed	222	2.35	82	4.08
ZT – flat sowing	234	2.14	179	4.24
ZT – raised-bed	241	2.33	212	4.04
LSD (P=0.05)	NS	0.25	53	0.30
*Weed control practices				
Unweeded	565	1.66	478	3.49
Weed-free	0	2.37	0	4.44
Herbicide 1	33	2.42	30	4.23
Herbicide 2	85	2.38	35	4.27
LSD (P=0.05)	22	0.17	35	0.21

*Herbicide 1: Pendimethalin at 0.75 kg/ha + hand weeding for cotton, and isoproturon at 1.0 kg/ha for wheat; herbicide 2- pendimethalin at 0.75 kg/ha + directed spray of paraquat for cotton, and sulfosulfuron at 0.025 kg/ha for wheat

Table 2. Effect of tillage and weed control practices on cotton in the second cycle (2008)

Treatment	Weed dry weight (g/m^2)	Seed cotton yield (t/ha)
Tillage and crop establishment		
CT – flat sowing	154	2.52
CT – raised-bed	170	2.78
ZT – flat sowing	220	2.11
ZT – raised-bed	246	2.32
LSD (P=0.05)	75	0.26
*Weed control practices		
Unweeded	603	0.91
Weed-free	0	3.05
Pendimethalin at 0.75 kg/ha + hand weeding	85	2.88
pendimethalin at 0.75 kg/ha + directed spray of paraquat	102	2.89
LSD (P=0.05)	50	0.23

CONCLUSION

Application of pendimethalin along with hand weeding or directed paraquat spray gave equal seed cotton yield, which was at par with weed-free treatment. Application of isoproturon and sulfosulfuron gave equal yields in wheat, which were on par with weed-free conditions.

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Zero-tillage combined with residue mulch suppressed weeds and increased yield in wheat in the Eastern India

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Wheat productivity in Eastern Indo-Gangetic Plains (IGP) is low compared to North-western IGP mainly because of late planting of wheat coupled with higher yield losses due to weeds. Late planting makes wheat more vulnerable to terminal heat stress and hence increases the risks of higher yield penalty. Zero-tillage (ZT) facilitates in early planting of wheat by reducing land preparation time (Singh *et al*. 2009). In addition, ZT with residue retention has been found effective in minimizing the adverse effects of terminal heat stress. In Northwest India, it has been reported that ZT combined with residue retention on soil surface as mulch is very effective in suppressing weeds in wheat (Kumar *et al*. 2013). The present study was conducted with the objective to study the effects of tillage and different levels of residues (no residue, anchored, anchored + loose) and herbicides on weed suppression, wheat productivity and profitability.

METHODOLOGY

An experiment was conducted at BHU, Varanasi, during *Rabi* season 2011-12 in a split plot design with four replications. Main plot treatments comprised of a combination of six tillage and residue management (conventional tillage without residue (TR_1), zero tillage without residue (TR_2), zero tillage with anchored residue (cut at 30 cm height) (TR_3) , zero tillage with anchored residue (cut at 30 cm height) + partial loose residue (1.5 t/ha) (TR_4), zero tillage with anchored residue + full loose residue (3.0 t/ha) (TR_5), zero tillage with anchored residue + full residue (3.0 t/ha) + *tricoderma* application (5% chemical grade) (TR_6). Sub plot treatments consisted of three weed management, *viz*. weedy (W_0), weed free (W_1), sulfosulfuron + metsulfuron methyl (25 + 4.0 g/ha) at 35 DAS (W_2).Wheat variety PBW-502 was sown at 100 kg seed/ha with the help of zero till-drill machine as per treatment in all zero tillage treatments. In conventional tillage seed was sown by broadcasting method after tillage (two harrow + two cultivator).

RESULTS

Zero tillage (ZT) reduced the weed population and weed biomass in the range of 29-70% and 31-72%, respectively as compared to conventional tillage (Table 1). ZT alone without residue suppressed weeds by 30% and suppression increased to 45% when ZT was combined with anchored residue. However, when ZT was combined with full residue (anchored + loose residue), weed density and biomass declined by 70% as compared to CT. The grain yield under ZT was 3-16% higher than CT. The highest yield (4.98-5.10 t/ha) was obtained in ZT with full residue (anchored + loose) with and without *Trichoderma* (TR_5 and TR_6). Better weed management and higher yield in ZT treatments (TR_2-TR_6) resulted in higher net return with added net income of Rs. 6,060-8,811 /ha in ZT + partial residue (TR_3 and TR_4) and Rs. 11,000 /ha in ZT with full residue (TR_5 and TR_6) compared to CT (TR_1). Ssulfusulfuron + metsulfuron was found very effective in controlling weeds and provided yield equivalent to weed free check.

CONCLUSION

Results show that ZT combined with residue retention on soil as mulch can be important strategies for weed control in wheat in Eastern Indo-Gangetic Plains. Weeds could be effectively controlled by post emergence application of sulfusulfuron + metsulfuron. .

Table1: Effect of tillage, residue and weed management on total weed population, weed dry weight, grain yield, straw yield, and economics of wheat

Treatment	Total weed population (/m^2) at 50 DAS	Weed dry weight (g/m^2) at 50 DAS	Grain yield (t/ha)	Straw yield (t/ha)	Net return (Rs./ha)	B:C ratio
Tillage and residue management						
TR_1	8.0 (96.8)*	48.3	4.38	6.65	45,462.76	2.09
TR_2	6.7 (68.8)	33.1	4.52	6.79	47,930.26	2.15
TR_3	5.9 (53.8)	26.6	4.70	7.06	51,523.21	2.24
TR_4	5.1 (40.3)	20.3	4.89	7.33	54,274.63	2.28
TR_5	4.5 (30.7)	14.2	4.98	7.55	56,384.53	2.33
TR_6	4.3 (28.8)	13.6	5.10	7.62	56,722.96	2.29
LSD (P=0.05)	0.3	1.27	12	14.6		
Weed management						
W_0	11.1 (127.9)	63.0	4.16	6.27	53,633.59	2.86
W_1	5.4 (31.67)	15.0	5.02	7.55	69,874.65	3.37
W_2	0.7 (0.0)	0.0	5.10	7.67	60,156.69	2.47
LSD (P=0.05)	0.12	0.06	95.47	14.7		

*Figures in parentheses are original values, which were subjected to square root transformation"(X+0.5)

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Yield performance of zero-till wheat as influenced by weed and nitrogen management in rice-based cropping system

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Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend Fiori and Paol.) cropping system is followed on an area of 1.06 M ha in Kymore Plateau and Satpura hills agro-climatic zone of Central India. This system has registered only sluggish productivity growth during the past two decades. Degradation of the natural resource-base resulting from inappropriate land use pattern and imbalance input use are the root causes of this situation. The sustainable agriculture practices, which herald a paradigm shift in tillage and land preparation options, aid farmers in cost-saving and yield enhancement by resource-saving practices. Conservation agriculture practices can help the wheat farmers to overcome the constraint of late sowing of the crop after harvesting late-maturing *basmati* rice and of the widespread incidence of *Phalaris minor.* Nitrogen is the primary nutrient, and inefficient N use contributes to greater use of energy resources, increased production cost, and possible pollution of water by nitrates. Therefore, the present study was carried out to study the performance of wheat with weed and nitrogen management after rice under conservation agriculture.

METHODOLOGY

An experiment was conducted during *Rabi*, 2014-15 at research farm of ICAR-Directorate of Weed Research, Jabalpur, M.P., India on sandy loam soil, slightly alkaline (pH 7.3), low in organic C (0.48%), and available N (238 kg/ha), medium in available P (16.4 kg/ha) and high in available K (340 kg/ha). The treatments included four tillage and residue management practices, *viz.* zero tillage with rice residue (ZT + RR), zero tillage with residue burnt (ZT + RB), conventional tillage with residue incorporation (CT + RI) and conventional tillage with residue burnt (CT + RB); two N-levels, *viz.* 100% recommended dose of nitrogen (RDN) and 125% RDN, and three weed management options, *viz.* control (unweeded check), mesosulfuron + iodosulfuron (12+2.4 g/ha) as post-emergence (POE) at 25 days after sowing (DAS) (Chemical approach), and sulfosulfuron 25 g/ha as POE at 25 DAS + HW at 45 DAS (integrated weed management). Thus, 24 treatment combinations were laid out in a thrice replicated split-split plot design, keeping tillage and residue management in main plots, N-levels in sub-plots and weed management options in sub-sub-plots. After the harvest of *Kharif* rice in November, land preparation was done as per treatment and sowing of wheat was done on 8 November, 2014 using *'JS-5233'* variety with seed rate of 100 kg/ha. The recommended dose of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha was applied. Nitrogen was applied as per the treatments and basal dose of 70% N, 100% P and K was applied at the time of sowing with the help of happy seeder and remaining 25% N was applied after the first irrigation. The sowing was done at 20 cm row spacing with the help of happy seeder. The crop was harvested on 10 April, 2015.

RESULTS

Tillers/m^2 at 60 DAS varied non-significantly, while plant height at harvest, spikes/m^2, spike length and yield were significant due to tillage and residue management practices (Table 1). Maximum height was noticed under ZT + RR, which was however, comparable withZT + RB. The lowest height was noticed under CT + RB. Zero tillage + RB significantly enhanced spikes/m^2. The lowest spikes/m^2 was noted under ZT + RR. The highest spike length was observed under ZT + RR, which was significantly superior over rest of the tillage and residue management. The grain yield was the highest under ZT + RR, which was on par with ZT + RB. The lowest grain yield was under CT + RB, which was significantly lower than ZT + RR. Zero tillage advanced the sowing date and resulted in proper placement of seed, early emergence of wheat seedlings and availability of higher nutrient and moisture content due to surface retention of previous crop residue, which might have helped the crop to compete with the crop sown under conventional tillage. Results corroborate to the findings given by Mishra and Singh (2012).

Tillers/m^2 at 60 DAS and plant height at harvest were significantly influenced by different N-levels. Crop fertilized with 125% RDN produced maximum tiller/m^2 and plant height which was significantly superior to 100% RDN. The differences in spikes/m^2, spike length and grain yield were not significant. However, the maximum spikes/m^2, spike length and grain yield were obtained with the application of 125% RDN.

Weed management options did not cause significant difference in tillers/m^2 at 60 DAS and plant height at harvest but spikes/m^2, spike length and grain yield differed significantly. Application of sulfosulfuron + HW recorded the highest spikes/m^2, spike length and grain yield which was at par with application of mesosulfuron + iodosulfuron . However, all these two weed management options were significantly superior to unweeded check.

Table 1. Yield performance of wheat as influenced by tillage and residue management, N-levels and weed management options

Treatment	Tillers/ m^2	Plant height at maturity (cm)	Spikes/ m^2	Spike length (cm)	Grain yield (t/ha)
Tillage and residue management					
ZT+RR	367.6	94.4	310.4	8.07	4.57
CT+RI	350.9	89.5	316.1	7.34	4.04
CT+RB	330.2	88.6	335.2	7.04	4.03
ZT+RB	339 .1	92.9	352.9	7.11	4.32
LSD (P=0.05)	NS	2.9	37.3	0.32	0.34
N levels					
100% RDN	333.8	90.5	310.0	7.23	4.21
125% RDN	360.2	92.1	330.3	7.35	4.27
LSD (P=0.05)	13.6	1.2	NS	NS	NS
Weed control					
Unweeded Check	332.5	91.2	283.1	7.25	3.65
Chemical approach	358.2	90.2	337.6	7.38	4.45
Integrated weed management	350.3	92.5	339.8	7.56	4.62
LSD (P=0.05)	NS	NS	22.1	0.18	0.30

CONCLUSION

Zero tillage with residue and recommended dose of N with effective weed control by integrated or chemical approach appeared to be the best practice for improving wheat productivity in rice-based cropping system.

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Theme 4

Weed management in horticulture, plantation crops and non-arable lands

Improved weed control in naturally glyphosate tolerant turmeric

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Turmeric (*Curcuma longa* L.) is one of the most valuable spice and medicinal crop of the world. It's delayed emergence, slow initial growth and canopy development provides ideal environment for weeds to grow and compete with the crop causing considerable reduction in rhizome yield (Kaur *et al.* 2008). Glyphosate [N-(phosphonomethyl) glycine] is a non-selective, broad spectrum, systemic, post-emergence herbicide. It inhibits the biosynthesis of three aromatic amino acids viz., phenylalanine, tryptophan and tyrosine. It has been used extensively throughout the world for weed control in non-cropped situations, as directed/protected spray, in widely spaced field and horticultural crops, and as blanket spray in genetically modified glyphosate tolerant crops. Tolerance to glyphosate has been reported for several bacteria and plant cells (Gressel 1996). Based on preliminary studies, we surmised that glyphosate can be used as a selective herbicide in turmeric.

METHODOLOGY

A field study was conducted on a loamy sand soil during summer seasons of 2012, 2013 and 2014 at Punjab Agricultural University, Ludhiana, India.Treatments consisted of glyphosate (isopropyl amine salt) applications at 0.379, 0.568 and 0.759 g/ha each at 30 and 60 days after planting (DAP), 0.568g at 30 DAP followed by (fb) 0.379 g/ha at 60 DAP, 0.759g at 30 DAP *fb* 0.379g and 0.568 g/ha at 60 DAP. Weed free check (with manual hoeings) and weedy check were kept for comparison. The study was conducted in randomized complete block design with three replications. The turmeric rhizomes were plantedin 4th week of April to 1st week of May using 2 t rhizomes/ha at 30cm x 20 cm spacing in a dry flat bed. The field was irrigated on the same day of planting. The herbicide was applied with knapsack sprayer fitted with flat fan nozzle which delivered 375 l of water/ha. The crop was harvested in January in the succeeding year.

RESULTS

The results, interpreted over three years' data, revealed that glyphosate acted as a selective herbicide in turmeric. It exhibited some phytotoxicity to turmeric plants when applied at 30 days stage, from which the plants recovered later on and did not reflect in final yield. Increase in dose of glyphosate from 0.379 to 0.568 to 0.759 g/ha improved weed control which enhanced crop vigour, yield parameters and fresh rhizome yield. Glyphosate application at all the doses and timings significantly increased the fresh rhizome yield as compared to weedy check (Table 1). Sequential application of glyphosate at 0.568 g *fb* 0.568 g, 0.759 g *fb* 0.568g and 0.759 g *fb* 0.759 ga.e./ha at 30 and 60 days after planting recorded fresh rhizome yield at par with weed free check, which recorded the highest rhizome yield. The glyphosate application did not influence chlorophyll fluorescence at 7 days after spray when compared with unsprayed hand weeded plots. The rhizome quality parameters like oil and curcumin content, dry and processed rhizome recovery under different glyphosate treatments were similar to unsprayed weed free treatment.

Table 1. Effect of glyphosate on fresh rhizome yield of turmeric (Mean of 3 years).

Treatments (dose in g/ha)	Fresh rhizome yield (t/ha)
Glyphosate 0.379 g at 30 DAP *fb* glyphosate 0.379 g at 60 DAP	11.67cd
Glyphosate 0.568 g 30DAP *fb* glyphosate 0.379 g at 60 DAP	15.62bcd
Glyphosate 0.568 g at 30 DAP *fb* glyphosate 0.568 g at 60 DAP	17.04abc
Glyphosate 0.759 g at 30 DAP *fb* glyphosate 0.379 g at 60 DAP	14.12d
Glyphosate 0.759 g at 30 DAP *fb* glyphosate 0.568 g at 60 DAP	17.31ab
Glyphosate 0.759 g at 30 DAP *fb* glyphosate 0.759 g at 60 DAP	18.62a
Weedy free check (hand hoeings)	19.32a
Weedy check	5.80e

CONCLUSION

The study indicated that turmeric possesses natural tolerance to glyphosate and two applications of glyphosate at 0.568-0.759 g/ha at 30 and 60 days after planting provided effective control of broad spectrum of weeds.

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Integrated weed management in turmeric

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Turmeric (*Curcuma longa* L.) is a most important spice and medicinal crop grown extensively through the tropical and sub-tropical parts of the country. Though India leads in production of turmeric with 75% of global production, its average productivity is quite low, mainly due to the competition offered by weeds which reduce yield by 30-75% (Krishnamurthy and Ayyaswamy, 2000). Slow initial growth and its poor canopy development provide an ideal environment for weeds to grow and compete with the crop. Farmers have to go for sequential weeding, which adds to the cost of weed management. Non-availability of labour hinders the timely removal of weeds. Pre-emergence herbicides, *viz*. pendimethalin (Kumar and Reddy, 2000) help to save the crop from severe weed competition at an early age.

METHODOLOGY

The Field experiments were conducted during *kharif 2012-13* and 2013-14 at the Research farm of Rajendra Agricultural University Bihar, Pusa in Randomized Block Design.The variety used was Rajendra Sonia. The experiment comprised of 10 weed management treatments. The treatments were Metribuzin 0.7 kg/ha *fb* two hoeing, Metribuzin 0.7 kg/ha *fb* Fenoxaprop at 67 g/ha+ Metsulfuron 4g/ha, Metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, Pendimethalin 1.0 kg/ha *fb* two hoeing, Pendimethalin 1.0 kg/ ha *fb* Fenoxaprop at 67 g/ha+ Metsulfuron 4 g/ha, Pendimethalin 1.0 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, Atrazine 0.75 kg/ha *fb* Fenoxaprop at 67 g/ha+ Metsulfuron 4 g/ha, Atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, Weed-free (hand weeding at 25 and 45 DAS) and Weedy check. The recommended dose of fertilizer *i.e.* 150- 60- 120 kg N-P_2O_5- K_2O/ha was applied. The recommended package and practices of Turmeric cultivation was adopted. Herbicides were applied with the help of Knapsack sprayer fitted with flat fan nozzle. Data were recorded on weeds and yield of the crop. The soil of experimental field was low in ongoing carbon (0.42%) and available nitrogen (208kg/ha), available phosphorus (18.9kg/ha) and potassium (108.5 kg/ha) and alkaline (pH 8.3).

RESULTS

The lowest weed count and weed dry weight, and the highest no of tillers per plant, no of leaves per plant and grain yield of turmeric were recorded by the treatment weed free (HW at 25 and 45 DAS). The lowest weed dry weight was recorded under weed free (HW at 25 and 45 DAS) treatment. The highest no of tillers per plant was recorded by treatment weed free which was statistically at par with treatment Atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, Atrazine 0.75 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4 g/ha, Pendimethalin 1.0 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4 g/ha and Metribuzin 0.7 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4g/ha and significantly superior over rest of the treatments. The highest no. of leaves per plant were recorded by the treatment weed free (HW at 25 and 45 DAS) which was statistically at par with Atrazine 0.75 kg/ha *fb* Fenoxaprop 67 g/ ha+ Metsulfuron 4 g/ha, Atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, Pendimethalin 1.0 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, Pendimethalin 1.0 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4 g/ha and Metribuzin 0.7 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4g/ha. The highest rhizome yield was recorded under the treatment weed free which was statistically at par with Atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ ha + Metsulfuron 4 g/ha. The highest weed control efficiency was recorded under the treatment weed free (HW at 25 and 45 DAS) which was closely followed by Atrazine 0.75 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4 g/ha, and Pendimethalin 1.0 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4 g/ha. Effective control of weeds in turmeric has been reported with Pendimethalin 1.0 kg/ha (Kumar and Reddy 2000). The highest B : C ratio was recorded by the treatment Atrazine 0.75 kg/ha *fb* Fenoxaprop 67 g/ha+ Metsulfuron 4 g/ha.

Table 1. Effect of different weed management treatments on yield attributes andyield of turmeric (Mean data of two years)

Treatment	Weed count (no./m^2)	Weed dry wt. (g/m^2)	WCE (%)	No of tillers/ plant	No of leaves/ plant	Grain yield (t/ha)	B:C ratio
Metribuzin 0.7 kg/ha *fb* two hoeing	12.76	22.91	65.17	3.54	13.39	41.30	1.54
Metribuzin 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4g/ ha	7.11	15.64	76.20	4.27	16.34	47.80	2.23
Metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW	10.87	21.80	66.83	3.71	14.31	44.95	1.56
Pendimethalin 1.0 kg/ha *fb* two hoeing	12.38	23.12	64.82	3.65	13.46	42.70	1.63
Pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	6.79	14.08	78.60	4.37	15.93	48.10	2.26
Pendimethalin 1.0 kg/ha *fb* straw mulch 10 tones /ha *fb* one HW	10.65	19.37	70.54	3.85	15.28	46.00	1.63
Atrazine 0.75 kgf/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	6.28	13.87	78.90	4.60	16.39	50.65	2.47
Atrazine 0.75 kgf/ha *fb* staw mulch 10 tones/ha *fb* one HW	9.63	17.23	73.81	4.25	15.72	47.90	1.76
Weed-free (hand weeding at 25 and 45 DAS)	4.21	10.11	84.62	4.71	18.00	52.05	2.25
Weedy check	36.30	65.84	-	2.62	11.35	29.80	1.09
LSD (P= 0.05)	1.30	4.90	-	0.64	3.36	3.50	0.28

CONCLUSION

Application of Atrazine at 0.75 kg/ha or Pendimethalin at 1.0 kg/ha or Metribuzin at 0.7 kg/ha followed by Fenoxaprop at 67 g/ha + Metsulfuron at 4 g/ha at 20 DAS is effective in controlling weeds and producing good yield of turmeric rhizome with higher B: C ratio.

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Effect of integrated weed management on productivity and profitability of turmeric

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Turmeric (*Curcuma longa* L.) is grown over an area of 194,000 ha in India with a production of 971,000 MT and productivity 5 MT/ha. Turmeric is largely grown as a rainfed crop during *Kharif* season, and has long time span of about 8 – 9 months. Delayed emergence, slow initial growth and poor canopy development of turmeric provides ideal environment for weeds to grow and cover the ground quickly and compete with the crop for nutrients, moisture and space causing considerable yield reduction of about 30-75%.

METHODOLOGY

Field experiment was conducted at Birsa Agricultural University, Ranchi during *kharif* season of 2014 to study the efficacy of weed control methods on weed dynamics and productivity of turmeric. The 15 treatments comprised integration of chemical and hand weeding *i.e*. metribuzin 0.7 kg/ha or pendimethalin 1.0 kg/ha or atrazine 0.75 kg/ha or oxyflurofin 0.3 kg/ha or oxadiargil 0.25 kg/ha PE or glyphosate 1.25 l/ha or glyphosate 1.85 l/ha PoE each *fb* 2 hand weedings at 45 and 75 DAP respectively and integration with metribuzin 0.7 kg/ha or pendimethalin 1.0 kg/ha or atrazine 0.75 kg/ha PE each *fb* fenoxyprop 67 g/ha + metsulfuron 4g/ha at 45 DAP; integration of metribuzin 0.7 kg/ha or pendimethalin 1.0 kg /ha or atrazine 1.0 kg/ha PE each *fb* straw mulch at 10 DAP *fb* hand weeding at 75 DAP respectively and hand weeding at 25,45 and 75 DAP and un-weeded check respectively.

RESULTS

Application of glyphosate 1.85 l/ha at 25 DAP *fb* 2 hand weedings at 45 and 75 DAP,being similar to hand weeding; whereas, application of metribuzin, 0.7 kg/ha PE *fb* fenoxaprop, 67g/ha + metsulfuron, 4 g/ha at 45 DAP recorded 89.31 and 66.96 percent at 90 DAP, and 86.46 and 54.67 percent at 150 DAP,reduced total weed density compared to weedy check and hand weeding respectively. Application of glyphosate, 1.85 l/ha at 25 DAP *fb* 2 hand weedings at 45 and 75 DAP recorded 71.04and 2.67 percent reduced total weed dry matter accumulation compared to weedy check and hand weeding respectively at 30 DAP, whereas metribuzin, 0.7 kg/ ha PE *fb* fenoxaprop, 67g/ha + metsulfuron, 4 g/ha at 45 DAP recorded 83.35 and 44.24 percent at 90 DAP, and 76.36 and 52.27percent at 150 DAP, reduced total weed dry matter accumulation compared to weedy check and hand weeding respectively. Application of atrazine, 0.75 kg/ha PE *fb* straw mulch at 10 DAP *fb* hand weeding at 75 DAP recorded higher rhizome yield (29.04 t/ha) and consequently higher gross return which was similar to metribuzin, 0.7 kg/ha PE *fb* straw mulch at 10 DAP *fb* hand weeding at 75 DAP and pendimethalin, 1.0 kg/ha PE *fb* straw mulch at 10 DAP *fb* hand weeding at 75 DAP. However, maximum net return and B:C ratio were recorded with application of atrazine, 0.75 kg/ha PE *fb* straw mulch at 10 DAP *fb* hand weeding at 75 DAP.

CONCLUSION

It can be concluded that application of atrazine, 0.75 kg/ ha or metribuzin 0.7 kg/ha or pendimethalin, 1.0 kg/ha PE followed by straw mulch at 10 DAP and hand weeding at 75 DAP can be practiced for higher productivity and profitability of turmeric.

Bioefficacy of different herbicide molecules against weeds in turmeric

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Turmeric is a major field spice crop of India occupying an area of 6% of the total area under spices and condiments. India leads in production of turmeric having 78% of global production. Its average productivity is quite low, mainly due to the competition offered by weeds. Uncontrolled weed growth reduces the rhizome yield upto 30-35 percent depending upon the nature of intensity and duration of weed competition in turmeric field. Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop production. Under chemical method of weed management, the rotation of herbicides is more essential to prevent the development of resistance to herbicides in weeds.

Thus, an experiment was conducted with an objective to study the bio-efficacy of different herbicide molecules applied alone and in integration of organic molecules in turmeric.

METHDOLOGY

The experiment was carried out during kharif season of 2012-13 in randomized block design with three replications on silt loam soil having slightly alkaline in reaction (pH 8.1), low in nitrogen, medium in phosphorus and high in potassium content at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The turmeric variety NH-1 was planted on beds at 45 x 10 cm apart on 26 June 2012. Recommended dose of fertilizernutrients 125,60,60 kg/ha NPK were applied in equal three split doses at planting 60 and 120 days after planting.The treatment details are given in Table 1. The herbicides were applied as per treatments using knapsack sprayer with of water 500 l for PE and 300 l/ha for POE with flat fan nozzle. Total weed dry weight, weed control efficiency and phytotoxicity were recorded at 60 Days after planting. Crop was harvested on 15 April 2013. A harvested crop rhizome yield was recorded and economics of various treatments was worked out.

RESULT

A perusal of data indicated that all the weed control treatments significantly reduced the total weed dry weight significantly over weedy check (Table 1). Among the various treatments at 60 DAP, all the treatments except in treatment with fenoxa prop + metasulfuron provided very good control of all types of weeds. Among the various treatments, metribuzin at 0.7 kg/ha PE *fb* straw mulch 10t/ha *fb* one HW recorded lowest dry weed weight and highest WCE as compared to all other treatments.

Among the various treatments metribuzin at 0.7 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW recorded significantly highest fresh rhizome yield as compared to other treatments except the treatment that included the straw mulch application. The increase in yield with straw mulch included treatments may be due to season long effective control of weeds which suppressed weed growth in later stage and due to herbicide during early stage.Weedy check recorded the lowest fresh rhizome yield.

Table 1. Rhizome yield, weeddry weight, weed control efficiency, net return, B-C ratio and phytotoxicity in turmeric as influenced by weed control treatments

Treatment	Fresh Rhizomes yield (t/ha)	Total weed dry weight at 60DAP (g/m^2)	WCE at 60DAP (%)	Phytotoxicity at 60 DAP (%)	Net return (x10^3 `/ha)	B – C (`/re)
Metribuzin at 700g/ha *fb* 2 H	26.8	8.9(79.3)	82.2	5.0	312.27	3.48
Metribuzin at 700 g/ha *fb* Fenoxaprop at 67g/ha + MSM at 4.0 g/ha	18.1	9.2(84.1)	81.3	33.0	184.09	2.08
Metribuzin at 700g/ha *fb* SM at 10 t/ha *fb* 1 HW	35.6	6.7(45.2)	88.9	2.5	423.97	3.85
Pendimethalin at 1000 g/ha *fb* 2 H	27.9	8.4(69.8)	84.5	0.0	328.1	3.63
Pendimethalin at 1000 g/ha *fb* Fenaxaprop at 67 g/ha + MSM at 4.0 g/ha	20.8	9.0(80.4)	82.1	35.0	253.89	2.80
Pendimethalin at 1000 g/ha *fb* SM at 10 t/ha *fb* 1 HW	33.7	7.1(49.8)	89.9	0.0	395.62	3.57
Atrazine at 750g/ha *fb* Fenaxaprop at 67 g/ha + MSM at 4.0 g/ha	21.3	8.9(78.8)	82.5	34.0	235.36	2.67
Atrazine at 750 g/ha *fb* SM at 10 t/ha *fb* 1 HW	32.5	7.3(52.5)	83.3	0.0	377.09	3.40
Weed free (hand weeding at 25, 45 and75 DAP)	28.6	6.7(43.4)	90.35	0.0	351.17	3.78
Weedy check	11.2	21.2(450.0)	-	0.0	81.17	0.93
LSD (P=0.05)	3.0	1.0	-	-	-	-

SM: Rice straw mulch, MSM: Metsulfuron-methyl

Among the weed management treatments, highest net returns and B:C ratio were recorded with metribuzine at 0.7 kg/ha PE *fb* straw mulch 10t/ha fbone HW.

CONCLUSION

On the basis ofresults, it may be concluded that effective and economic weed management in turmeric can be achieved with IWM treatment of metribuzin at 0.7 kg/ha PE *fb* straw mulch at 10 t/ha *fb* one hand weeding.

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On-farm testing of selected mulches on growth, yield and economics of ginger

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Ginger (*Zingiber officinale* Rosc.) is grown in tropical and subtropical regions of the world for its spice and medicinal values. Mulching with green leave is an important cultural operation in rainfed ginger production mainly to check the weed growth and soil moisture conservation but availability of green leaves and labourers for application have become scarce. Hence, field experiment was conducted during 2011-2014 at Indian Institute of Spices Research, experimental farm Peruvannamuzhi to manage the weeds with different mulches including plastic and control. From the results, the best five treatments were evaluated in two farmer's field at northern agroclimatic zone of Kerala.

METHODOLOGY

Raised beds of 3 x 1 m size were prepared at farmers field located at Kannur and Kozhikode. Rhizomes of ginger variety IISR Varada weighing 25 g was sown in the beds during the year 2013-2014 at a spacing of 25 x 25 cm after spreading cowdung at 30 t/ha. The treatments were (i) application of green leaves *(Glycosmis pentaphylla)* at the time of planting + 45 and 90 days after planting (DAP), total 30 t/ha (control) ii) One season old paddy straw 6 t/ha at the time of planting + Green leaf (7.5 t/ha) at 45 and 90 DAP, iii) Coir pith compost 4 t/ha at the time of planting + Green leaf (7.5 t/ha) 45 and 90 DAP, iv) Dried Coconut leaves alone 5.40 t/ha at the time of planting v) Dried coconut leaves alone 5.40 t/ha at the time of planting. The recommended package of practices of IISR was given to the crop during the growing period. The experiment was laid out in RBD with five treatments and four replications. Data on weed growth yield and economics were recorded.

Table 1. Weed growth, yield and economics of ginger as influenced by different weed management practices

Treatment	Tiller (nos)		Dry weight of weeds (kg/ha) 45DAP		Yield (t/ha)		B:C ratio	
	Kannur	Kozhikode	Kannur	Kozhikode	Kannur	Kozhikode	Kannur	Kozhikode
Glycosmispentaphylla (Control)	7.25	6.75	216	114	14.75	11.25	1.32	1.0
Paddy straw	6.75	7.65	110	46	16.95	18.45	1.39	1.65
Coir pith compost	7.25	6.65	106	43	15.25	18.58	1.32	1.56
Coconut leaf+Mulch	6.00	7.00	108	35	19.75	16.20	1.54	1.42
Coconut leaves alone	10.25	10.75	90	19	20.25	25.35	1.87	2.34
LSD(P=0.05)	1.59	1.01	12.1	17	4.11	2.72		

DAP-days after planting

RESULTS

At 45 days after planting, significantly less dry weight of weeds was recorded by the application of dried coconut leaves at the time of planting 5.40 t/ha. Maximum number of tillers, yield was recorded by application of dried coconut leaves at Kannur and same treatment recorded increased yield at Kozhikode. The B: C ratio recorded due to the application of dried coconut leaves in ginger beds at Kannur and Kozhikode were 1.87 and 2.34 respectively. The beneficial microorganism added due to the decomposition of the coconut leaf had increased the nutrient availability in the ginger beds as (N, P, K, Zn and Cu) as compared to non mulched treatments.

CONCLUSION

It is concluded that application of dried coconut leaves 5400 kg/ha was beneficial in suppressing the weeds and augment the yield besides it is low cost and environment friendly.

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Effect of herbicides on weeds and fruit yield of green chilli

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Chilli (*Capsicum annuum* L.) is one of the most importantvegetable-cum-spice crops grown in India and world too. The high market price is attributed to the heavy demand from the consumers and has become money spinner for the farmers of all over the country. In India, it is cultivated in an area of about 7.90 lakh ha with the average productivity 1740 kg/ha of dry chilli and exports only 2.75to 7.50% of its total production (Datta and Jana, 2011). It shows slow growth at initial stage and gets infested with both grassy and broad-leaf weeds, causing severe competition for nutrients, space, light and moisture. Sharma *et al*. (2011) reported 60-80% yield loss in chilli due to weeds. Farmers usually control weeds manually but repeated flushes of weeds make the manual weeding ineffective and costly. Therefore, an experiment was conducted to evaluate different herbicides forlong-season weed control in chilli.

METHODOLOGY

The field experiment was conducted during the *kharif* season of 2012-13 and 2013-14 at Agronomy Farm, BHU, Varanasi (23^o.20' N, 83^o .03' E and 128.93 m above mean sea-level). The experimental soil was sandy clay loam with pH 7.6. The soil was low in available nitrogen (241.05 kg/ha), medium in available phosphorus (25.0 kg/ha) and high in available potassium (228 kg/ha). The experiment was conducted in randomized block design with 3 replications having 6 weed control treatments viz. propaquizafop 10% EC 50 g ai/ha, propaquizafop 10% EC 62.5 g ai/ha, propaquizafop 10% EC 100 g ai/ha, pendimethalin 320% EC, weed free check and control. Herbicides were applied as per the treatments with a knapsack sprayer using a spray volume 650 litres/ha. Seedlings of 35 days age of were transplanted on 29July during both the years at 45 x 30 cm row spacing in 5 x 3.5 m of gross plot. The crop was grown with recommended package of practices. Weed dry weight was recorded at 45 days after transplanting of crop from an area of 0.25/m^2 randomly selected at three places in each plot. Oven dry weight of weeds was recorded at 70^{0}C for 48 hr and expressed as dry matter production/m^2. Data on dry weight of weed were subjected to square root (x+1) transformation. Data on yield attributes and yield was recorded at harvest. Data collected on various parameters were analyzed statistically for valid conclusion.

RESULTS

Among herbicidal treatments, application of propaquizafop (10% EC) 100 g/ha resulted in significant reduction in dry weight of weeds and highest fruits/plant and fruit yield over propaquizafop (10% EC) 50 g/ha and fenoxaprop-p-ethyl 9.3% EC, respectively and were at par with propaquizafop (10% EC) 62.5 g/ha. Effect of chemical weed management on broad leaves weed was not significant. However, weed free check was found more effective than the herbicides with respect to dry weight of weeds and fruit yield of tomato.

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Evaluation of glyphosate and paraquat for control of wide range of weed flora under non-cropped situation

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The non-cropped land masses all over the world are invariably infested with the different species that are not easily controlled and acts as a source of infestation to agriculture. In most cases, mechanical and cultural measures are time consuming, laborious, and are not much effective. Therefore, use of herbicide in control of weeds assumes importance in the day present context. Post emergence application of glyphosate at 4.0 kg/ha proved most effective for controlling *Cyndon dactylon* (Patil *et* al. 1993). More than 95% control of *Lantana camara* and *Parthenium hysterophorus* was achieved with glyphosate at 1.5 kg/ha (Mishra and Bhan 1995). Thus, considering the effectiveness of glyphosate against the wide range of weed flora, it was felt necessary to study the effect of glyphosate dry (RD) for wide range of general weed control under non-cropped situation.

METHODOLOGY

Field investigation was carried out at farm of Department Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 1998 – 1999. The experimental field was sandy clay loam in texture, medium in available nitrogen and phosphorus and was slightly rich in potassium. The soil was slightly alkaline in reaction. The rainfall received during the season was 793.8 mm in 33 rainy days. Observations on weed population, dry matter production and weed control efficiency at 7, 14, 30, 45, & 60 days after spraying were recorded and statistical analysis was done as per procedure given by Panse and Sukhatme (1978).

RESULT

Euphorbia spp., *Commelina benghalensis, Lagascea mollis, Phyllanthus niruri, Digera arvensis, Parthenium hysterophorus, Cardiospermum helicacabum, Sida acuta, Xanthium strumarium, Datura fastuosa, Psoralea corylifolia, Alysicarpus rugosus, Portulaca oleracea, Panicum* spp., and *Sorghum halepense* were observed in the experimental field. Significant differences due to different herbicidal treatments at all the stages of observation were observed on weed population, dry matter accumulation and accordingly affect the weed control efficiency. At 7 and 14 DAS (Days after spraying), application of paraquat at 0.36-0.6 kg/ha, recorded significantly more reduction in weed population, dry matter and weed control efficiency than other herbicidal treatments during initial stages.. Regeneration of weeds was observed in paraquat sprayed plots. However, at 30, 45, and 60 DAS, application of glyphosate dry at 4.0 and 8.0 kg/ha lowered the population and dry matter of weeds and accordingly recorded maximum weed control efficiency. This may be due to translocated herbicidal action of glyphosate on weeds.

Table1. Weed population, dry matter of weeds and weed control efficiency

Treatment (Dose g/ha)	Weed Population (no./m^2)					Weed dry Matter (g/m^2)					Weed control efficiency (%)				
	Days after spraying (DAS)					Days after spraying (DAS)					Days after spraying (DAS)				
	7	14	30	45	60	7	14	30	45	60	7	14	30	45	60
T_1- Control	12.0	13.1	13.9	14.5	15.4	14.2	15.5	16.4	17.0	17.4	-	-	-	-	-
T_2 – RD 0.5	10.4	9.6	9.4	3.1	9.9	12.3	11.4	11.1	11.5	12.3	24.6	46.6	54.2	54.1	59.5
T_3 - RD 1.0	9.7	9.8	8.2	8.2	8.8	11.4	10.4	9.7	9.8	11.2	35.4	55.2	65.4	66.5	58.4
T_4 – RD 1.5	8.8	8.0	7.3	7.5	8.3	10.4	9.4	8.7	9.1	9.8	49.7	63.2	71.9	71.2	68.3
T_5 - RD 2.0	7.9	7.0	6.5	6.6	7.5	9.4	8.3	8.0	8.6	8.8	56.2	71.5	76.1	74.3	74.0
T_6 - RD 4.0	7.3	5.9	2.8	2.5	3.2	8.5	7.0	3.2	3.0	3.9	64.0	79.9	96.1	96.9	94.8
T_7 - RD 8.0	6.5	4.2	1.3	0.88	2.1	7.7	5.0	1.3	0.9	2.5	70.6	89.6	99.3	99.7	97.8
T_8 – Gr. 1.5	6.3	5.9	7.4	8.2	9.4	6.5	6.9	8.8	9.7	11.1	72.1	79.8	71.6	67.7	69.3
T_9 - Gr. 2.5	8.2	7.4	7.1	7.1	8.1	6.1	6.1	8.1	9.1	9.8	81.3	84.5	75.3	71.8	67.5
LSD (P=0.05)	0.47	0.47	0.49	0.58	0.55	0.55	0.47	0.58	0.38	0.44	-	-	-	-	-

(Values are given in square root transform values) Provide data on 7, 30 and 60 DASp only;

Provide both original and square root transformed data together

CONCLUSION

Post emergence application of glyphosate dry at 4.0-8.0 kg/ha effectively lowered the density and dry matter of weeds and no generation was observed up to 60 days after spraying.

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Weed dynamics under bamboo-based agroforestry system in semi-arid region

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Agroforestry, which involves both woody perennials (long term) and annual (short term) components plays a significant role in maintaining the resource base and increasing overall productivity. Woody perennials under agroforestry not only conserve land and water, but also enhance water productivity, strengthen rural livelihoods and helps in moderation of micro-climate. Integration of bamboo under agroforestry systems provides higher economic returns than mono-cropping systems. Complementary effect of shading, mulch from prunings, and potential allelopathy from hedge row species reduce weed populations in alley cropping (Rao *et al*. 1991). The present study was undertaken to understand the weed dynamics under bamboo based agroforestry system.

METHODOLOGY

This study was carried out at the research farm of Central Agroforestry Research Institute, Jhansi (U.P), India during 2013-14 in an ongoing experiment of bamboo (*Bambusa vulgaris and B. tulda*) based agroforestry system (AFS) initiated during 2007. The experimental field was situated at 25^0 30' - 25' 32^0 N latitude and 78^0 32' – 78^0 34' E longitudes at 272 m above msl. The soil was intermixed red and black soil (alfisols). 12 clumps/plot (3 x 4: rows x clumps) having100 clumps/ha (10 x 10m) were maintained in the experiment. Sesame and chickpea crops were grown during *kharif* and *Rabi* as intercrops and sole crops. The observations on weed density and biomass were taken by selecting six quadrates measuring 50 x 50cm randomly at 60 days after sowing (DAS).

RESULTS

Growth parameters recorded in bamboo revealed that it gained 7.74 m height and 4.13 cmDBH, 12.83 number of internodes/culm, 22.37 cm internodal length and 25.53 culms/ clump. It was observed that in *kharif* season *B. vulgaris* based AFS was predominantly infested with *E. crusgalli* (11.48 No./m^2), *C. benghalensis* (5.74 No./m^2) and *D. sanguinalis* (5.29 No./m^2) at 60 DAS. Average density of weeds was 22.51 no./m^2 with biomass accumulation of 34.97 g/ m^2. Sesame (sole) was infested with similar weed species with weed density (35.94 no./m^2) and biomass accumulation (53.56 g/m^2)(Table 1).

During *rabi* season the chickpea intercrop was infested predominantly with *C. album* (8.53 No./m^2) and *A. arvensis* (4.28 No./m^2). Similarly chickpea (sole) was also infested with *C. album* (12.29 No./ m^2) and *A. arvensis* (16.59 No./m^2. Corresponding biomass accumulation was maximum in *C. album*. Average density of weeds was 17.26 and 26.46 no./m^2 in intercrop and sole crop of chickpea, respectively and corresponding biomass was 37.80 and 53.46 g/m^2. Grain yield of sesame was 895 (bamboo based agroforestry system) and 1.10 t/ha (sole crop) and chickpea yield was 1.19 and 1.47 t/ha, respectively. Dhyani *et al.* (2008) found that weed infestation could be greatly reduced under suitable agroforestry systems. In the present study presence of bamboo reduced the weed density by 37.36 and biomass by 34.71% during *kharif* and 34.70 and 29.30% during *rabi*, respectively, however there was about 23 and 22% reduction in sesame and chickpea yield under AFS. Bamboo culms were harvested during 2012 and a stock of 5.19 t culms/ha was obtained. By and large the overall benefits were much higher under AFS than mono cropping.

Table 1. Weed density (no./m^2) and biomass (DW g/m^2) in bamboo + sesame-chickpea based AFS at 60 DAS

Weed species	Density (average)	Biomass (average)	Density (average)	Biomass (average)
	B. vulgaris + sesame		Sesame	
Kharif				
Commelina benghalensis	5.74	4.27	7.28	8.39
Echinochloa crusgalli	11.48	23.24	18.97	32.73
Digitaria sanguinalis	5.29	7.46	9.69	12.44
Av. density & biomass	22.51	34.97	35.94	53.56
Grain yield (kg/ha)	895		1103	
Rabi	*B. vulgaris*+ chickpea		Chickpea	
Anagallis arvensis	4.28	14.18	6.83	16.59
Chenopodium album	8.53	16.38	12.29	22.76
Sonchus oleraceous	2.58	4.67	3.63	8.49
Vicia sativa	1.87	2.57	3.71	5.62
Av. density & biomass	17.26	37.8	26.46	53.46
Grain yield (kg/ha)	1193		1478	

CONCLUSION

In bamboo based AFS, presence of bamboo reduced the weed density by 37.36 and biomass by 34.71% during *kharif* and 34.70 and 29.30% during *Rabi*, respectively, however there was about 23 and 22% reduction in sesame and chickpea yield under AFS.

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Effect of weed management practices on weed growth, yield and economics of okra

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Okra (*Abelmoschus esculentus* (L) Moench) is one of the most popular vegetables in North East India. It is the lucrative vegetable used in fresh form as well as canned food and is a common crop of tropical and sub-tropical region.Weeds are a permanent constraint to crop productivity in agriculture. In okra, yield losses due to weeds may range from 40-80% depending on the type of weed flora, their intensity and stages (Sharma and Patel, 2011).The present investigation was, therefore, designed to assess the influence of weed management practices on weed growth, yield and economics of okra.

METHODOLOGY

An experiment was undertaken at Vegetable farm of College of Horticulture and Forestry, Pasighat, Arunachal Pradesh during *Kharif* 2014. The soil of the experimental site was sandy loam with a pH of 5.6. Nine weed control treatments consisting of T_1: Weed free (upto 60 days stage),T_2:Weedy check (control), T_3: Pendimethalin 30EC at 0.5 kg/ha, T_4: Pendimethalin 30EC at 1 k/ha, T_5: Pendimethalin 30EC at 1.5 kg/ha, T_6: Pendimethalin 30EC at 0.5 kg/ha+ one hand weeding, T_7: Pendimethalin 30EC at 1 kg/ha + one hand weeding, T_8: Pendimethalin 30EC at 1.5 kg/ha + one hand weeding and T_9:two hand weedingat 20 and 40 DAS were evaluated in Randomized Complete Block Design (RCBD) with three replications. Seed of Okra cv ArkaAnamika was sown at 45 x 20cm spacing with the recommended doses of fertilizers (100 kg N, 80 kg P_2O_5 and 80 kg K_2O /ha).Crop received total rainfall of 2194.90 mm.

The observations on weeds density/m^2, dry weight g/m^2, and weed control efficiency, % and the crop growth and yield parameters of okra were recorded. The data for different parameters were statistically analyzed by following the standard methods.

RESULTS

The major weeds observed in experimental field were *Cynodon dactylon, Digitaria sanguinalis, Eleusine indica, Cyperus iria, Commelina benghalensis, Murdania kiosak, Urena lobata, Ageratum conyzoids, Spilanthes acmella and Sida acuta*. All the weed control treatments proved effective in significantly reducing the density and dry weight of weeds as compared to weedy check (Table 1). Weed free treatment recorded the lowest weed count and weed dry matter accumulation as well as the highest weed control efficiency. It like wise produced the maximum number of fruits/plant, highest fruits/plant and fruit yield. The application of pendimethalin at 1.5 kg/ha as PE coupled with one hand weeding significantly increased fruit yield and its attributes, which were very close to those obtained from weed free treatments (Table 1). In unweeded plots, fruit yield was reduced by 45.91per cent compared with weed-free plots. Weed free plot recorded 85.39% higher fruit yield over weedy check. Higher net return/kg fruit yield along with BCR was recorded with pendimethalin at 1.5 kg/ha as PE followed by one hand weeding, whereas, the lowest net return/kg fruit yield was noted in weedy check.

Table 1. Weed growth, yield attributes, yield and economics as influenced by weed management practices.

Treatment	Weed density (m^2)	Weed dry weight (g/m^2)	WCE (%)	Number of fruit/plant	Fruit yield (g/plant)	Fruit yield (t/ha)	Gross Income (`/ha)	Net Benefit/kg pod (Rs/ha)	BCR
T1	6.32 (39.57)	2.61 (6.36)	60.16	15.17	101.13	11.24	168600	10.46	3.51
T2	10.04 (100.5)	4.05 (15.92)	0.0	8.17	54.71	6.08	91200	8.09	2.28
T3	8.26 (67.85)	3.47 (11.53)	26.81	11.0	73.31	8.15	122250	9.68	2.97
T4	8.5 (71.82)	3.40 (11.06)	29.67	12.16	82.58	9.18	137700	10.17	3.27
T5	8.4 (70.19)	3.35 !0.73)	32.42	12.83	87.40	9.72	145800	10.34	3.39
T6	8.28 (68.12)	3.25 (10.11)	36.03	12.97	87.47	9.74	146100	10.25	3.33
T7	8.13 (65.69)	3.21 (9.82)	37.48	13.40	90.53	10.08	151200	10.31	3.38
T8	7.73 (59.30)	3.13 (9.33)	40.65	14.73	98.99	11.02	165300	10.62	3.62
T9	8.14 (65.76)	3.17 (9.59)	39.39	13.20	89.62	9.96	149400	10.18	3.30
LSD (P=0.05)	0.33	0.13	4.99	0.99	6.91	0.77	---	---	----

*Transformed data "(x+0.5), data in parentheses are original value

CONCLUSION

Findings of present experiment suggested that weed free condition (T1) and spraying of pendimethalin at 1.5 kg/ha as PE followed by one hand weeding (T8) were the best to manage the weeds andimproving fruit yield and profitability of crop.

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Weed management in cumin (*Cuminu mcyminum*)

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India is the home of spice and holds a premium position in export, productivity, production *etc*. Arid and semi arid regions of India are well known for quality production of seed spices. Therefore, seed spices are low volume but high value and more remunerative crop of these regions. Cumin is highly remunerative and short duration but risky seed spice crop of these regions, which requires less costly inputs i.e. fertilizers, irrigation, seed *etc*. Slight change in climatic condition may result in failure of the crop. Sowing done by broadcasting, delay in germination (8-10 days), requires one extra irrigation for better germination and initial slow growth rate are responsible for dominancy of weed during initial crop growth stage which, resulted in poor seed yield. Use of pre-emergence herbicides and hand weeding is common practices for weed management. Farmers of these regions are practicing herbicides widely as pre and post emergence for managing weed under scarce labour condition.

METHODOLOGY

An investigation was under taken during *Rabi* season of 2010-11 to 2012-13 at Center for Research on Seed Spices, S.D.Agricultural University, Jagudan to study the weed management in cumin with the objectives to find out the effective weedicide to control the weed and economics of different treatments on cumin crop. Eleven different treatments incuding physical and chemical weed control were replicated in RBD with three replications.

RESULTS

The major weed species appeared in the experimental plot during the crop growth period were *Cynodon dactylon* L. and *Cyperus rotundus* L. as major sedges in the weedy check treatment. In case of monocot weed species, *Asphodelus tenuifolius* L., *Melilotus indica* L. and *Digitaria sanguinalis* L. However, as far as dicot weed species are concerned, the major population of *Chenopodium album* L., *Amaranthus spinosus* L., *Amaranthus viridis* L., *Spergula arvensis* L., *Boerhavia diffusa* L., *Launae anudicaulis* L., *Phyllanthus niruri* L. and *Portulaca oleracea* L. were observed in during three years of study.

Significantly the lowest weed density was recorded under weed free up to 45 DAS (T_{10}). The maximum weed dnsity was recorded with unweeded control (T_{11}) and was at par with T_2 but significantly higher than rest of the treatments. Dry weight of weeds was effectively controlled by different weed control treatments.Significantly minimum dry weight of weeds was recorded with treatment T_{10}. Penmdimethalin and oxadiargyl as pre-emergence were significantly superior to reduce dry weight of total dry weed weight than post emergence application of oxadiargyl. Maximum weed control efficiency was recorded with treatment T_{10}, followed by T_9 and T_1 .Seed yield of cumin was significantly influenced by different weed management practices and was higher in treatment T_{10} and was remianed at par with treatments T_1,T_3,T_4 and T_9 but significantly superior over rest of the treatments. In general, pre-emergence application of pendimethalin at 1.0 kg/ ha or oxadirgyl at 100 or 120 g/ha found more effective than post emergence application of oxadiargyl and paraquat in respect to control weeds and seed yield. However, effect of weed management practices was non-significant on volatile oil content of seed. The maximum BCR value of 2.5 were recorded under weed free up to 45 DAS (T_{10}),which was closely followed by treatments T_9 (2.5), T_1 (2.5), T_4 (2.0).

Table 1. Weed growth, yield, quality and economics of cumin as influenced by different weed control treatments (pooled data)

Treatment	Weed density (no./m^2)	Weed dry weight (kg/ha)	WCE (%)	Cumin seed yield (kg/ha)	BCR	Volatile oil (%)
T_1 Pendimethalin at 1.0 kg/ha as PE	3.46	259	82	575	2.5	4.62
T_2 Paraquat at 500 g/ha as PE (6-8 DAS)	5.49	1418	1	194	0.9	4.48
T_3 Oxadiargyl at 100 g/ha as PE	3.98	365	75	470	2.0	4.60
T_4 Oxadiargyl at 120 g/ha as PE	4.06	357	75	478	2.0	4.53
T_5 Oxadiargyl at 100 g/ha as POE at 15 DAS	4.16	581	60	382	1.7	4.67
T_6 Oxadiargyl at 120 g/ha as POE at 15 DAS	4.19	590	59	397	1.7	4.58
T_7 Oxadiargyl at 100 g/ha as POE at 30 DAS	4.07	585	60	395	1.7	4.52
T_8 Oxadiargyl at 100 g/ha as POE at 30 DAS	4.09	582	61	401	1.7	4.51
T_9 Hand weeding and IC at 25 and 40 DAS	2.59	211	85	603	2.5	4.58
T_{10} Weed free up to 45 DAS	1.67	167	88	612	2.5	4.67
T_{11} Unweeded control	5.68	1439	0	143	0.7	4.39
LSD (P=0.05)	0.28	211	-	153	153	NS

CONCLUSION

For effective control of weeds and to get the maximum seed yield and income, it is advisable to keep crop weed free up to 45 DAS or adopt interculture *fb* hand weedings at 25 and 40 DAS and during scarcity of labour, apply pendimethalin at 1 kg/ha or oxadiargyl at 100 or 120 g/ha as pre emergence.

Evaluation of pendimethalin against weeds in cumin

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Wide adoptability of seed spices under arid and semiarid regions, increasing national and international demand and more profitability as compared to other *Rabi* crops, seed spices known as low volume but high value crops of Gujarat. Cumin is one of the important spice crops and need to narrower the use of certain chemicals due to its consideration as export commodity. The change in formulation of single molecules may some time resulted in effectiveness in control of weeds with economization. STOMP Xtra is a pre-emergence herbicide with capsule suspension gainst stomp EC, which is a member of the dinitroanaline group of herbicides. STOMP Xtra acts by inhibition of tubulin formation.

METHODOLOGY

The trial was conducted under irrigated condition during *Rabi* 2010-11 and 2011-12 in Randomized Block Design with three replications to study the bioefficacy as well as phytotoxic effect of weedicides STOMP XTRA on cumin. All the recommended practices as per need were followed to raise the crop. The weedicides as per treatments were applied as pre-emergence at 2 and 3 days after application of irrigation water in the years 2010-11 and 2011-12, respectively. The weeds were counted at 20, 40 and 60 DAS. In order to draw valid conclusion, the weed count data were subjected to square root transformation (x + 0.5) before statistical analysis. The weeds were air dried completely till they reached to constant weight and finally dry weight of weeds was recorded for each treatment after harvest and converted in to kg/ha. The weed control efficiency was calculated by using the following formula.

$$\text{WCE} = \frac{\text{DWC-DWT}}{\text{DWC}} \times 100$$

Where, WCE = Weed control efficiency

DWT = Dry weight of weeds in treated plot.

DWC = Dry weight of weeds in unweeded control plot.

The greengram as succeeding crop was sown in the same plot for assessment of phytotoxic effect of herbicides after harvest of cumin crop. The phytotoxicity was assessed using standard scale.

RESULTS

The major weed species appeared in the experimental plot during the crop growth period were *Cyperus rotundus* L., monocot, *viz. Eragrostis major* L., *Spergula arvensis* L., *Asphodelus tenuifolius* L., *Chenopodium album* L., *Amaranthus spinosus* L., *Amaranthus viridis* L., *Trianthema monogyma* L., *Melilotus indica* L., *Phyllanthus niruri* L., *Digeria arvensis* L., *Tribulus terrestris* L. and *Portulaca oleracea* L.

Table 1 Weed count,dry weight of weeds (Kg/ha), seed yield of cumin and weed control efficincy (%) as influenced by different treatments of weed control

Treatment	Weed count at 20 DAS	Weed count at 40 DAS	Weed count at 60 DAS	Dry weight (kg/ha)	Seed yield (kg/ha)	WCE (%)
T_1 :Pendimethalin 38.7% CS at 483.75 g/ha	4.43	5.20	5.76	358.75	429	61
T_2 :Pendimethalin 38.7% CS at 580.5 g/ha	4.41	5.15	5.66	353.41	437	61
T_3 :Pendimethalin 38.7% CS at 677.25 g/ha	4.35	5.00	5.55	299.40	534	67
T_4 :Pendimethalin 30% EC at 750 g/ha	4.22	4.92	5.46	291.55	546	68
T_5 :Two H.W. + Two I.C.(25 and 40 DAS)	6.36	3.65	4.24	237.22	578	74
T_6 :Unweeded control	6.62	9.54	10.76	915.13	169	0
LSD (P=0.0)	0.22	0.22	0.20	21.73	57.95	-

The weed count at 20, 40 and 60 DAS on pooled basis found significant due to different treatments of weed management. The maximum weed count at 20 DAS were recorded under physical and unweeded control plot, whereas these were lower under pendimethalin applied at varying levels with two different formulation. Physical method recorded lowest weed count at 40 and 60 DAS. Among different herbicides, pendimethalin 30 EC applied 750g/ha recorded lower weed count.The maximum weed count at 40 and 60 DAS were recorded under unweeded control. Weed dry weight was also significantly influenced due to different weed management practices.The minimum and maximum dry weight was recorded with physical method and unweeded control, respectively.Among herbicides, both the formulation found effective at higher levels of their application. Higher seed yield of cumiin was recorded with the physical method of weed control and was remained at par with higher levels of both the formulation under study. The maximum weed control efficiency was recorded with physical method of weed control followed by pendimethalin 30 % EC at 750 g/ha and Pendimethalin 38.7% CS at 677.25 g/ ha. There was no adverse effect or any deformities found with application of pendimethalin 38.7 % CS at various concentration as pre-emergence on cumin crop germination and growth during the period of experimentation. Also, harmful effect of different weedicides on succeeding greengram crop was not observed.

CONCLUSION

Application of pendimethalin 30 EC at 750 g/ha or pendimethalin 38.7% CS at 677.25 g/ha as pre-emergence were found effective to control weeds in cumin crop and achieved statistically similar yield as obtained in physical method (two H.W. + two I.C. at 25 and 40 DAS) of weed control. There was no adverse effect or any deformities found on cumin crop and harmful effect of different weedicides on succeeding greengram crop.

Integrated weed management in cumin (*Cuminum cyminum*)

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Cumin (*Cuminum cyminum*) is one of the most important seed spice crops of arid region of Gujarat and Rajasthan, which is used both as medicinal as well as flavouring agent. It is cultivated on about 558000 hectares with a total production of 394000 tonnes in the country (DOES, 2013). In Gujarat, it occupies an area of 370600 ha with production of 259500 t and productivity of 700 kg/ha (DOA, 2014). Cumin is a short stature crop with slow growth at initial stage, which makes it incapable to offer competition with weeds. The weed infestation may lead to reduction in seed yield up to 92%. Manual removal of weeds in cumin field is tedious, labour consuming and expensive. This situation creates wide scope for use of herbicides. Therefore, present experiment was conducted to evaluate efficacy of new herbicides for weed control in cumin.

METHODOLOGY

The field experiment was conducted on medium black calcareous clayey soil at Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during *rabi* season of 2011-12 to 2013-14 to evaluate weed management in cumin. The experimental soil was clayey in texture and slightly alkaline inreaction with pH 7.9 and EC 0.60 dS/m. It was medium in available nitrogen (234 kg/ha),low in available phosphorus (24 kg/ha) andhigh in available potash (381 kg/ha).The experiment comprised 10treatments viz., T_1:Pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS, T_2:Oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS, T_3:Glyphosate 500 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS, T_4:Glyphosate 1000 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS, T_5:Pendimethalin 900 g/ha as pre-emergence *fb* Quizalofop-ethyl 40 g/ha as post-emergence at 45 DAS, T_6:Pendimethalin 900 g/ha as pre-emergence *fb* Fenoxaprop-ethyl 75 g/ha as post-emergence at 45 DAS, T_7:Pendimethalin 900 g/ha as pre-emergence *fb* Propaquizafop 75 g/ha as post-emergence at 45 DAS, T_8:Pendimethalin 900 g/ha as pre emergence *fb* Oxadiargyl 75 g/ha as post-emergence at 45 DAS, T_9:Weed free check and T_{10}: Unweeded controlwere replicated thrice in randomized block design. The cumin variety'Gujarat Cumin4' was sown in November at spacing of 30 cm x 10 cm using seed rate of 15 kg/ha. The gross and net plot size was 4.0 m x 2.4 m and 3.0m x 1.8 m, respectively. The entire dose of fertilizer i.e. 30-15-0 kg N-P_2O_5-K_2O/ha was applied as basal applicationin form of urea and diammonium phosphate at just before sowing in the furrows. The crop was raised as per the standard package of practices. All the herbicides were applied with manually operated knapsack sprayer fitted with flood jet nozzle at a spray volume of 500 L/ha. Dry weight of weeds was recorded at harvest. Weed index (WI) and weed control efficiency (WCE) were worked out using following formulae given below.

$$WI=\frac{Y_{WF} - Y_T}{Y_{WF}} \times 100$$

Where; Y_{WF} and Y_T are the yield from weed-free plot and yield from treated plot, respectively.

$$WCE\ (\%)=\frac{DW_C - DW_T}{DW_C} \times 100$$

Where, DW_C = Dry matter accumulation of weeds in unweeded control, DW_T=Dry matter accumulation of weeds in treated plot.

RESULTS

Weed flora

Experimental field was infested with monocot weeds viz., *Brachiaria* spp., *Asphodelus tenuifolius* L. Cav.,*Indigofera glandulosa* L., *Echinocloa colona* L. and *Dactyloctenium aegyptium* Beauv, dicot weeds viz., *Chenopodium album* L., *Digera arvensis* Forsk, *Amaranthus viridis* L.,*Portulaca oleracea* L., *Physalisminima* L., *Euphorbia hirta* L. and *Leucas aspera* (Willd.) Spreng, and sedge weed *Cyperus rotundus* L.

Growth and yield

The growth and yield attributes of cumin were significantly influenced by different weed management practices (Table 1). Significantly highest plant height, number of branches/plant, number of umbels/plant, number of umbellates/umbel, number of seeds/umbel and 1000-seed weight were recorded under the weed free check (T_9), however it remained at par with application of pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) in case of plant height, number of umbels/plant, number of umbellates/umbel and number of seeds/umbel, with application of pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1), oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2), glyphosate 1000 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_4), glyphosate 500 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_3) and pendimethalin 900 g/ha as pre emergence *fb* oxadiargyl 75 g/ha as post-emergence at 45 DAS (T_8). While it remained on par with parameters like number of branches/plant, and with pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1), oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) and glyphosate 1000 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_4).

Significantly higher mean stalk yield was recorded under weed free check (T_9), which remained statistically at par with treatments comprising pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2. On the other hand, significantly the lowest mean stalk yield was recorded under the unweeded control (T_{10}).

The different weed management treatments significantly influenced the seed yield of cumin during individual years and in pooled results. The weed free check (T_9) out yielded by producing significantly the highest seed yield during 2011-12, 2012-13, 2013-14 and in pooled results, however it remained statistically at par with pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl

Table 1. Growth and yield of cuminunder different weed management practices

Treatment	Dose (g/ha)	Plant height (cm)	Branches/ plant	Umbels/ plant	Umbellates /umbel	Seeds/ umbel	1000-seed weight (g)	Stalk yield (t/ha)	Seed yield (q/ha)			
									2011-12	2012-13	2013-14	Pooled
Pendimethalin *fb* HW	900	28.7	4.78	12.00	5.70	16.05	4.14	1.89	7.80	10.36	9.88	9.34
Oxadiargyl *fb* HW	75	27.7	4.65	11.77	5.65	15.90	4.10	1.85	7.75	10.16	9.67	9.19
Glyphosate *fb* HW	500	26.5	4.30	10.55	5.15	13.75	3.80	1.47	6.10	6.09	5.99	6.06
Glyphosate *fb* HW	1000	26.6	4.42	10.58	5.28	13.89	3.95	1.55	6.31	7.10	6.79	6.73
Pendimethalin *fb* quizalofop	900 *fb* 40	24.5	3.75	9.69	4.79	12.63	3.30	1.01	5.01	4.71	4.78	4.84
Pendimethalin *fb* fenoxaprop	900 *fb* 75	25.5	3.77	9.83	4.87	12.74	3.52	0.95	5.12	4.72	4.69	4.85
Pendimethalin *fb* propaquizafop	900 *fb* 75	23.7	2.82	8.76	4.75	11.98	3.25	0.91	4.57	3.26	3.18	3.67
Pendimethalin *fb* oxadiargyl	900 *fb* 75	26.2	4.28	11.52	5.08	13.72	3.67	1.45	6.27	5.56	5.09	5.64
Weed free		29.6	4.89	12.45	5.92	16.09	4.25	2.01	8.14	10.67	10.20	9.67
Unweeded check		18.1	1.15	5.80	3.90	8.92	2.37	0.58	3.32	1.88	1.88	2.36
LSD (P=0.05)		2.3	0.74	1.67	0.57	1.58	0.42	0.19	1.56	1.22	1.27	0.75

Table 2. Weed parameters and economicsunder different weed management practices

	Treatment	Dose (g/ha)	Dry weight of weeds (kg/ha)				WI (%)	WCE (%)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C
			2011-12	2012-13	2013-14	Pooled						
T_1	Pendimethalin *fb* HW	900	191	177	198	188	3.38	89.62	90652	23880	66772	3.80
T_2	Oxadiargyl *fb* HW	75	211	217	222	217	4.95	88.06	89171	23843	65328	3.74
T_3	Glyphosate *fb* HW	500	507	520	556	528	37.34	70.93	59042	23009	36033	2.57
T_4	Glyphosate *fb*HW	1000	334	235	259	276	30.36	84.79	65524	23339	42185	2.81
T_5	Pendimethalin *fb* quizalofop	900 *fb* 40	1199	1025	1111	1112	50.00	38.75	46942	23460	23482	2.00
T_6	Pendimethalin *fb* fenoxaprop	900 *fb* 75	1089	849	926	955	49.89	47.40	46988	23505	23483	2.00
T_7	Pendimethalin *fb* propaquizafop	900 *fb* 75	1360	1215	1296	1291	62.06	28.90	35767	24030	11737	1.49
T_8	Pendimethalin *fb*oxadiargyl	900 *fb* 75	737	745	864	782	41.68	56.91	55028	23543	31485	2.34
T_9	Weed free		67	77	62	69	0.00	96.21	93871	29580	64291	3.17
T_{10}	Unweeded check		1712	1850	1883	1815	75.57	0.00	23018	20580	2438	1.12
LSD (P=0.05)			174	218	217	112						

Market price: Pendimethalin: Rs. 400/L; Quizalofop: Rs. 1350/L; Oxadiargyl: Rs. 930/L; Fenoxaprop: Rs. 1500/L; Glyphosate: Rs. 270/L; Propaquizafop: Rs. 1400/L; Cumin seed: Rs. 95/kg; Cumin stalk: Rs. 1/kg

75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) in 2011-12, 2012-13, 2013-14 and in pooled results. The yield increased in treatments T_9, T_1 and T_2 over the unweeded control (T_{10}). Significantly the lowest seed yield was observed under the unweeded control (T_{10}) during all the three years and in pooled results.

Weed parameters

Different weed management treatments exerted significant effect on dry weight of weeds during 2011-12, 2012-13, 2013-14 and in pooled results (Table 2). During all the individual years and in pooled results, the weed free treatment (T_9) recorded significantly the lowest weed dry weight, which was statistically at par with pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) in 2011-12 and pooled results, and with pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1), oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) and glyphosate 1000 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_4) in 2012-13 and 2013-14. Whereas, the unweeded control (T_{10}) recorded the highest dry weight of weeds.

The application of pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) recorded lower WI. Similarly, the weed free check (T_9) recorded the highest WCE, followed by treatments *viz.*, pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2).

Economics

The mean data of three years indicated that maximum gross returns were recorded under the weed free (T_9), followed by pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) and oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2).

Application of pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1) recorded maximum net returns, followed by oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) and weed free (T_9).

The maximum B:C ratio was accrued with pendimethalin 900 g/ha as pre-emergence *fb* HW at 45 DAS (T_1), closely followed by oxadiargyl 75 g/ha as early post-emergence at 7 DAS *fb* HW at 45 DAS (T_2) and weed free check (T_9).

CONCLUSION

It could be concluded that effective management of weeds with economicalproduction of cumin on clayey soil under south Saurashtra Agro-climatic conditions can be obtained by application of pendimethalin 900 g/ha as pre-emergence supplimented with hand weeding at 45 DAS or oxadiargyl 75 g/ha as early post-emergence along with hand weeding at 45 DAS.

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Smothering effect of legume intercrops on weed biomass in banana

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Kadapa district is potential area for production of banana. Since banana is a long duration and wider spaced crop, there is a scope to grow short duration narrow spaced intercrops especially legumes which can relocate fixed nitrogen to intercropped crops for better utilization of resources and greater stability of yields. Apart from yield benefits, intercropping strategies altered/reduced weed density and biomass. Researchers are confronted with the complex problem of weed management by ecological means giving due consideration to minimal use of chemicals with least disturbance to the environment. Such type of investigations in banana is scant; hence the present study was undertaken.

METHODOLOGY

An effort was made at Horticultural College and Research Institute, Anantharajupet, Kadapa district of Andhra Pradesh in 2010 -11 to evaluate seven legumes as intercrops in banana in Randomized Complete Block Design with eight treatments replicated thrice. Grand naine banana seedlings of 50 days old were transplanted on first week of September at a spacing of 2 x 2 m to accommodate 3 rows of bush beans, dolichos beans, cluster beans, black gram, green gram and 2 rows of cow pea and field bean. Data on weed parameters and crop characters were recorded. Banana equivalent yield was calculated by converting yield of intercrops to the yield of banana on the basis of prevailing market prices of the individual crops. Weed smothering efficiency (WSE) was used for calculating the relative efficiency of intercrops in suppressing weeds.

RESULTS

WSE (%) was significantly superior in intercropping of banana with field bean followed by cow pea over other legumes tried. This might be due to fast vegetative growth leading quick covering of interspaces by the intercrop foliage. The intercropping systems of pea or chickpea with baby corn were most suppressive of weeds (Sharma and Banik, 2013).

Table 1. Weed smothering efficiency, banana yield,banana equivalent yield and Land equivalent ratio The as influenced by intercropping of banana with legumes

Treatment	Weed smothering efficiency (%)	Banana yield (t/ha)	Banana equivalent yield (t/ha)	Land equivalent ratio
T_1: Sole banana	0.00	47.00	47.00	1.00
T_2: Banana + bush beans	3.37	42.43	42.32	1.44
T_3: Banana + dolichos bean	9.50	46.53	45.92	1.48
T_4: Banana + clusterbean	7.73	48.82	48.96	1.58
T_5: Banana + blackgram	14.67	48.14	48.51	1.49
T_6: Banana + greengram	8.48	45.82	45.95	1.47
T_7: Banana + cowpea	17.52	43.96	43.72	1.45
T_8: Banana + field bean	18.00	47.51	47.76	1.49
LSD (P=0.05)	0.13	2.61	1.12	0.03

Highest banana yield was recorded in banana when intercropped with cluster bean which maintained parity to that of black gram, field bean, sole banana and dolichos bean. Intercropping with cluster bean showed highest banana equivalent yield which was comparable with that of black gram followed by field bean and sole banana. It was lesser than sole banana in rest of the intercropping combinations. The Land equivalent ratio (LER) was greater in all the intercropping systems. The LER was significantly higher with cluster bean followed by other legume intercrops.

CONCLUSION

Conclusively, all the legume intercrops tried were found to be advantageous over sole banana, since LER was greater than one. Field bean followed by cowpea were effective in smothering weeds over other legume intercrops tried in the present study.

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Bioefficacy of glyphosate for management of weeds in tea

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Weeds reduce the quality of tea, besides competing for nutrients and moisture. Among the different categories of weeds, the creepers and trailing types weeds are mainly responsible for reducing quality. During plucking, these are also often plucked with young tea twigs. Further, weeds are problematic in young tea as the field is newly established. Hence, an experiment was conducted to study the effectiveness of Glyphosate at different doses on weeds in young tea gardens.

METHODOLOGY

An experiment was conducted at Sector 5 of the Gurjangjhora Tea Estate, Malbazar, Jalpaiguri during kharif seasons of 2013 and 2014. Soil pH of the experimental block was 6.6, blackish grey in colour mostly due to high organic matter and poor bases, rich in available major three nutrients. The experimental design was RBD replicated thrice with 7 treatments, *viz*. testing herbicide Glyphosate 41% SL at 410, 820, 1230 g/ha, standard Glyphosate 41% SL at 1230 g/ha and Paraquat dichloride 24% SL at 1230 g/ha besides hand weeding (HW) at 40 and 85 days after application (DAA), and control. The spraying of the herbicides was done in the first week of August on weeds present in the inter and intra rows of a perennial matured tea garde. Knapsack sprayer with a flood jet nozzle WFN was used in a spray volume of 500 l/ha. Necessary hood was used for spraying herbicide on the weed flora inside the rows of the tea plants only. The observations on weed biomass and density of weed species were taken atstart (before spraying), 40 and 60 DAA and phytotoxicity effect on tea plants was also recorded.

RESULTS

The predominant weed species at initial stage were*Axonopuscompressus*and *Cynodon dactylon* among grassy weeds; *Cyperus aromaticus, C. rotundus* and *C. difformis* among sedges; whereas *Borreria and B. hispida, Polygonum perfoliatum, Oldenlandia diffusa* and *Ageratum conyzoides* among broadleaf weeds were observed. The results revealed that both the weed density and biomass at 40 and 60 DAA (pooled data of 2013 and 2014) of all the herbicidal treatments were significantly superior to untreated control. The testing herbicide Glyphosate 41% SL at 1230 g/ha followed by standard Glyphosate 41% SL at 1230 g/ha gave significantly better control of major pernicious tea weeds like *Axonopus compressus, Borreria spp*. etc. The testing Glyphosate 41% S l at 820 g/ha also showed better results in comparison to its lower dose. The maximum WCE was also recorded with Glyphosate 41% SL at 1230 g/ha which was followed by its lower doses and was at par with the market standard Glyphosate 41% SL. The resurgence of weed flora was observed after two months of application. Application of the herbicide i.e. both testing and standard Glyphosate 41% SL, did not show any kind of symptoms of the phytotoxicity (tea leaf epinasty and hyponasty, vein clearing, wilting, injury to leaf tips and leaf surface)on the matured tea plants throughout the observation period.

CONCLUSION

It was concluded that the weeds were controlled very effectively by applying Glyphosate 41% SL at the highest dose *i.e.* at 1230 g/ha. No phytotoxicity was observed on tea crop at any of the doses of tested.

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Integrated weed management in garlic

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Garlic is the second most widely used cultivated *Allium* after onion. India ranks second after China in area and production of garlic in the world. In India, it is grown on 2.42 lakh hectares producing 12.28 lakh tonnes with the productivity of 5.074 t/ha. In India, major growing states are Madhya Pradesh, Gujarat, Rajasthan and Orissa. Through the export of garlic and their products, India earns about 374.2 million rupees annually (NHRDF, 2006). Gujarat stands second in area (41800 ha) and production (261400 t) of garlic with the productivity of 6.256 t/ha.

There are some production constraints and weed problem is one of them because of non-branching habit, sparse foliage and shallow root system. Garlic crop is closely planted crop, manual weeding is tedious, expensive and often damages the plants. Hence, efficacy of different new herbicides needs to be tested.

METHODOLOGY

The field experiment was conducted on medium black calcareous clayey soil at Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during *Rabi* season of 2011-12 to 2013-14 to evaluate weed management in garlic. The experimental soil was clayey in texture and slightly alkaline in reaction with pH 8.1 and EC 0.62dS/m. It was medium in available nitrogen (243 kg/ha), low in available phosphorus (22 kg/ha) and high in available potash (396 kg/ha).The experiment comprised 10 treatments *viz.* T_1: Oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS, T_2: Oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS, T_3: Propaquizafop 90 g/ha as pre-emergence *fb* HW at 40 DAS, T_4: Oxyfluorfen 240 g/ha as pre-emergence *fb* Oxadiargyl 90 g/ha as post-emergence at 45-60 DAS, T_5: Oxyfluorfen 240 g/ha as pre-emergence *fb* Propaquizafop 90 g/ha as post emergence at 45-60 DAS, T_6: Oxyfluorfen 240 g/ha as pre-emergence *fb* Quizalofop-ethyl 40 g/ha post emergence at 45-60 DAS, T_7:Oxyfluorfen 240 g/ha as pre-emergence *fb*Fenoxaprop-ethyl 75 g/ha post emergence at 45-60 DAS, T_8: HW at 30 and 60 DAS, T_9: Weed free check and T_{10}: Unweeded control were replicated thrice in arandomized block design. The garlic variety 'Gujarat Garlic3' was sown in November at spacing of 15 x 10 cm using seed rate of 600 kg/ha. The gross and net plot size was 4.0 x 2.7 m and 3.0m x 2.1 m, respectively. The entire dose of fertilizer *i.e.* 50-50-50 kg N-P_2O_5-K_2O/ha was applied as basal application in the form of urea, diammonium phosphate and potassium chloride just before sowing in the furrows. The crop was raised as per the standard package of practices. All the herbicide were applied with manually operated knapsack sprayer fitted with flood jet nozzle at a spray volume of 500 l/ha. Dry weight of weeds was recorded at harvest. Weed index (WI) and weed control efficiency (WCE) were worked out using following formulae given below.

$$WI = \frac{Y_{WF} - Y_T}{Y_{WF}} \times 100$$

Where; Y_{WF} and Y_T are the yield from weed-free plot and yield from treated plot, respectively.

$$WCE\ (\%) = \frac{DW_C - DW_T}{DW_C} \times 100,$$

Where, DW_C = Dry matter accumulation of weeds in unweeded control, DW_T=Dry matter accumulation of weeds in treated plot.

RESULTS

Weed flora

Experimental field was infested with monocot weeds, *viz. Brachiaria* spp., *Indigofera glandulosa* L., *Asphodelus tenuifolius* L. Cav., *Echinocloa colona* L., and *Dactyloctenium aegyptium* Beauv, dicot weeds, *viz. Digera arvensis* Forsk, *Chenopodium album* L., *Amaranthus viridis* L., *Physalis minima* L., *Portulaca oleracea* L., *Euphorbia hirta* L. and *Leucas aspera* (Willd.) Spreng, and sedge weed *Cyperus rotundus* L.

Growth and yield

Significantly highest plant height, bulb diameter, fresh and dry weight of bulb, number of cloves/bulb and 100-clove weight were recorded under the weed free check (T_9)over other treatments, however, it remained at par with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1), oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) and HW at 30 & 60 DAS (T_8) in case of plant height, bulb diameter and number of cloves/bulb, and with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) and oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) in case of fresh and dry weight of bulb and 100-clove weight (Table 1). Whereas, significantly the lowest values of these growth and yield attributes were registered under the weedy check (T_{10}).

The different weed management treatments significantly influenced the bulb yield of garlic during individual years and in pooled results (Table 1). The weed free check (T_9) produced significantly the highest bulb yield during 2011-12, 2012-13, 2013-14 and in pooled results and it remained statistically at par with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1), oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) and HW at 30 & 60 DAS (T_8) during 2011-12 and 2012-13, with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1), oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2), HW at 30 & 60 DAS (T_8),propaquizafop 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_3) and oxyfluorfen 240 g/ha as pre-emergence *fb* oxadiargyl 90 g/ha as post-emergence at 45-60 DAS (T_4) in 2013-14 and with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) and oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) in pooled results. The yield increased with treatments T_9, T_1 and T_2 over the unweeded control (T_{10}) was to the tune of 274, 265 and 263%, respectively. Significantly the lowest bulb yieldwas observed under the unweeded control (T_{10}) during all the three years and in pooled results.

Table 1. Growth andyield of garlicunder different weed management practices

Treatment		Dose (g/ha)	Plant height (cm)	Bulb diameter (cm)	Fresh weight of bulb(g)	Dry weight of bulb (g)	Cloves/ bulb	100-clove weight (g)	Bulb yield (t/ha)			
									2011-12	2012-13	2013-14	Pooled
T_1	Oxyfluorfen*fb* HW	240	41.48	3.33	16.65	13.55	19.27	70.75	2.92	4.33	4.29	3.84
T_2	Oxadiargyl *fb* HW	90	40.18	3.27	15.48	12.70	19.03	66.07	2.90	4.30	4.27	3.82
T_3	Propaquizafop *fb* HW	90	37.25	3.04	11.75	9.90	17.60	56.19	2.28	3.73	3.81	3.28
T_4	Oxyfluorfen *fb* oxadiargyl	240 *fb* 90	37.00	3.00	11.70	9.75	17.79	54.87	2.22	3.68	3.73	3.21
T_5	Oxyfluorfen *fb* propaquizafop	240 *fb* 90	36.85	2.97	10.74	8.95	17.34	53.00	1.92	1.65	3.28	2.28
T_6	Oxyfluorfen *fb* quizalofop	240 *fb* 40	36.37	2.94	10.56	8.80	16.96	52.70	1.68	1.62	3.17	2.16
T_7	Oxyfluorfen *fb* fenoxaprop	240 *fb* 75	37.00	3.00	11.56	9.25	17.86	51.48	2.07	1.80	3.39	2.42
T_8	2 HW		39.20	3.19	14.24	12.20	18.74	63.37	2.69	3.89	3.97	3.52
T_9	Weed free		42.38	3.39	17.57	14.35	19.83	72.92	3.03	4.45	4.36	3.94
T_{10}	Unweeded check		29.88	2.37	4.76	4.03	12.63	31.84	1.23	0.98	095	1.05
LSD (P=0.05)			4.81	0.31	2.72	2.06	1.84	8.60	0.43	0.70	0.66	0.33

Table 2. Weed parameters and economicsunder different weed management practices in garlic

Treatment		Dose (g/ha)	Dry weight of weeds (kg/ha)				WI (%)	WCE (%)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C
			2011-12	2012-13	2013-14	Pooled						
T_1	Oxyfluorfen*fb* HW	240	278	244	141	221	2.57	90.21	80707	38986	41721	2.07
T_2	Oxadiargyl *fb* HW	90	249	233	120	201	3.12	91.11	80252	38581	41671	2.08
T_3	Propaquizafop *fb* HW	90	939	713	794	815	16.95	63.85	68793	38446	30347	1.79
T_4	Oxyfluorfen*fb* oxadiargyl	240 *fb* 90	1171	909	873	984	18.60	56.36	67426	38881	28545	1.73
T_5	Oxyfluorfen *fb* propaquizafop	240 *fb* 90	1270	1643	1032	1315	42.18	41.70	47893	38746	9147	1.24
T_6	Oxyfluorfen *fb* quizalofop	240 *fb* 40	1355	1739	979	1358	45.30	39.82	45311	38566	6745	1.17
T_7	Oxyfluorfen *fb* fenoxaprop	240 *fb* 75	1231	1585	926	1247	38.72	44.71	50763	38611	12152	1.31
T_8	2 HW		833	369	410	538	10.87	76.17	73830	38686	35144	1.91
T_9	Weed free		50	106	98	85	0.00	96.24	82833	44086	38747	1.88
T_{10}	Unweeded check		2343	2316	2107	2256	73.28	0.00	22130	35086	-12956	0.63
LSD (P=0.05)			311	297	194	150						

Market price: Oxyfluorfen: Rs. 1800/L Quizalofop: Rs. 1350/L Oxadiargyl: Rs. 930/L Fenoxaprop : Rs. 1500/L
Propaquizafop: Rs. 1400/L Garlic bulb: Rs. 21/kg

Weed parameters

The different weed management treatments exerted significant effect on dry weight of weeds during 2011-12, 2012-13, 2013-14 and in pooled results (Table 2). All the weed management treatments including weed free treatment significantly reduced dry weight of weeds over the unweeded control (T_{-10}). During all the individual years and in pooled results, the weed free treatment (T_9) recorded significantly the lowest weed dry weight, which was statistically at par with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) and oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) in 2012-13, 2013-14 and pooled results, and with oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1), oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) and HW at 30 and 60 DAS (T_8) in 2012-13.

The application of oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1), oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2) and HW at 30 & 60 DAS (T_8) recorded lower WI. Similarly, the weed free check (T_9) recorded the highest WCE, followed by treatments *viz*., oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2), oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) and HW at 30 & 60 DAS (T_8) by recording WCE. The weedy check (T_{10}) recorded significantly the highest dry weight of weeds owing to uncontrolled condition favoured luxurious weed growth leading to increased weed dry matter.

Economics

The mean data of three years indicated that maximum gross returns were under the weed free (T_9), followed by oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) and oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2). Application of oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) recorded maximum net returns, closely followed by oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2), and weed free (T_9). The maximum B:C ratio was accrued with oxadiargyl 90 g/ha as pre-emergence *fb* HW at 40 DAS (T_2), closely followed by oxyfluorfen 240 g/ha as pre-emergence *fb* HW at 40 DAS (T_1) and HW at 30 and 60 DAS (T_8).

CONCLUSION

It could be concluded that effective management of weeds with economical production of garlic on clayey soil under south Saurashtra Agro-climatic conditions can be obtained by application of oxyfluorfen 240 g/ha as pre-emergence supplimented with hand weeding at 40 DAS or oxadiargyl 90 g/ha as pre-emergence along with hand weeding at 40 DAS.

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Efficacy of different herbicides against weed flora in onion

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Onion is the most important species of Allium group and is regarded as the single most important vegetable spice in the world after tomatoes and the top most export commodity among vegetables. Onion bulb is rich in minerals, especially calcium and phosphorus besides having fairly good quantities of carbohydrates, proteins and vitamin-C. In Maharashtra, it is grown over an area of 0.26 million hectares with a total production of 4.66 million metric tonnes, with an average productivity of 17.9 metric tonnes/ha. It is essential to keep onion field weed free for about 15 to 60 days after transplanting. Yield loss due to weed infestation in onion is to the tune of 40-80% (Channapagoudar and Biradar, 2007). Use of pre and post emergence herbicides for weed control is becoming popular and regarded potentially as one of the most labour saving innovations in modern agriculture. Hence the present investigation was undertaken.

METHODOLOGY

A field investigation was carried out at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during the *rabi* season of 2014. The experiment was laid out in randomized block design with sev en treatments, replicated thrice. The experimental site was fairly uniform in topography with clayey in texture and slightly alkaline. Overall, the rainfall and its distribution were satisfactory for the crop. Transplanting of onion, variety Akola Safed was done on 24th January, 2014. Herbicides were applied as per the treatments. Phytotoxicity symptoms due to herbicides on crop were recorded by using a visual score scale of 0-10.

RESULTS

The major weed flora during summer season in onion crop comprised of weed species *viz;, Commelina benghalensis, Dinebra arabica, Poaannua, Echinochloa crusgalli, Eragrostis major, Cynodon dactylon, Cyperus rotundus, Lagasca mollis, Euphorbia hirta, Digera arvensis, Tridex procumbense, Parthenium hysterophorus, Celosia argentea, Euphorbia geniculata, Alysicarpusrugosus, Alternanathera triandra, Xanthium strumarium, Portulaca oleraceae, Amaranthus viridis*. All the herbicidal treatments significantly minimized the weed number and weed dry matter when compared with unweeded control. None of the herbicides under study showed any phytotoxicity symptoms on crop. Among the various treatments lowest total weed count was observed under weed free treatment followed by Oxyfluorfen at 0.200 kg/ha which recorded the lowest weed count at harvest but was found at par with Pendimethalin at 1.0 kg/ha PE fb1 HW at 30 DAT. This might be due to combination of both herbicides and handweeding that have longer effect on controlling both monocot and dicot weed population in sequential application.–Similar trend was also observed in weed dry matter. Lowest weed index and highest weed control efficiency was also recorded in the same treatment.

Table 1. Various parameters as influenced by weed control treatments in onion

Treatment	Total weed count (no./m^2)	Weed dry weight (g/m^2)	WCE (%)	Weed Index (%)	Bulb yield (t/ha)	Equatorial diameter of bulb (cm)
T1- Pendimethalin at 1.0 kg/ha PE *fb* 1 HW at 30 DAT	5.64* (31.33)	3.63 (12.67)	86.39	14.39	25.11	6.16
T2- Oxyfluorfen at 0.200 kg/ha PoE	4.60 (20.67)	2.97 (8.36)	91.02	4.54	28.00	6.21
T3- Propaquizafop at 0.100 kg/ha PoE	8.79 (79.00)	5.79 (34.00)	63.50	29.54	20.66	5.88
T4- Quizalofop ethyl at 0.075 kg/ha PoE	10.01 (100.33)	6.42 (40.90)	56.09	34.84	19.11	5.64
T5- Fluazifop-p-butyl at 0.125 kg/ha PoE	9.59 (92.67)	6.19 (37.94)	59.27	33.33	19.55	5.76
T6- Weed free.	0.71 (0.00)	0.71 (0.00)	100.0	0.00	29.33	6.34
T7- Weedy check.	13.82 (191.00)	9.67 (93.16)	0.00	50.75	14.44	4.25
LSD (P=0.05)	1.61	0.87	-	-	2.51	1.22

* $\sqrt{x}$ transformed values; Figures in parentheses are original values

The highest bulb yield was also recorded in weed free treatment. Among different chemical treatments, highest yield was recorded under Oxyfluorfen at 0.200 kg/ha PoE treatment. Different weed management practices significantly improved the seed yield over weedy check.This might be due to the better weed control associated with decrease in weed population and improvement in yield contributing characters in hese treatments.

CONCLUSION

Oxyfluorfen at 0.200 kg/ha PoE was effective in reducing weed count, weed dry matter accumulation and weed indexresulting in higher weed control efficiency and bulb yield of onion.

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Efficacy of different herbicides for weed management in onion

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Onion (*Allium cepa* L.) is the most important species of *Allium* group. It is most important vegetable spices in the world. Onion exhibits greater susceptibility to weed competition as compared to other crops due to its inherent characteristics such as slow germination, extremely slow growth in the initial stages, non-branching habit, sparse foliage and shallow root system. In onion, weeds emerge with transplanting of seedlings and grow along with them. This favours quick and fast growth of weeds in the initial stages and competition thus tends to be severe. If the weeds are present throughout the crop growth period, there may be complete loss of marketable yield. Herbicides when used with one or two hand weedings showed improved efficiency in control of weeds. It is essential to screen several newly released herbicides and to fix optimum doses in all type of combination for effective control of weeds in onion.

METHODOLOGY

The field experiment was conducted at Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (MS) during *kharif*, 2012. The experiment was laid out in Randomized Block Design with nine treatments in three replications. The treatments consisted of different weed control methods, *viz*. weed free, weedy check (control), pendimethalin at 1.0 kg/ha (PE) *fb* 1 HW at 45 DAT, oxyfluorfen at 0.150 kg/ha (PE) *fb* 1HW at 45 DAT, quizolofop ethyl at 0.05 kg/ha at 21DAT (PoE) *fb* 1 HW at 45 DAT, pendimethalin at 1.0 kg/ha (PE) *fb* oxyfluorfen at 0.25 kg/ha at 45 DAT (PoE), pendimethalin at 1.0 kg/ha (PE) *fb* quizolofop ethyl at 0.05 kg/ha at 45 DAT (PoE), pendimethalin at 1.0 kg/ha (PE) *fb* quizolofop ethyl at 0.037 kg /ha + oxyfluorfen at 0.18 kg /ha at 45 DAT (PoE), quizolofop ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg/ha at 21 DAT (PoE) *fb* 1 HW at 45 DAT. The onion, cv. Baswant-780, was transplanted on ridges and furrow at 15 x 10 cm spacing, the gross and net plot sizes were 3.00 x 4.20 m and 2.40 x 3.80 m, respectively.

RESULTS

Weed flora

The major weed species observed during the course of investigations in the experimental plot were *Echinochloa crusgalli, Parthenium hysterophorus*; sedges *i.e. Cyperus rotundus* and monocot weeds *viz. Cynodon dactylon, Amaranthus spinosus, Convolvulus arvensis, Digera arvensis* and *Euphorbia sp.*

Weed studies

Weed population and weed dry matter were recorded the lowest in weed free check and were at par with application of quizolofop ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg/ha at 21 DAT (PoE) *fb* 1 HW at 45 DAT and it was followed by spraying of pendimethalin at 1.0 kg /ha (PE) *fb* quizolofop-ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg/ha at 45 DAT, These treatments, in similar order recorded the highest WCE. The weed index was lower in the treatment quizolofop-ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg/ha at 21 DAT *fb 1HW* at 45 DAT among the herbicideal treatment.

Table 1. Weed dynamics, growth and yield attributes, yield and economic of onion as influenced by different treatments

Treatment	Weed density (no./m^2)				Bulb yield (t/ha)	Cost of cultivation (x 10^3 Rs/ha)	Gross monetary returns (x10^3 Rs/ha)	Net monetary returns (x10^3 Rs/ha)	B: C ratio
	28 DAT	56 DAT	84 DAT	At harvest					
Pendimethalin at 1.0 kg / ha (PE) *fb* 1 HW at 45 DAT	2(1.91)	4(2.5)	2(1.91)	14(4.24)	22.90	69.98	229.08	159.10	3.27
Oxyfluorfen at 0.150 kg/ha (PE) *fb* 1 HW at 45 DAT	22(5.16)	4(2.5)	10(3.66)	18(4.74)	21.62	68.74	216.24	147.51	3.15
Quizolofop ethyl at 0.05 kg/ha at 21 DAT (PoE) *fb* 1 HW at 45 DAT	48(7.43)	3(2.3)	6(2.95)	12(3.96)	20.78	69.65	207.83	138.18	2.98
Pendimethalin at 1.0 kg/ha (PE) *fb* Oxyfluorfen at 0.25 kg /ha at 45 DAT (PoE)	2(1.91)	8(3.33)	11(3.82)	15(4.37)	22.34	66.48	223.44	156.96	3.36
Pendimethalin at 1.0 kg/ha (PE) *fb* Quizolofop ethyl at 0.05 kg/ha at 45 DAT (PoE)	2(1.91)	8(3.33)	15(4.37)	18(4.74)	19.41	66.94	194.12	127.18	2.90
Pendimethalin at 1.0 kg /ha (PE) *fb* Quizolofop ethyl at 0.037 kg /ha + Oxyfluorfen at 0.18 kg /ha at 45 DAT	1(1.5)	3(2.23)	3(2.23)	11(3.82)	23.50	67.46	235.04	167.58	3.48
Quizolofop ethyl at 0.037 kg/ha + Oxyfluorfen at 0.18 kg /ha at 21 DAT (PoE) *fb* 1 HW at 45 DAT	3(2.23)	0(0.7)	3(2.23)	11(3.82)	23.80	70.18	238.02	167.84	3.39
Weed free	0	0	0	0	24.42	77.15	244.25	167.10	3.16
Weedy check (control)	78(9.3)	96(10.3)	108(10.9)	136(12.2)	7.06	62.84	70.63	7.79	1.12
LSD at P= 0.05	2.13	1.65	2.33	1.78	1.31	-	13.19	13.19	0.18

HW- Hand weeding, ***fb*** – followed by, DAT- days after transplanting, PE- Pre- emergence, POE- Post emergence, WI- weed Index, WCE- Weed Control efficiency

Growth and yield attributes and yield

Weed free check was found to be superior in all growth attributing characters, *viz.* plant height, number of leaves and yield attributes, *viz.* polar and equatorial diameter, fresh weight of bulb and bulb yield. Among the herbicidal treatments, application of quizolofop-ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg /ha at 21 DAT (PoE) *fb* 1 HW at 45 DAT recorded the highest growth and yield attributing charactersa and the bulb yield.

Application of quizolofop ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg/ha at 21 DAT (PoE) *fb* 1 HW 45 DAT proved to be most remunerative weed control treatment with the highest net monetary returns.

CONCLUSION

It is concluded that for obtaining higher yields with net monetary returns of onion, application of herbicide quizolofop ethyl at 0.037 kg/ha + oxyfluorfen at 0.18 kg/ha at 21 DAT (PoE) *fb* 1 HW at 45 DAT found to be effective weed control measure under *kharif* season.

Effect of herbicides on weeds and fruit yield of tomato

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Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetable crops cultivated all over the world for its fleshy fruits. Tomato occupies large scale cultivation in India with a production of 4.6 MT per year. It is considered as protective as well as productive food because of its special nutritive value and also wide spread production. Tomato is a major contributor of carotenoids (especially lycopene), phenolics, vitamin C and small amounts of vitamin E in daily diets (Sood *et al.* 2015). Weeds are the major competitor for growth resources and finally reduces crop yield. Weed grow vigorously and, if left uncontrolled, result in tomato yield reductions of up to 60% at weed densities as low as 5 plants/m^2 (Nurse *et al.* 2006). Use of herbicides either alone or in combination is gaining popularity for controlling weeds effectively. Not much work on chemical weed control in tomato under Eastern Uttar Pradesh condition has been carried out earlier. Keeping in view the importance of the crop and losses caused by weeds, the present study was undertaken.

METHODOLOGY

A field study was conducted during the *kharif* seasons of 2012-13 and 2013-14 at Agronomy Farm, BHU, Varanasi (23°.20' N, 83° .03' E and 128.93 m above mean sea-level). The experimental soil was sandy clay loam with pH 7.7. The soil was low in available nitrogen (242.05 kg/ha), medium in available phosphorus (24.0 kg/ha) and high in available potassium (227 kg/ha). The experiment was conducted in randomized block design with 3 replications having 6 weed control treatments viz. propaquizafop 10% EC 50 g/ha, propaquizafop 10% EC 62.5 g/ha, propaquizafop 10% EC 100g ai/ha, Fenoxaprop-P-ethyl 9.3% w/w EC 100 g/ha, weed free check and control.The tomato seedlings were transplanted manually at 60 x 40 cm row spacing on 16 July 2012 and 21 July 2013 in 6m x 4.5 m gross plot size. All the herbicides were applied with the help of flat fan nozzle attached to the foot sprayer using volume of spray 500 l/ha as per the treatments. Recommended doses of fertilizers were applied in all the treatments as basal dose (150+60+60 kg N, P, K/ha).

Weed dry weight was recorded at 45 days after transplanting of crop from an area of 0.25/m^2 randomly selected at three places in each plot. Oven dry weight of weeds was recorded at 70^{0}C for 48 hr and expressed as dry matter production/m^2. Data on dry weight of weed were subjected to square root (x+1) transformation. Data on yield attributes and yield was recorded at harvest. Data collected on various parameters were analyzed statistically for valid conclusion.

RESULTS

Among herbicidal treatments, application of propaquizafop (10% EC) 100 g/ha caused significant reduction in dry weight of weeds and resulted the highest fruits/plant and fruit yield (363.1 q/ha) over propaquizafop (10% EC) 50 g/ha and fenoxaprop-p-ethyl 9.3% EC, respectively and it were at par with propaquizafop (10% EC) 62.5 g/ha. Effect of chemical weed management on broad leaves weed was found to be not significant. However, weed free check was found more effective than the herbicides with respect to dry weight of weeds and fruit yield of tomato.

Table 1. Effect of weed control treatments on weed dry weight (g/m^2) and yield of tomato (Pooled data of two year)

Treatment	Rate g/ha	*Echinochloa sp.*	*Digitaria sanguinalis*	*Dactyloctenium aegyptium*	*Eleucine indica*	Other monocot	Broad Leaves weed	Fruits/ plant	Fruit yield (t/ha)
Propaquizafop 10% EC	50	5.81(2.5)	3.32(1.94)	3.42(1.98)	2.70(1.78)	3.26(1.84)	15.69(3.96)	29.08	30.8
Propaquizafop 10% EC	62.5	2.36(1.69)	1.40(1.37)	1.50(1.41)	1.18(1.29)	1.31(1.3)	13.21(3.85)	38.75	35.9
Propaquizafop 10% EC	100	2.24(1.65)	1.33(1.34)	1.40(1.38)	1.10(1.26)	1.21(1.27)	14.48(3.82)	39.17	36.3
Fenoxaprop-P-ethyl 9.3% w/w EC (9%w/v)	100	3.56(2.01)	2.05(1.58)	2.18(1.64)	1.73(1.49)	2.07(1.54)	15.04(3.89)	33.21	32.9
Weed free check	-	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	40.63	37.1
Control	-	18.40(4.33)	10.60(3.29)	11.14(3.4)	8.49(2.97)	10.36(3.08)	17.90(4.22)	24.25	27.8
LSD (P=0.05)	-	0.27	0.14	0.18	0.16	0.19	NS	2.45	1.60

Figures in the parentheses square root transformed value

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Weed dry matter accumulation in tomato as influenced by drip fertigation and plastic mulches

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Tomato (*Lycopersicon esculentum* L.) is one of the most popular and versatile cash earning vegetable crop and plays a vital role in culinary purposes for its nutrients, delicious taste and various modes of consumption. Compared to productivity levels attained in countries like USA (58.8 t/ha), Greece (49.8 t/ha) and Italy (46.6 t/ha); the average productivity in our country (17.39 t/ha) is relatively low (Kumar and Rai, 2007). Plastic mulch application is effective in increasing soil temperature, conserving soil moisture and weed control (Patel *et al*. 2009) in many horticultural crops and its scope is enhanced when used in conjunction with drip irrigation or fertigation. Hence, the present investigation was undertaken.

METHODOLOGY

An investigation was conducted at Precision Farming Development Centre, College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The study consisted of field experiments on tomato- sweet corn cropping system during *rabi* and summer seasons in successive years of 2010-11 and 2011-12 respectively. The experimental soil was sandy clay loam in texture, neutral in reaction, medium in organic carbon, low in available nitrogen and medium in available phosphorous and available potassium.

The experiment for tomato was laid out in split plot design, replicated thrice. Naveen a high yielding tomato hybrid was used. The treatments consisted of four nitrogen levels allotted to main plots and three mulch treatments, *viz*. black mulch (25 ì), red mulch (25 ì) and soil mulch assigned to sub plots. The recommended dose of fertilizer was 120:60:60 N, P_2O_5, K_2O kg/ha. The P_2O_5 and K_2O was applied through single super phosphate and muriate of potash, respectively as basal dose to all the plots. In fertigation treatments, depending upon the quantity to be applied to the crop, required quantity of urea was dissolved and applied through ventury to the field starting from 20-120 days after planting at 10 days interval. In conventional plots, nitrogen was applied in three equal splits at 30, 45 and 60 days after planting. The gross plot size was 4.8 x 6.0 m and net plot size was 2.4 x 5.0 m. In drip plots, 40 x 50 cm paired row spacing with lateral spacing of 120 cm and in conventional method; 60 x 50 cm crop row spacing was adopted. Black and red polythene mulch film of 25 ì thickness was cut into size of 6.1 x 55 cm to cover 80% of the area in the main field. The weed dry matter was recorded at 30, 45 and 60 days after planting. In case of soil mulch treatments, the top soil was disturbed with the help of a kurpi so as to form mulch at 30, 45 and 60 days after planting around the plants after recording the weed dry matter.

RESULTS

The weed dry matter decreased with the advancement of crop growth at 30, 45 and 60 days after planting during both the years of experimentation. The weed dry matter at all the three stages of sampling varied significantly due to nitrogen levels and mulches and the interaction effect was also significant at these crop growth stages.

Table 1. Weed dry matter accumulation (g/m^2) in tomato at 30, 45 and 60 days after planting as influenced by nitrogen levels and muches during 2010-11 and 2011-12 respectively

Treatment	30 days after planting		45 days after planting		60 days after planting	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Main plots						
100 % RDN through drip **	6.02 (41.43) *	5.34 (32.05)	4.71 (22.72)	4.39 (19.66)	3.65 (12.87)	3.14 (9.46)
80 % RDN through drip	5.80 (38.13)	5.22 (30.94)	4.66 (21.79)	4.29 (18.60)	3.60 (12.53)	3.17 (9.56)
60 % RDN through drip	5.32 (32.28)	4.61 (24.12)	4.06 (16.43)	3.65 (13.09)	2.68 (6.33)	2.43 (5.11)
100 % RDN through conventional method	9.20 (85.11)	8.12 (65.19)	6.60 (45.14)	6.25 (40.19)	4.68 (21.89)	4.23 (17.86)
LSD (P=0.05)	0.61	0.23	0.22	0.38	0.24	0.27
Sub plots						
Black mulch (25 μ)	5.04 (28.27)	4.49 (22.75)	4.02 (15.90)	3.73 (13.75)	3.11 (9.05)	2.79 (7.15)
Red mulch (25 μ)	5.25 (30.04)	4.82 (25.59)	4.34 (18.53)	4.01 (15.91)	3.24 (9.89)	2.79 (7.16)
Soil mulch	9.46 (89.40)	8.16 (65.88)	6.66 (45.13)	6.19 (38.99)	4.60 (21.27)	4.14 (17.19)
LSD (P=0.05)	0.26	0.32	0.27	0.27	0.20	0.29

* Values in parentheses are original. Data transformed to square root transformation**100 % recommended dose of nitrogen (RDN) through drip: 120 kg/ha

During both the years of study, at 30, 45 and 60 days after planting; the drip fertigation treatments differed significantly with conventional method and recorded lower weed dry matter. Further, among the drip fertigation treatments, significantly lowest weed dry matter was recorded with 60% recommended dose of nitrogen (RDN) except at 30 days after planting during first year where 80 % RDN through drip and 60 % RDN through drip were on par. Among the three mulches, significantly lower weed dry matter at 30, 45 and 60 days after planting was recorded with black mulch followed by red mulch when compared to soil mulch which recorded the highest weed dry matter at said crop growth stages. The plastic mulch treatments were however on par with each other at 30 days after planting during first year and at 60 days after planting during both the years.

The interaction effect of nitrogen levels and mulches on weed dry matter was significant at all the three stages of sampling except at 45 days after planting during 2011-12.

CONCLUSION

Lowest weed dry matter was recorded under drip fertigation treatments over 100% RDN through conventional method at 30, 45 and 60 DAP. Black and red mulch were efficient in suppressing the weeds and recorded significantly lesser weed dry matter over soil mulch.

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Weed management in plantation crops and cropping systems of Andaman & Nicobar Islands

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The Andaman and Nicobar group of islands with humid (>80% mean relative humidity) tropical (24-34^{0}C) climate is bestowed with a seasonal (May-November) rain fall exceeding 300 cm that provides congenial environment for the growth of vegetation including weeds round the year. After natural forests (>85%), plantation crops {coconut (21,800 ha), areca nut (3,447 ha), cashew nut (153 ha)} and red oil palm (in insignificant area)} account for major use of total agricultural land of about 50, 000 ha. Multitier cropping or homestead farming of coconut both under inorganic (Andaman Islands) and organic (Nicobar Islands) and areca nut under inorganic mode supports not only the farmers but also the employees engaged in processing and marketing. These two major plantation systems encounter enormous weed pressure and thus incur exorbitant yield losses. Uneven terrain of island forces the farmers to retain ground vegetation cover (most of the times grasses) for protecting the soil from erosion loss, which also promotes proliferation of weeds. No use of herbicide (in Nicobar Islands that accounts for >50% of coconut area of islands) or limited use of herbicides (in Andaman Islands) due to various socio-economic and technological constraints are providing a competitive edge to weeds over plantation crops. Weed management through manual and mechanical interventions become not only more cumbersome but also less effective. The paper brings out the developments in the plantation crop weed management in Island ecosystem over last four decades.

Vast diversity in weed flora was observed in plantation crops of islands that include both native and introduced species. Several plants introduced for ornamental purpose have become weeds later like *Lantana camara* in the islands. Similarly, the introduction of new animals and their free grazing in absence of predators (except palm civet) in the forests have paved the way for destruction of native vegetation and spread of weeds like *Chromolna odorata, Lantana camara* and *Mikania cridata* that later moved into surrounding plantation crops. The movement of weed seed through run off rain water from forests and with moving live stock has also led to spread of more and more weeds into the farm lands. The ungrazed grasslands of Nicobar (heaths) and vast waste lands are producing weed seeds unabatedly and are forming important supply source of weed seeds into crop fields dispersed by different agents. The food grains channelled from mainland into the islands to fill the demand and supply gap has also contributed to the introduction of problematic weeds like *Parthenium hysterophorus*. In the grassy ground cover of plantations, *Mimosa pudica* is commonly reported and is rapidly spreading to new areas. Application of improperly decomposed FYM to nourish plantation crops (especially in homestead and organic farms of Nicobar) is adding to weed seed supplies and their proliferation in fields. Thus plantation crops of islands have a wide weed flora of about 45 species with predominance of Asteraceae family weeds *Chromolena, Mikania, Ageratum, Vernonia, Spilanthes, Eleutheranthera* sps. Among grasses, *Anoxopuscompressus, Cyrotococcumaccressens* and *Brachiaria* (Poaceae) are most prominent. *Hyptis capitata* (Lamiaceae) and *Ureanalobata* (Malvaceae) are the other prominent weeds reported in plantations. Despite wide and intense weed pressure in plantation crops, no systematic studies have been made to date to quantify weed induced yield losses.

The weed management followed by farmers to keep the pits free of weed include periodical manual weeding (slashing) and digging / ploughing around trees twice / thrice *i.e.* at start May / June, flag end September / October and end of rainy season in January. Mulching with leaves, crown waste, dried spathes and husk of coconut / areca nut, commonly followed by farmers, contributes to weed suppression in addition to reduced evaporation losses of water and thus its saving. Multitier cropping of coconut / areca nut with tree spices, root ginger, turmeric tuber crops (*Colocassia, Dscorea*) also provides competitive suppression of weeds.

To tide over the vast green fodder shortages in islands for livestock sector, integration of perennial grasses (Napier bajra hybrid, guinea grass *etc.* along with *Stylosanthes* legume) into plantation crops is practiced. Frequent harvest of these cultivated or native grasses and or direct animal grazing on under storey vegetation in plantations has led to the suppression of weed seed production and thus aided in weed management. Cultivation of cover crops (*Calapogonim muconoides, Mimosa invisa, Stylosanthes gracilis*) or green manure crops (*Crotolaria juncea, Tephrosia purpurea, Indigofera hirsute, Pueraria phaseoloides*) was also followed for partly meeting nutrient demand of plantation crops that also contributes to weed management. These practices (one or more) form the pillars of weed management in organic coconut production system of Nicobar Islands. The high density planting of coconut in these islands also adds to weed suppression. In other part of islands (Andaman), in addition to above cultural weed management practices, use of herbicides i.e. gramaxone and glyphosate is increasingly relied. Thus, these herbicides are commonly available in Andaman Islands for farmers. The impetus the islands' horticulture sector got under the aegis of National Horticulture Mission (NHM) has brought in protective irrigation (drip) facilities to farmers' fields. Drip irrigation selectively supplying water (conserved in farm ponds, check dams etc) to plantation crops in their basins along with pit digging and or herbicide application has effectively managed weeds in plantation crops.

CONCLUSION

By integration of all the methods of weed management, yield penalties in plantation crops can be effectively nullified. The ever increasing manpower shortage and the escalating labour charge are limiting their use in cultural weed management practices there is need to test and introduce new and potent selective herbicides suitable for multi storey cropping systems of plantations.

The combination effect of MSMA and Diuron in controlling glyphosate resistant *Eleusine indica* in oil palm plantation

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In every production system of crops, the vital component is weed management. This is because the presence of weeds affects the yield and growth of crops due to competition in terms of basic growth requirement. Typically, weeds compete with crops for water, light and soil nutrients. Goosegrass (*Eleusine indica*) is one of the weeds that has problems associated with herbicide resistance. *E. indica* is normally controlled by herbicides such as glyphosate. The intensive use of herbicides has resulted in the weed developing herbicide resistance (Heap and Lebaron, 2001). In Malaysia, the first case of glyphosate-resistant *E. indica* was reported in a four-year-old orchard in Teluk Intan, Perak in 1998 after glyphosate failed to control of *E. indica* adequately. The level of resistance in the resistant biotype in Teluk Intan was found to be 8-12 times higher than the susceptible biotype (Lim and Ngim 2000).

METHODOLOGY

An experiment was conducted with the objective to test the efficacy of a herbicide mixture of MSMA 39.5% w/w and Diuron 7.8% w/w in SC formulation and its tank-mix with Paraquat dichloride 13% w/w or Glufosinate ammonium 13.5% w/w, for controlling the resistant biotype *E. indica* in a nursery trial.

RESULTS

It was observed that resistance of *E. indica* to glyphosate was significant as only 10% of the *E.indica* treated with glyphosate died during the experiment. It was noted that treatmens T1-T4 recorded significantly higher percentage kill of goose grass (more than 95%) compared to T5 and T6 at one week after treatment. T3 and T4 recorded 100% *E. indica* kill at four weeks after treatment (Table 1).

Table 1. The percentage mortality of *E. indica* treated with various treatment of herbicides

Treatmemt	Active ingredients	Rate	Percentage of *E. indica* killed (%)			
			Week 1	Week 2	Week 3	Week 4
T1	MSMA 39.5%w/w + Diuron 7.8%w/w	5L/ha	95a	99a	99a	99a
T2	(MSMA 39.5%w/w + Diuron 7.8%w/w) + Paraquat dichloride 13%w/w	3L/Ha + 3L/Ha	98a	98a	98a	98a
T3	(MSMA 39.5%w/w + Diuron 7.8%w/w) + Paraquat dichloride 13%w/w	3.5L/Ha + 3L/Ha.	98a	99a	99a	100a
T4	Glufosinate ammonium 13.5%w/w	3.3L/Ha	95a	99a	99a	100a
T5	Paraquat dichloride 13%w/w	6L/Ha	80b	80b	80b	80b
T6	Glyphosate isopropylammonium 41%w/w	3L/Ha	10c	10c	10c	10c
T7	Control (water only)		0d	0d	0d	0d

*Different letters denote a significance ($p<0.05$) between treatments; data analyzed by Tukey HSD

CONCLUSION

The resistance of *E. indica* to glyphosate was observed to be significant as only 10% of the *E.indica* treated with glyphosate was killed. This study shows that Glufosinate ammonium 13.5% w/w or the combination of MSMA 39.5%w/w + Diuron 7.8% w/w) + Paraquat dichloride 13%w/w (3.5L/Ha + 3l/ha can effectively control *E. indica.*

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Weed management in potato in cold arid region

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Ladakh lies between 32°15'-36° N and 75°15'-80°15' E, and is a high altitude cold arid region of India. The region suffers from an extremely harsh climate with winter temperature (-30°C). Due to heavy snowfall, Ladakh remains cut off for almost seven months *i.e.* from October – May from rest of the world by surface transportation. Agriculture and harvesting glacier water in the lap of Himalaya has developed a small-scale farming system adapted to this unique and extreme environment. Families rely essentially on subsistence agriculture based on principal crops like wheat, barley and potato. Potato, being main vegetable during winter season, is a main cash crop grown during May-October in the region. Huge quantity of potato is imported as the production is very confined to limited area and low productivity mainly due to less holding area and weed pressure. In majority of the situations, land holdings are only one to two hectares, but easily sufficient. In fact, under such topographic situations, there is little desire to own large areas of land. Most villages outside the Indus Valley are small and tucked into narrow valleys. Nevertheless, people have utilized waters from glacial-fed rivers in their stone-built terracesto practice cultivation. Later manures are used to facilitate the planting of staples. Its conservation of old land races of cultivated plants, especially of alfalfa, is of global importance. However, weeds not only compete for space and moisture, but also reduce the yield and quality of produce to a significant level.

METHODOLGY

A field trial was carried out by Regional Research Station, CAZRI, Leh on farmer's field in Stakmo village during 2014-15 to identify the extent and characteristics of grassy and broad-leaved weeds and to find out suitable herbicide for weed control in potato under existing practices. Six treatments consisting of pre-emergence application of metribuzin, pendimethalin, atrazine at 1.0 kg/ha along with hand weeding, farmers'method and weedy were arranged in a randomised block design with a variety '*Jyoti'* in sandy loam soil. The recommended package of practices was followed under existing situation of potato cultivation, besides traditional practice of fertilizer and FYM application. Data on weeds and crop parameters were recorded. Mean annual precipitation is about 80-300 mm, which is very scanty and negligible.

RESULTS

Major weeds observed were *Chenopodium carinatum*, *Chenopodium album*, *Convolvulus arvensis*, *Agropyron repens*, *Malwa neglecta*, *Setaria* sp. Presence of weeds caused 40-50% yield reduction in potato. Results revealed that application of herbicides significantly influenced all the growth and yield parameters, tuber yield of potato and controlled weeds significantly (Table 1). Maximum tuber yield was recorded under weed free situation followed by application of pendimethalin as compared to farmers' method and control. It was observed that potato crop can be saved from weeds with application of herbicides, keeping in view the higher labour charges.

Table 1. Tuber yield of potato and weed index (WI) as influenced by weed management methods

Treatment	Potato yield (t/ha)	WI (%)
Metribuzin (1.0 kg/ ha)	12.72	25.1
Atrazine (1.0 kg/ ha)	12.23	28.0
Pendimethalin (1.0 kg/ha)	15.10	11.1
Farmers' method	8.40	50.5
Hand weeding + earthing-up at 25 DAP	16.99	0.0
Weedy	10.34	39.1

The weedy condition and farmers' method have resulted in almost 40 and 51 per cent reduction in the tuber yield. The weed free plot recorded significantly higher tuber yield over chemical treatments. Hand weeding + earthing up at 25 days recorded 16.99 t/ha yield which is 64-100% more than weedy (control) and farmers' method, respectively.

CONCLUSION

It is concluded that pre-emergence application of pendimethalin at 1.0 kg/ha is most effective for controlling weeds, improving potato yield which is comparable to hand weeding + earthing-up at 25 days after planting.

Effect of integrated weed management on weed indices, yield and economics of ajwain

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Ajwain, commonly known as bishop's weed and vaamu in Telugu, is widely grown in arid and semi-arid regions. The total area under ajwain cultivation in India during 2012-13 was 35.38 m ha, with a production of 26.78 m t and an average productivity of 760 kg/ha. In Andhra Pradesh, during 2012-13 the total area under ajwain was 5.08 ha, with a production of 2.4 t and productivity of 470 kg/ha (India stat.com). The fruit find its use as an antispasmodic, anti-flatulent, anti-rheumatic, diuretic anti microbial. Ajwain takes 12-15 days for germination and initial growth is slow. This results in severe weed competition and yield loss as high as 91.4%. Use of herbicides for weed control is most effective and economic but use of herbicides is not always feasible due to unavailability of proper herbicides and cropping system requirement *etc*. Therefore, it is necessary to explore and test other alternative and economical methods of weed control.

METHODOLOGY

The experiment was carried out during *Rabi* 2012-13 at college farm, college of agriculture, ANGRAU, Hyderabad, Telangana. The experiment was laid out in a randomized block design with three replications. Bold and healthy local variety seeds were used for the study and the recommended package of practices was followed. Nutrients were applied through urea, single super phosphate and murate of potash @ 40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha, respectively. Data on weed parameters, yield and economics were recorded.

RESULTS

Cynodon dactylon among grasses, *Cyperus rotundus* among sedges and *Parthenium hysterophorus* among broad leaved weeds were the most dominant ones. Hand weeding (20, 40 and 60 DAS) treatment recorded the lowest weed density and weed dry matter at harvest. The next best treatment was oxyfluorfen 0.12 kg/ha as PE *fb* quizalfop-p-ethyl 0.05 kg/ha as PoE at 20 DAS. Significantly lower weed index was noticed with application ofoxyfluorfen 0.12 kg/ha as PE fb quizalfop-p-ethyl 0.05 kg/ha as PoE at 20 DAS and oxyfluorfen 0.12 kg/ha as PE *fb* hand weeding at 40 DAS (Table 1).

Hand weeding at 20, 40 and 60 DAS recorded significantly higher seed and haulm yield over other treatments. Application of oxyfluorfen 0.12 kg/ha as PE fb quizalfop-p-ethyl 0.05 kg/ha as PoE at 20 DAS resulted in higher seed and haulm yield and was on par with oxyfluorfen 0.12 kg/ha as PE fb hand weeding at 40 DAS. Integrated weed management treatments resulted in considerably lower cost of cultivation as compared to hand weeding. The benefit cost ratio was highest with application of oxyfluorfen 0.12 kg/ha as PE *fb* quizalfop-p-ethyl 0.05 kg/ha as PoE at 20 DAS followed by oxyfluorfen 0.12 kg/ha as PE *fb* hand weeding at 40 DAS.

Table1. Weed growth, yield and economics of ajwain as influenced by different integrated weed control treatments

Treatment	Weed density (no/m^2)	Weed dry matter (g/m^2)	Weed Index (%)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Cost of cultivation (Rs./ha)	B:C
Pendimethalin 1.0 kg/ha as PE fb hand weeding at 40 DAS	7.09 (49.3)*	8.45 (70.53)	35.9	740	886	40,950	1.8
Oxyfluorfen 0.12 kg/ha as PE fb hand weeding at 40 DAS	5.61 (30.6)	7.06 (48.92)	16.9	959	1212	40,668	2.4
Pretilachlor 0.5 kg/ha as PE fb hand weeding at 40 DAS	7.47 (54.9)	8.81 (76.66)	45.6	628	834	40,188	1.6
Quizalfop-p-ethyl 0.05 kg/ha as PoE at 20 DAS	8.49 (71.2)	9.63 (91.86)	54.9	520	641	37,208	1.4
Propaquizafop 0.05 kg/ha as PoE at 20 DAS	9.08 (81.6)	10.24 (104.00)	57.1	495	626	36,418	1.4
Pendimethalin 1.0 kg/ha as PE fb quizalfo-p-p-ethyl 0.05 kg/ha as PoE at 20 DAS	6.74 (44.5)	8.63 (73.73)	33.1	772	931	38,090	2.0
Oxyfluorfen 0.12 kg/ha as PE fb quizalfo-p-p-ethyl 0.05 kga*i* ha^{-1} as PoE at 20 DAS	6.31 (38.9)	6.80 (45.13)	11.7	1065	1222	38,808	2.7
Pretilachlor 0.5 kg/ha as PE fb quizalfop -p-ethyl 0.05 kg/ha as PoE at 20 DAS	7.9 (62.3)	9.31 (85.80)	48.2	598	665	38,328	1.6
Pendimethalin 1.0 kg/ha as PE fb propaquizafop 0.05 kg/ha as PoE at 20 DAS	8.74 (75.5)	9.10 (81.86)	42.9	659	787	37,300	1.8
Oxyfluorfen 0.12 kg/ha as PE fb propaquizafop 0.05 kg/ha as PoE at 20 DAS	8.31 (68.2)	8.87 (77.73)	36.2	736	813	38,018	1.9
Pretilachlor 0.5 kg/ha as PE fb propaquizafop 0.05 kg/ha as PoE at 20 DAS	8.73 (75.3)	9.31 (85.73)	53.5	536	673	37,538	1.4
Hand weeding at 20, 40 and 60 DAS	4.9 (24.0)	5.87 (33.60)	-	1155	1316	50,068	2.3
Weedy check	11.3 (130.6)	12.91 (165.90)	64.3	412	600	35,068	1.2
SEm±	0.96	0.37		29	31.2		
CD (P=0.05)	2.83	1.08		84	91		

*Original values are given in parentheses, which were transformed to "x+1

CONCLUSION

It is concluded that oxyfluorfen 0.12 kg/ha *fb* quizalfop-p-ethyl 0.05 kg/ha 20 DAS is most effective for controlling weeds, improving seed yield and profitability of ajwain.

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Weed biomass and seedling emergence patterns as affected by different ground cover management systems in coconut plantations of Sri Lanka

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The unutilized space beneath the coconut (*Cocos nucifera* L) plantation is invaded by a wide range of perennial and annual weed species. Such weeds invariably compete with coconut for soil moisture and nutrients, affecting growth and yield and obstructing routine management practices (Senarathne *et al*. 2003). In order to develop a sustainable integrated weed management strategy, a detailed understanding of the seed bank is required, incorporating germination characteristics of weed seeds and factors that regulate emergence and establishment of seedlings in the field. Therefore, a study was conducted to evaluate the effect of different practices of weed management on the seedling emerging pattern and emerged seedling population under field condition.

METHODOLOGY

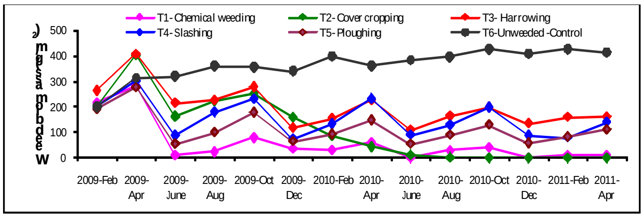
The experiment was carried out from August 2009 to May 2012 at the Coconut Research Institute, Sri Lanka with six treatments, *viz*. T_1-chemical weeding (application of glyphosate 1.44 kg/ha at six months interval), T_2-establishment of cover crop (*Puereria phasioloides*), T_3-tractor harrowing once in six months (0- 15 cm depth), T_4-tractor slashing once in six months, T_5- Tractor ploughing once in six months (0-45 cm depth) and T_6- unweeded (control) in a randomized complete block design with three replicates. Tractor harrowing, slashing and ploughing were done at the latter part of the rainy season. The data on weed growth, number of weed seedling emerged and depth of emergence were recorded.

RESULTS

The total weed biomass was very high at the initial stages in cover cropped plots which declined gradually later. With time, *Pueraria* regenerated with seeds and formed a good ground cover, thereby suppressing weed populations (Fig. 1). The three mechanical weeding treatments suppressed the weed growth initially, but rapid re-growth was observed. Harrowing and ploughing reduced the weed biomass significantly when compared to slashing. Both methods were helpful to bury weed seeds in deep layers and thus reduced the population of weeds on the surface. However, this practice loosened the soil and which would create a suitable environment for the germination of some weed species seeds (Senarathne and Sangakkara 2009).

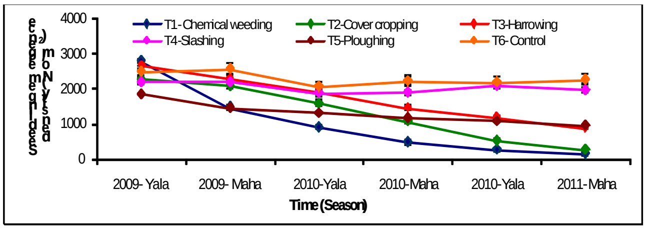
The numbers of weed seedlings emerged gradually decreased with time in all weeding treatments except in control (Fig. 2). A high weed seedling density was observed on the surface in control and slashing treatments. The seedling emergence density was significantly low and similar ($P<0.05$) in chemical and cover cropping treatments. The total weed seedling emergence densities were almost similar in ploughed and harrowed plots. Chemical weeding and cover cropping were found to be the best methods to reduce weed seedling emergence.

The seed depth of emerged weed seedling of selected weed species was very high in harrowed and ploughed treatments (1.63 and 1.05 cm depths of the soil, respectively) when compared to other weeding treatments. These results indicated that loosening the soil created more favorable environment for germination of weed seeds buried in soil layers.



Treatments were applied in May 2009, October 2009, May 2010, October 2010 and May 2011.

Fig.1 Effect of different ground cover management systems on total weed biomass



Treatments were applied in May 2009, October 2009, May 2010, October 2010 and May 2011.

Fig.2 Effect of different ground cover management systems on weed seedling emergence density

CONCLUSION

Application of glyphosate and cover cropping are very effective methods to reduce total weed biomass and weed seedling emergence density. However the depths of weed seedling emergence of many species were very high in harrowing and ploughing treatment plots when compared to the other weeding methods.

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Efficacy of different weed control methods in brinjal

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Brinjal (*Solanum melongena* L.) is one of the most important, common and popular vegetable crops cultivated in the tropical and sub-tropical regions of the world. It is a hardy vegetable crop with wider adaptability. It is grown throughout the year in India. Because of its year the round growing habit, it provides continuous and cumulative source of income to the farmer. As brinjal is grown on a large area and under wide climatic conditions, weeds pose a major problem in brinjal cultivation. The present investigation was undertaken to evaluate different weed control methods in brinjal.

METHODOLOGY

A field experiment was conducted in a randomised block design with three replications during *kharif* 2004 at College of Agriculture, Pune to find out the mosteffective method of weed control in brinjal. There were nine treatment combinations consisting mechanical and chemical methods. The brinjal *cv.* '*Phule Harita*' was grown with recommended dose of fertilizer (150:50:50 kg N, P_2O_5 and K_2O/ha) in the form of urea, single superphosphate and muriate of potash, respectively. The data on weed growth, yield parameters and economics were recorded.

RESULTS

The major weeds in the experimental field were: *Panicum isachmi, Cynodon dactylon, Convolvulus arvensis, Cyperus rotundus, Parthenium hysterophorus* and *Commelina benghalensis*. The lowest weed population and dry matter at harvest was observed under three hand weedings followed by pendimethalin 1.25 kg/ha + one hand weeding at 40 DAT. The weed control efficiency was highest under three hand weedings. The weed index was maximum in unweeded check and lowest in three hand weedings at 20, 40 and 60 DAT. The highest fruit yield was recorded in three hand weeding at 20, 40 and 60 DAT followed by pendimethalin 1.25 kg/ha + one hand weedings at 40 DAT while the lowest fruit yield was observed in unweeded check. The cost of cultivation was lowest in unweeded check whereas the B:C ratio was highest in three hand weedings at 20, 40 and 60 DAT (Table 1).

Table 1. Weed growth, fruit yield and economics of brinjal as influenced by weed control methods

Treatment	Weed density (no/m^2)	Weed drymatter (g/m^2)	Weed control effiency (%)	Weed index (%)	Fruit yield (t/ha)	Cost of cultivation (Rs/ha)	B: C ratio
Un weeded control	189.26	122.2	---	41.0	19.98	30,270	1.94
Three hand weeding at 20,40 and 60DAT	47.30	30.8	76.7	0	33.89	37,770	2.93
Pendimethalin (PE) 1.25 kg/ha	125.37	92.4	30.3	28.7	24.16	34,168	2.35
Pendimethalin (PE) 1.25 kg/ha + one hand weeding at 40 DAT	53.13	46.0	65.2	8.1	31.12	36,668	2.84
Fluchloralin(PPI) 1.25 kg /ha	133.53	95.0	28.1	30.8	23.44	32,823	2.34
Fluchloralin(PPI) 1.25 kg/ha + one hand 340weeding at 40 DAT	57.57	51.0	62.0	12.8	29.52	35,323	2.81
Glyphosate 1.25 kg/ha at 25 DAT	135.85	96.1	27.3	34.5	22.18	31,385	2.37
Pendimethalin(PE) 1.25 kg/ha + Glyphosate 1.25 kg/ha at 40 DAT	66.67	69.5	47.4	20.0	27.13	35,283	2.56
Fluchloralin(PPI) 1.25 kg/ha + Glyphosate 1.25 kg/ha at 40 DAT	72.80	72.0	45.8	22.4	26.15	33,938	2.55
CD (P=0.05)	7.40	1.0	5.9	4.4	2.48	3,477	0.40

CONCLUSION

It is concluded that the three hand weedings at 20, 40 and 60 DAT is the most effective method for controlling weeds and getting higher fruit yield and profitability in *kharif* brinjal.

Integrated weed management in ginger

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Ginger is an herbaceous perennial plant, the rhizomes of which are used as a spice. India is a leading producer of ginger in the world. During 2012-13, the country produced 7.45 lakh tonnes of the spice from an area of 157,839 ha (GOK 2012). Ginger is cultivated in most of the states in India. The area under ginger cultivation in Kerala has declined to 4,505 ha during 2012-2013. The major constraint in the production of ginger in the state is labour shortage, infestation by large number of weeds and high incidence of pest and diseases. Hence, the present investigation was undertaken to develop an intergrated weed management method in ginger.

METHODOLOGY

A field experiment was carried out at College of Horticulture, Vellanikkara during March 2013 to January 2015. The experiment involved ten treatments (Table 1) in a randomised block design with three replications. The pre-emergence herbicides were applied at three days after sowing whereas the post-emergence herbicides were applied at twenty five days after planting, just before the emergence of sprouts of ginger. Fertilizers (75: 50: 50 kg N, P_2O_5 and K_2O/ha) were applied uniformly in all the treatments through urea, SSP and MOP. The data on weed population, weed dry matter, yield attributes, yield and economics were recorded.

RESULTS AND DISCUSSION

Application of glyphosate + oxyfluorfen (T_7) resulted in the least count of weeds at 45, 90 and 180 DAP (Table 1) and was on par with two hand weeding (T_8). This may be due to the longer period of persistence of oxiflourfen in soil. Soil solarization (T_{10}) as well as application of pendimethalin or oxyfluorfen followed by hand weeding (T_3 and T_4) also resulted in significant reduction in weed count than other treatments. The weed dry matter production at 45, 90 and 180 DAP also showed the same trend. Application of these herbicides did not cause any phytotoxic symptoms to the crop. The highest yield was recorded by glyphosate + oxyfluorfen (T_7) closely followed by two hand weeding. The treatment oxyfluorfen, oxyfluorfen + hand weeding, pendimethalin + hand weeding and solarization also resulted in higher yields. Similar trend was followed in tiller count also. Glyphosate + oxyfluorfen (T_7) resulted in the highest B:C ratio followed by pendimethalin+hand weeding (T_3) and oxyfluorfen + hand weeding (T_4). The lowest B:C ratio was recorded in unweeded control. Even though hand weeding resulted in high yield, similar to that by glyphosate + oxyfluorfen, the B:C ratio was low because of the high cost of cultivation due to large number of laborers engaged for hand weeding.

Table 1. Weed count, weed drymatter, ginger yield and tiller count and economics of ginger production as influenced by weed control treatments

Treatment	Weed count (no/m²)			Weed dry matter (g/m²)			Yield (t/ha)	B:C ratio
	45 DAP	90 DAP	180 DAP	45 DAP	90 DAP	180 DAP		
T_1–Pendimethalin	3.5^b (12.0)	4.3^b (18.0)	4.7^b (22.3)	$22.^e$ (488.4)	28.68^e (825.5)	34.4^d (1187.0)	5.67^c	2.5
T_2–Oxyflourfen	2.7^c (7.3)	3.1^d (9.3)	3.7^d (13.6)	22.01^e (484.4)	28.72^e (827.4)	34.19^d (1170.1)	10.10^{ab}	4.4
T_3 - Pendimethalin+HW	2.0^d (3.6)	2.3^e (5.0)	2.9^e (8.6)	19.06^f (363.4)	12.04^h (146.4)	24.73^f (612.8)	11.97^{ab}	5.0
T_4 - Oxyflourfen + HW	2.0^d (3.6)	3.0^d (9.0)	3.9^{cd} (15.3)	18.62^f (346.4)	11.64^h (135.3)	25.06^f (627.5)	11.72^{ab}	4.9
T_5– Glyphosate	3.5^b (12.3)	3.5^{cd} (12.3)	4.3^c (18.3)	35.460^c (1262.0)	41.03^c (1685.0)	44.26^c (1960.1)	5.63^c	2.4
T_6 - Pendimethalin + Glyphosate	2.8^c (7.6)	3.8^c (14.6)	4.5^c (20.0)	22.16^e (490.6)	25.75^f (663.1)	34.27^d (1177.2)	9.27^b	4.0
T_7 - Oxyflourfen + Glyphosate	1.6^d (2.3)	2.1^e (4.0)	2.4^f (5.3)	10.92^g (118.8)	18.48^g (341.3)	21.00^g (440.9)	13.53^a	5.9
T_8 – Two hand weeding	1.4^d (1.6)	1.7^e (2.6)	2.1^f (4.)	11.04^g (121.5)	18.37^g (337.1)	20.81^g (434.3)	13.35^a	4.1
T_9 - Unweeded control	4.5^a (20.3)	5.7^a (32.6)	5.9^a (35.0)	51.39^a (2645.0)	53.82^a (2897.0)	56.45^a (3186.5)	4.23^c	1.8
T_{10} - Soil solarisation	2.3^{cd} (5.0)	3.2^d (10.0)	3.3^{de} (10.6)	23.95^e (580.3)	25.90^f (676.5)	26.93^e (733.2)	10.62^{ab}	3.6
CD (P=0.05)	0.6	0.5	0.5	2.165	1.834	1.629	3.083	

The values given in the paranthesis are original. In a column, values followed by same alphabets do not differ significantly

CONCLUSION

It is concluded that the combined application of pre emergence and post emergence herbicide iss most effective for controlling weeds, improving yield and profitablility of ginger cultivation.

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Crop and weed contamination by radioactive cesium and countermeasure after the Fukushima nuclear accident

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Tokyo Electric Power Company's Fukushima Dai-ichi nuclear power plant released radioactive cesium (R-Cs) into the environment after the Great East Japan Earthquake of March, 2011. After the nuclear accident, field crops'grain lots exceeding the standard limits for radioactive Cs concentration (100 Bq/kg) established by the Japanese government were detected in eastern Japan. Wheat, barley and oilseed rape grains were the first case of detection of R-Cs concentration over

100 Bq/kg in 2011, because these crops had been growing before the accident. It was later revealed that the contamination attributed to fallout from the nuclear plant, not to root absorption. Our studies also clarified that R-Cs released from the nuclear plant was hardly accumulated in wheat and barley grains by root absorption (unpublished). Thereafter, grains of high R-Cs concentration over 100 Bq/kg were found in other important field crops: paddy rice and soybean.

Prominent effect of potassium(K) fertilization in decreasing R-Cs concentration was first found for paddy rice after trials of many possible countermeasures by Dr. Kato of NARO and his colleagues (Kato *et al.* 2015). Based on their research, Japanese and local governments strongly recommended to farmers additional K fertilization and also offered financial support for it. Owing to the action, R-Cs concentration of paddy rice produced by farmers in the following yearswas markedly decreased.

As for soybean, K fertilization was also effective but not sufficient to decrease R-Cs concentration: some other important factors probably involve R-Cs concentration of soybean (Shimada *et al.* unpublished). Thus, research for decreasing R-Cs concentration of soybean has been going on.

Buckwheat grains of high R-Cs over 100 Bq/kg were detected first in 2012, a year later than the other crops described above. So, we next tried to reveal the R-Cs decreasing effect of Kin buckwheat.

Two-year experiment was conducted employing a farmer's field where R-Cs concentration was roughly 5,000 Bq/kg for a soil layer of 0-15 cm deep. The effect of K application on the reduction of R-Cs concentration in buckwheat grain was confirmed by the field experiment (Kubo *et al.* 2015). In detail, K fertilization such that exchangeable K concentration of soil (0-15 cm deep) increases to 30 mg K_2O/100g or overstably provided grain R-Cs concentration of much lower than 100 Bq/kg. A pot experiment using soil of 4093 Bq/kg collected from another farmer's field arrived at the same result as the field experiment. Japanese and local governments' recommendation of additional K fertilization based on our research decreased R-Cs concentration of buck wheat produced by farmers in the following years as well as paddy rice described above.

We also studied R-Cs concentration of weeds growing around crop fields. Weeds have been widely used as forage by small cattle farmers in eastern Japan to cut down the cost of production. This study was conducted to ensure the safety of weed usage as forage. In brief, we successfully found that R-Cs concentration of weed species growing in the soil of high exchangeable K concentration was stably low even if the soil R-Cs concentration is high. Summary of this study in Japanese is now on the NARO web site (https://www.naro.affrc.go.jp/publicity_report/publication/laboratory/narc/manual/058047.html). But, efficacy of K application in reducing R-Cs concentration of weeds is not confirmed yet. We consider it's an important project that should be demonstrated in the near future.

CONCLUSION

Many Japanese researchers' efforts revealed the high correlation between K concentration of soil and R-Cs concentration of many plant species including field crops and weeds irrespective of the taxonomic groups they are belonging to. We believe the knowledge should be effectively used in possible nuclear disasters in the future.

ACKNOWLEDGMENT

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Effect of mulch and intercrop under organic, inorganic and integrated system of weed management in cauliflower

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Cauliflower is an important winter season vegetable grown in India. Weed management is an important component in cauliflower cultivation. Losses in cauliflower head weight due to season long weed competition were recorded up to 76.1% (Qasem 2007). Integrated weed management strategies like hand weeding, mulches, intercrops and herbicides could be a better option than relying on any single method. Therefore, a field study was conducted to know the effect of mulch and intercrop under organic, inorganic and integrated system of soil fertility and weed control on weeds and yield of cauliflower.

METHODOLOGY

The field experiment was conducted during *Rabi* season of 2009-10 at Jabalpur. The soil of the experimental field was clay loam with pH 6.9, OC 0.71%, low in available nitrogen and medium in available phosphorus and potassium. The experiment comprising three levels of organic, inorganic and integrated system of soil fertility/weed control in the main plots and four levels of mulches/intercrop in sub-plots was laid out in a split plot design replicated thrice with plot size of 4.8 m x 3 m. Twenty-five days old seedlings of cauliflower '*Snowball 16*' were planted at a spacing of 60 x 30 cm. Fertilizer and weed control was taken up as per the treatments. Data on weed growth and cauliflower curd yield were recorded.

RESULTS

The major weed flora observed in the experimental field was *Medicago denticulata, Chenopodium album, Vicia sativa, Physalis minima* and others. The weed density at 60 DAS was lowest under the integrated treatment of 50% FYM + 50% NPK+herbicide *fb* 1 hand weeding and with black polythene mulch. However, the weed dry weight was lower and similar under FYM + 2 hand weeding and 50% FYM + 50% NPK+ herbicide *fb* 1 hand weeding and the black polythene and straw mulch treatments (Table 1). The curd yield of cauliflower was equal under recommended NPK (120:60:40 kg NPK/ha) + pendimethalin 1.0 kg/ha PE (14.77 t/ha) and 50% FYM + 50% NPK+herbicide *fb* 1 hand weeding. The treatment of black polythene mulch produced the highest curd yield of 19.36 t/ha.

Table 1. Effect of treatments on weed density, biomass at 60 DAS and yield of cauliflower

Treatment	Weed density (no/m²)	Weed biomass (g/m²)	Curd yield (t/ha)
M1: FYM (22.5 t/ha) + 2 hand weeding	5.1 (25.5)	2.3 (4.8)	9.24
M2: Recommended NPK (120:60:40 kg NPK /ha) + pendimethalin 1.0 kg/ha PE	5.8 (33.1)	3.9 (14.7)	14.77
M3: 50% FYM + 50% NPK+ herbicide fb 1 hand weeding	3.4 (11.1)	2.0 (3.5)	15.29
LSD (P=0.05)	0.7	1.1	1.73
S1: Cauliflower (sole)	7.2 (51.3)	4.9 (23.5)	10.04
S2: Cauliflower + radish	5.1 (25.5)	2.8 (7.3)	7.44 (21.8)*
S3: Cauliflower + straw mulch	3.9 (14.7)	2.0 (3.5)	15.56
S4: Cauliflower + black polythene	2.8 (7.3)	1.3 (1.2)	19.36
LSD (P=0.05)	0.5	1.0	0.98

Weed data sq root transformed, original values are in parenthesis; *Intercrop yield

CONCLUSION

It can be concluded that integrated weed management (50% FYM + 50% NPK+ herbicide *fb* 1 hand weeding) along with black polythene mulch was the best practice of nutrient and weed management in cauliflower.

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Comparative efficacy of herbicides to manage *Chromolaena odorata*

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A field trial on "Comparative efficacy of herbicides to manage *Chromolaena odorata*" under wasteland situation was conducted at Gandhi KrishiVigyan Kendra, UAS, Bangalore during

2003-2004, to evaluate suitable herbicide combinations involving four herbicides each at four concentrations *viz*., glyphosate 41 SL 0.4, 0.8, 1.2 and 1.6 kg/ha, paraquat 24 SL 0.4, 0.6, 0.8 and 1.0 kg/ha, chlorimuron-ethyl 10WP + metsulfuron-methyl 10 WP (Almix 20WP) 2.0, 3.0, 4.0 and 5.0 g/ha and 2, 4-D Na salt 80 WP 1.0, 1.5, 2.0 and 2.5 kg/ha. These herbicidal treatments were compared with manual cutting and unsprayed control.

Application of paraquat at 0.4-1.0 kg/ha or glyphosate at 0.4 to 1.6 kg/ha caused 100% mortality and drying of *Chromolaena* plants, in plantation crops or wasteland, without regrowth till 90 days after spraying in old existing as well as de-topped plants, through lowered relative water content, stomatal conductance and transpiration rate with concomitant increase in leaf temperature resulting in death of plants. Further, usage of herbicides at all concentrations was cheaper in both old and de-topped plants than manual weeding.

The combination effect of MSMA and diuron in controlling glyphosate resistant *Eleusine indica* in oil palm plantation

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In every production system of crops, weed management is a vital component because the presence of weeds affects the yields and growth of crops due to competition in terms of basic growth requirement. Typically, weeds compete with crops for water, light and soil nutrients. Goose grass (*Eleusine indica*) is one of the weeds that has problem associated with herbicide resistance. *E. indica* is normally controlled by herbicides such as glyphosate. The intensive use of herbicides has resulted in the development of herbicide resistance (Heap and Lebaron 2001). In Malaysia, the first case of the glyphosate-resistant *E. indica* was reported in a four-year-old orchard in Teluk Intan, Perak in 1998 after glyphosate failed to control of *E. indica* adequately. The level of resistance in the resistant biotype in Teluk Intan was found to be 8 to 12 times higher than the susceptible biotype (Lim and Ngim 2000). Therefore, a study to test the efficacy of mixture of MSMA 39.5% w/w and diuron 7.8% w/w in SC formulation and its tank-mix with paraquat dichloride 13% w/w or glufosinate ammonium 13.5% w/w for controlling the resistant *E. indica* in a nursery was conducted.

RESULTS

It was observed that resistance of *E. indica* to glyphosate was significant in this study as only 10% of the *E.indica* treated with glyphosate was killed. During the experimentation, it was noted that the treatments MSMA 39.5% + diuron 7.8%, MSMA 39.5% + diuron 7.8% + paraquat dichloride 13%, MSMA 39.5% + diuron 7.8% + paraquat dichloride 13% and glufosinate ammonium 13.5% recorded significantly higher weed kill (more than 95%) as compared to paraquat dichloride 13% or glyphosate isopropyl ammonium 41% at the one week after treatment. The treatments MSMA 39.5% + diuron 7.8% + paraquat dichloride 13% and glufosinate ammonium 13.5% recorded 100% *E. indica* kill at four weeks after treatment (Table 1).

Table 1. The percentage mortality of *E. indica* treated with various herbicides

Treatment		Rate	Percentage of *E. indica* killed			
			Week 1	Week 2	Week 3	Week 4
T_1:	MSMA 39.5% + diuron 7.8%	5 L/ha	95a	99a	99a	99a
T_2:	(MSMA 39.5%+ diuron 7.8%) + Paraquat dichloride 13%	3 L + 3L/ha	98a	98a	98a	98a
T_3:	(MSMA 39.5%+ diuron 7.8%)+ Paraquat dichloride 13%	3.5 L+ 3L/ha	98a	99a	99a	100a
T_4:	Glufosinate ammonium 13.5%	3.3 L/ha	95a	99a	99a	100a
T_5:	Paraquat dichloride 13%	6 L/ha	80b	80b	80b	80b
T_6:	Glyphosate isopropylammonium 41%	3 L/ha	10c	10c	10c	10c
T_7:	Control (water spray)		0d	0d	0d	0d

*Different letters denote a significance ($p<0.05$) between treatments; data analyzed by Tukey HSD.

Results obtained in Experiment 2 also echoed the results of Experiment 1 as resistance of *E. indica* to glyphosate was observed to be significant when treated with glyphosate isopropylammonium with only

10 % kill of *E. indica*. The treatments MSMA 39.5% + diuron 7.8%, MSMA 39.5% + diuron 7.8% + paraquat dichloride 13%, MSMA 39.5% + diuron 7.8% + paraquat dichloride 13% and glufosinate ammonium 13.5% once again recorded significantly higher percentage of *E. indica* kill (more than 99%) at four weeks after treatment.

CONCLUSION

The inability of glyphosate to control *E. indica* at the nursery trials showed classic cases of resistant *E. indica* towards glyphosate application. This study shows that the combination of alternative herbicides (MSMA 39.5% w/w + diuron 7.8% w/w) + Paraquat dichloride 13%w/w (3.5 l/ha + 3 l/ha) and Glufosinate ammonium 13.5% w/w can effectively control *E. indica* up to 4 weeks after treatment.

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Efficacy of glyphosate monoammonium and other commercial herbicides to control volunteer oil palm seedlings in oil palm plantation

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Thick growth of noxious weeds may disturb daily field activities such as harvesting and evacuation of fresh fruit bunches, loose fruit collection, fertilizer application and other supervisory works. Interruption of loose fruit collection by weed infestation can contribute to more problems in managing weeds. Uncollected loose fruits will germinate and will eventually become volunteer oil palm seedlings (VOPs). In addition, rotten bunches left on the field, the use of incomplete stripped empty fruit bunches as mulching material, seeds left in the field from the previous cultivation in replanting area will also lead to germination of VOPs. The sequential use of a single herbicide that eradicated grass weeds will also facilitate VOPs succession by giving space for growth (Law *et al*. 2006). Chung (1996) had recommended spraying paraquat at 2.8 L/ha sprayed wet (drench). Ngim *et al.* (1995) found that paraquat at 110 ml/18 litre water sprayed-to-wet effectively controlled VOPs. A number of commercial herbicides are available in the market claimed to have potential to control VOPs. However, the efficacy of these herbicides is unclear. Therefore, a study to evaluate commercial herbicides with potential to control VOPS was carried out.

METHODOLOGY

In this study, eleven commercial herbicides with potential efficacy against VOPs (Table 1) were evaluated along with a control. The herbicides were tested at the spray volume normally applied for general weed spraying (GWC).

RESULTS

At 1, 2 and 3 DAA, no VOPs were killed by any treatment. But at 7 DAA, paraquat dichloride at 5.0 l/ha (93% kill) and MSMA at 5.0 l/ha (20% kill) gave significant control of VOPs compared to other herbicides (Table 1). At 14 DAA, there was 100% kill by glyphosate monoammonium at 5.0 l/ha followed by paraquat dichloride at 5.0 l/ha (93%) and glyphosate isopropylamine at 4.0 l/ha (70%). Both glyphosate herbicides appeared to have good efficacy to control VOPs. At 56 DAA, all herbicides killed more than 50% of VOPs except for glyphosate isopropylamine + MCPA mixture at 3.0 l/ha (47%), MSMA (43%) and glyphosate dimethylamine 3.0 l/ha (33%). Treatments with diuron at 1.0 kg/ha, imazapyr isopropylamine at 2.5 l/ha and a mixture of glufosinate ammonium + imazapyr + 2,4-D at 1.2 l/ha were found to be ineffective to kill VOPs. Regrowth of treated VOPs were observed for all herbicides except for glyphosate monoammonium.

Table 1. Control of VOPs by different commercial herbicides

Treatment	Dose (L/ha or kg/ha)	7 DAA##	14 DAA	21 DAA	28 DAA	35 DAA	42 DAA	49 DAA	56 DAA
			Perentage of VOPs killed #						
2,4-D isopropylamine 45% w/w	2.5	0c	10f	13h	17g	17f	37e	53cd	67c
Diuron 80% w/w	1.0	0c	0g	3i	3h	3g	3f	3f	3e
Glufosinate ammonium 13.5% w/w	3.3	0c	40d	67d	67d	67d	67d	67c	67c
Glufosinate ammonium 5.8% w/w + imazapyr 5.5% w/w + 2,4-D 4.7% w/w	1.2	0c	0g	0i	0h	0g	0f	3f	3e
Glyphosate dimethylamine 52% w/w	3.0	0c	0g	20gh	27fg	30e	30e	33e	33d
Glyphosate isopropylamine 41% w/w	4.0	0c	70c	87c	87c	87c	87c	87b	87b
Glyphosate isopropylamine 34% w/w + MCPA isopropylamine 6.5% w/w	3.0	0c	3g	30fg	33ef	40e	40e	40de	47d
Glyphosate monoammonium 33.6% w/w	5.0	0c	100a	100a	100a	100a	100a	100a	100a
Imazapyr isopropylamine 11.9% w/w	2.5	0c	0g	0i	0h	0g	0f	0f	0e
MSMA 35.5% w/w	5.0	20b	27de	33ef	40e	40e	43e	43de	43d
Paraquat dichloride 13% w/w	5.0	93a	93b	93b	93b	93b	93b	93b	93b
Untreated (control)	--	0c	0g	0i	0h	0g	0f	0f	0e

#Means with the same letter in the same column are not significantly different according to Least Significant Different (LSD) test at p= 0.05
##DAA = days after application

CONCLUSION

Based on this study, it can be concluded that glyphosate monoammonium (5.0 l/ha), paraquat dichloride (5.0 l/ha) or glyphosate isopropylamine (4.0 l/ha) could be used to control VOPs using normal knapsack GWC spray volume of 450 l/ha.

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Effect of weed management in mango seedling nursery

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Mango is one of the important fruit crops grown in south Gujarat region which is declared as export zone of mango. In this context, production of good quality mango root stocks is need of time. The slow initial growth of mango seedlings, availability of sufficient moisture and nutrients and favourable climatic conditions allow the weeds to grow vigorously. Being hardy in nature and adaptive habitat, weeds compete well with mango seedlings resulting in their poor growth and quality. Very scarce scientific information on weed management in mango seedling nursery is available. Hence, the present investigation was conducted.

METHODOLOGY

A field experiment was conducted at Instructional Farm, Navsari Agricultural University, Navsari for three years from 2004-05-2006-07. Eleven treatments (Table 1) were tested in a randomized block design with three replications. A local mango variety was planted at 45 x 10 cm spcing, during second week of July. The crop was fertilized with recommended dose of 150:75:0 kg NPK/ha. The shallow furrows were opened manually in each plot as per treatments and entire quantity of phosphorous in the form of single super phosphate and 50 kg N/ha in the form of urea were manually applied uniformly before planting of mango during all the years. Remaining 100 kg N/ha in the form of urea was applied at 30 and 60 days after planting. The mango seedlings were uprooted in third week of June during all the years after light irrigation or onset of monsoon. Data on weed growth, mango seedlings and economics were recorded.

RESULTS

The predominant weed species observed in experimental field were: *Cyperus rotundus* L. (sedge); *Echinochloa colonum* link, *Brachiaria* sp., *Digitaria sanguinalis*., *Eragrosits major*, *Cynodon dactylon* and *Sorghum halepense* (monocots) and *Amaranthus viridis* L., *Alternenthera sessilis* L., *Digera arvensis*, *Convolvulus arvensis*, *Eclipta alba* L., *Vernonia cinerea*, *Euphorbia hitra* L., *Phylanthus madraspentesis*, *Physalis minima* L. and *Trianthema portulacastrum* (dicots). All weed control methods significantly reduced the population and dry weight of weeds as compared to control. Among them, weed free throughout the year recoded the minimum number of weeds. Similar trend was observed for the dry weight of weeds at 90 DAS also. All herbicidal treatments were equally effective and recorded higher weed control efficiency.

Table 1. Weed parameters, growth of mango seedlings and eonomics as influenced by different weed management treatments (Pooled data of three years)

Treatment	Weed count (no/m^2)	Weed dry weight (g/m^2)	Weed control efficiency (%)	Stem girth (cm)	Sur-vival %	Market-able seedling per ha	Net income (Rs /ha)	BC Ratio
Butachlor 3 kg/ha (PE)	10.7 (114.6)	9.7 (94.2)	41.3	6.33	61.8	1,68,325	3,13,575	2.63
Atrazine 2 kg/ ha (PE)	9.0 (80.9)	8.2 (67.2)	58.0	7.78	72.5	1,93,942	3,65,426	2.74
Pendimethalin 2 kg/ha (PE)	9.8 (95.8)	8.6 (73.3)	54.3	7.19	71.1	1,90,900	3,58,326	2.67
Interculturing at 30,60 and 90 DAP	10.1 (101.5)	9.1 (83.8)	47.8	7.07	72.2	1,90,036	3,57,858	2.68
Mulching sugarcane trash 10 t/ha	9.9 (98.4)	9.0 (81.6)	49.1	7.10	71.5	1,84,081	3,50,993	2.64
Mulching f paddy straw 10 t/ha	9.9 (98.5)	9.0 (81.7)	49.1	7.16	72.4	1,90,313	3,61,189	2.71
Hand weeding at 30,60 and 90 DAP	3.4 (11.7)	2.6 (6.5)	95.8	6.96	71.9	1,90,036	2,70,838	2.32
Weed free throughout year	0.7 (0.0)	0.7 (0.0)	100.0	6.89	72.2	1,90,688	2,60,595	2.21
Cover crop up to fibre formation (cowpea)	10.2 (104.8)	9.7(93.5)	41.8	6.96	71.9	1,90,112	2,71,780	2.34
Cover crop up to fibre formation (sun hemp)	10.2 (105.0)	9.6(91.6)	42.9	6.97	71.4	1,91,694	3,09,860	2.53
Un weeded control	13.4 (180.0)	12.6 (160.6)	-	5.93	70.3	1,80,434	2,04,493	2.31
LSD (P=0.05)	0.16	0.23		0.15	1.24			

Weed data in parenthesis indicate actual value and those outside are $\sqrt{x + 0.5}$ transformed value

The maximum stem girth and survival percentage of the mango stalks were obtained with application of atrazine 2 kg/ ha as pre emergence, leading to greater number of marketable seedlings, higher net income and BCR (Table 1). The increase in net income with application of atrazine 2 kg/ha as pre emergence was 78.7% over unweeded control.

CONCLUSION

It is concluded that application of atrazine 2 kg/ha as pre emergence in mango nursery is the most effective weed contorl method for getting quality mango seedlings and obtaining higher net income.

Weed and fertilizer management in onion

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India, in spite of being a major onion producing country, has very low productivity as compared to many other countries. Onion has very poor competetive ability with weeds due to its inherent characteristics such as short stature, non branching habit, sparse foliage, shallow root system and extremely slow growth during initial stage. Yield losses due to weed infestation in onion are as high as 82.2%. Further, onion requires higher levels of N, P and K fertilizer for maximum yields than most of other vegetable crops. The shallow root and dense population of onion make them responsive to fertilizers. This study was undertaken to develop effective weed and fertilizer management strategies for onion bulb crop.

METHODOLOGY

A field experiment was conducted during 2008-09 and 2009-10 at the research farm of Navsari Agricultural University, Navsari, Gujarat. There were thirty treatment combinations consisting of ten treatments of weed management [W_1: pendimethalin 1 kg/ha as (PE), W_2: oxyfluorfen 0.24 kg/ha (PE), W_3: pendimethalin 1 kg/ha (PE)+ fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_4: oxyfluorfen 0.24 kg/ha (PE)+ fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_5: pendimethalin 1 kg/ha (PE) + hand weeding at 40 DAT, W_6: oxyfluorfen 0.24 kg/ha (PE) + hand weeding at 40 DAT, W_7: hand weeding at 20 DAT + fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_8: two hand weeding at 20 and 40 DAT, W_9: weed free control (hand weeding at 20, 40 and 60 DAT), W_{10}: weedy check] and three levels of fertilizer [F_1: 75 % RDF, F_2: 100 % RDF (100:50:50, $N:P_2O_5:K_2O$ kg/ha) and F_3: 125 % RDF], laid out in randomized block design with factorial concept having three replications. The onion *cv* '*Guj. Onion White-1*' was sown at 15 x 10 cm spacing. All the agronomic management practices were followed as per the standard recommendations. Data on yield parameters, yield and economics were recorded.

RESULTS

The highest weight, volume and diameter of onion bulb was recorded under pendimethalin 1.0 kg/ha + hand weeding at 40 DAT, which was at par with oxyfluorfen 0.24 kg/ha + hand weeding at 40 DAT during both the years (Table 1). Whereas, weedy check recorded the lowest weight and volume of onion bulb during both the years. The reduced crop-weed competition provided better environment for proper development of growth as well as and yield attributes *viz*. bulb diameter, bulb volume and bulb weight, ultimately leading to the enhanced bulb yield. Application of 125% RDF proved superior by producing significantly higher bulb yield to tune of 19.43 and 10.52 %, over F_2 and F_1 respectively. The highest net income and B:C ratio were obtained under pendimethalin 1 kg/ha + hand weeding at 40 DAT followed by oxyfluorfen 0.24 kg/ha + hand weeding at 40 and weed free control. Similarly, the maximum net return with B:C ratio of 7.31 was registered under 125% RDF.

Table 1. Yield attributes, yield and economics of onion as influenced by weed management and fertilizer levels

Treatment	Weight of bulb (g/bulb)		Volume of bulb (cm³)		Diameter of bulb (cm)		Bulb yield (t/ha)			Net income (Rs/ha)	B:C ratio
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	Pooled		
Weed management (W)											
W_1	64.6	58.4	50.1	41.0	5.85	4.82	31.8	30.2	31.0	2,15,662	6.67
W_2	63.2	57.2	49.3	39.8	5.92	4.76	31.0	29.0	30.0	2,08,450	6.59
W_3	76.5	70.2	56.1	48.4	6.52	6.01	36.5	32.9	34.7	2,42,002	6.83
W_4	75.4	69.2	55.5	47.4	6.28	5.90	36.4	32.6	34.5	2,40,050	6.72
W_5	80.0	73.8	58.2	52.0	7.42	6.36	39.3	36.6	38.0	2,69,422	7.85
W_6	79.2	73.2	57.5	51.4	7.17	6.31	38.9	35.3	37.1	2,63,410	7.83
W_7	72.6	66.4	55.4	46.2	6.06	5.63	36.3	31.9	34.1	2,36,890	6.63
W_8	67.6	61.4	54.4	44.2	5.93	5.17	33.0	29.0	31.0	2,13,430	6.16
W_9	77.7	70.5	56.4	48.8	7.00	6.08	37.4	34.8	36.1	2,51,910	6.87
W_{10}	45.1	39.1	38.3	26.3	4.73	2.90	23.7	16.7	20.2	1,30,710	4.26
CD (P=0.05)	4.8	4.9	3.4	3.5	0.46	0.48	2.60	2.35	1.76		
Fertilizer levels (F)											
F_1	64.5	58.3	50.1	38.7	5.66	4.82	31.9	27.9	29.9	2,06,322	6.28
F_2	71.4	65.2	53.4	44.9	6.36	5.41	34.1	30.5	32.3	2,24,860	6.69
F_3	74.6	68.3	55.8	50.1	6.85	5.95	37.3	34.2	35.7	2,51,317	7.31
CD (P=0.05)	2.6	2.7	1.8	1.9	0.25	0.26	1.4	1.2	0.94		
Interaction (W x F)											
CD (P=0.05)	8.4	8.6	NS	6.0	NS	NS	4.5	4.0	2.8		

CONCLUSION

It is concluded that pre-emergence application of either pendimethalin at 1.0 kg/ha or oxyfluorfen at 0.24 kg/ha supplemented with one hand weeding at 40 days after transplanting is found to be the efficient weed management strategy. Further, application of fertilizer at 125:62.5:62.5 kg NPK/ha gave higher and profitable onion bulb yield.

Weed management in horticultural crops

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Horticulture industry is observed to be an important sub-sector of Indian economy. In addition to provision of food, it also generates foreign exchange, creates employment and provides raw materials for processing industries. The major aspect of horticultural industry is quality product. Poor quality and low yields result from many factors such as high temperature, low relative humidity, drought due to low rainfall and weed infestation. Generally, farmers do not understand the negative implications of weeds in term of yield losses and the cost of its control. Since most horticultural crops are very slow in growth especially at the early stages of their establishment, it becomes imperative to begin weed control early enough in order to ensure high yields and quality. The first step in weed management is to understand the weeds and their life cycles. Weeds can be categorised according to their life cycles and management strategies must be developed accordingly. Annual weeds complete their life cycle in one year and reproduce solely by seeds. The perennial weeds live for more than two years and can reproduce by seed or vegetative structures such as stolons, rhizomes, corms, tubers, bulbs and roots. Because perennial weeds are difficult to manage in vegetables, it is better not to use a field with severe perennial weed problems. Many non-chemical weed management methods are simple farming practices. These practices are of increasing importance due to consumer concerns about pesticides residues, environmental pollution from pesticides and non availability of some of the older herbicides.

Table 1. Herbicides recommended in major vegetables crop

Crop	Herbicide	Rate of application (kg/ha)	Time of application	Types of weeds controlled
Okra	Fluchloralin	1-1.5 + HW 45 DAS	PPI	AG, BI
	Pendimethalin	1-1.5 + HW 45 DAS	PE	AG, BI
	Alachlor	2-2.5	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
Brinjal	Fluchloralin	1-1.5 + HW 45 DAS	PPI	AG, BI
	Pendimethalin	1-1.5 + HW 45 DAS	PE	AG, BI
	Alachlor	1-1.5 + HW 45 DAS	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
	Oxadiazon	1.0	PE	AG, BI
Chillies/ Capsicum	Fluchloralin	1-1.5 + HW 45 DAS	PPI	AG, BI
	Pendimethalin	1-1.5 + HW 45 DAS	PE	AG, BI
	Oxadiazon	1.0	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
Cole crops	Alachlor	2.5 + HW 45 DAS	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
	Pendimethalin	1-1.5 + HW 45 DAS	PPI	AG, BI
Tomato	Metribuzin	0.5-1.0	PE and POE	AG, BI, NS
	Fluchloralin	1-1.5 + HW 45 DAS	PPI	AG, BI
	Oxadiazon	1.0	PE	AG, BI
	Alachlor	1-2	PPI	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
Peas	Fluchloralin	1-1.5	PPI	AG, BI
	Pendimethalin	1-1.5	PE	AG, BI
	Alachlor	0.75 + HW 45 DAS	PE	AG, BI
Potato	Paraquat	0.5	POE	AG, BI, NS
	Metribuzin	0.5-1.0	PE and POE	AG, BI, NS
	Pendimethalin	1-1.5	PE	AG, BI
	Alachlor	2-2.5	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
Onion	Alachlor	1-1.5	PE	AG, BI
	Fluchloralin	1-1.5 + HW 45 DAS	PPI	AG, BI
	Pendimethalin	1-1.5 + HW 45 DAS	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
	Oxadiazon	1.0	PE	AG, BI
Coriander	Pendimethalin	1-1.5	PE	AG, BI
Bean	Alachlor	2-2.5	PE	AG, BI
	Fluchloralin	1-1.5	PPI	AG, BI
	Pendimethalin	1-1.5	PE	AG, BI
Root crops	Alachlor	1-1.5	PE	AG, BI
	Fluchloralin	1-1.5	PPI	AG, BI
	Pendimethalin	1-1.5	PE	AG, BI
	Oxyfluorfen	0.1-0.25	PE	AG, BI
Fenugreek	Fluchloralin	1-1.5	PPI	AG, BI
	Pendimethalin	1-1.5	PE	AG, BI

Effect of weeds on horticultural crops

Weeds compete with crops for water, nutrients, space, light and oxygen resulting into a delay in maturity and low yields. Generally, these losses occur as a result of reduced yield, quality, harbouring of pests/diseases, allelopathic effects on crops and interference of major farm operations such as weeding, fertilizer application, herbicide application and harvesting. Research works have demonstrated that up to 80% yield losses occur in okra as a result of infestation by *Imperata cylindrica.* Reports have shown that weeds reduce onion bulbs, heads in lettuce and cabbage and fruit size in apple (*Malus* spp). Weeds serve as many hosts for pests and

Table 2. Important herbicide recommendations in orchards

Herbicide	Type of treatment	Remarks
I. Contact herbicides (with no soil residues)		
Herbicidal oils	Directed spray around the tree bases	Avoid drift to the tree trunks.
Paraquat/ diquat	Directed spray around the tree bases	Drift will not darmage woody stems. To obtain residual control, paraquat can be combined with simazine in tolerant crops like apple and peach.
II. Soil active herbicides		
Terbacil (2-10 kg/ha)	Directed spray	Use for ring weeding in two years' or older apple, peach and citrus orchards
Simazine (1-2 kg/ha)	Preemergence to weeds	Use in citrus, apple, and other deciduous orchards, as well as in nuts and vineyards. Established apple and pear are tolerant up to 5 kg/ha simazine, once in two years.
Diuron (1-3 kg/ha)	Preemergence to weeds	Use in apple, pear, peach, citrus, banana, and pineapple plantations, as well as in vineyards. Vineyards can tolerate up to 3.5 kg/ha of diuron.
Monuron (1-2 kg/ha)	Preemergence to weeds	It is used in citrus grooves in low rainfall areas only.
Dalapon (1%)	Directed spray	It is used for ring weeding four years' or older apple and pear orchards. Also, citrus and vineyards can be treated while these are dormant.
2,4-D (1-2 kg/ha)	Directed and protected spray	Fruit trees with exposed suckers should not be treated with it. Avoid ester formulations of 2,4-D. Apply as inverts or with drift control agents to avoid spray drift hazards.
Glyphosate (kg/ha)	Directed spray	Apply 2-3 times in the season for ring weeding of orchards. It can also be used to clean interrows of strawberry, fig, and banana orchards, particularly for bermudagrass control.

Feasibility of using problematic aquatic weeds in productive manner by generating vermicompost in coconut growing areas

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Vermicompost is an effective method of composting where, compost can be obtained from the shortest possible time with maximum possible nutrients. It is also an ecologically sound, economically viable and sociologically acceptable manner of producing compost (Singh 1997). However, numerous organic materials can be used to produce vermicompost. Aquatic weeds are considered as a huge threat all over the world and these problematic weeds can be used to productive manner like composting. The objective of this study was to evaluate the feasibility of producing vermicompost from problematic aquatic weeds namely *Salvinia molesta*, *Eichhornia crassipes* and *Lagenandra toxicaria*.

METHODOLOGY

An experiment was carried out at the Coconut Research Institute, Sri Lanka from August 2010 to May 2011. Eight treatments involving selected aquatic weeds (*Salvinia molesta*, *Eichhonia crasipes*, *Lagenandra toxicaria*) were tested in a completely randomized design with five replications. Known quantities of selected aquatic weeds withered materials, *Gliricidia* and grass cuttings were weighed and mixed well with cow dung slurry, to get the different treatment combinations and were placed in the respective pots. Compost and vermicompost were prepared in black plastic pots with a volume of 8 dm^3. After introducing treatments, vermicomposting and composting pots were aerated by mixing once in every ten days. Data on worm growth and nutrient analysis of vermicompost were recorded.

RESULTS

Chemical properties such as pH, electrical conductivity (EC), organic carbon, nitrogen, phosphorous, potassium, calcium and magnesium were significantly higher in vermicomposting treatments compared to composting treatments whereas C: N ratio was significantly lower.

The pH value was not significantly different among the vermicomposts. *Lagenandra toxicaria* registered the highest electrical conductivity (6.75 dS/m) and orgnic C content (13.2%). The highest nitrogen content was recorded in *Gliricidia* +grass vermicompost (3.93%) while the C: N ratio was found to be significantly lower in *Gliricidia* + grass followed by *Salvinia*, *Eichhornia* and *Lagenandra*. Significantly higher phosphorous and potassium contents were found in *Lagenandra toxicaria* (Fig. 1).

The variation of the earthworm number, total biomass gain, individual biomass gain, mortality rate and number of juveniles at the harvesting time, varied with respect to time and material of vermicomposting (Fig. 2). *Salvinia* and *Eichhornia* were found to be better substrate for earthworms to grow and reproduce as they registered higher number of total adult earthworms and lower mortality rate.

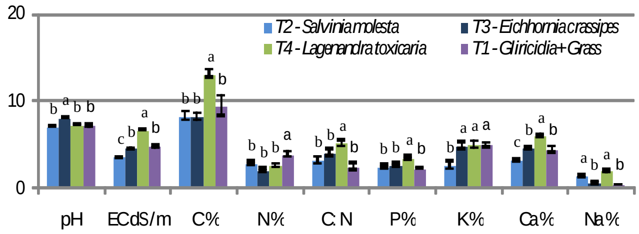

Fig. 1. Variation of chemical properties in vermicompost with respect to substrate

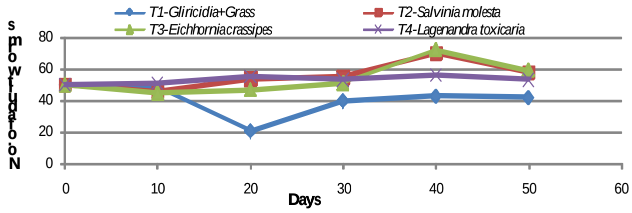

Fig. 2. Adult earthworm number with time of vermicomposting

CONCLUSION

It is concluded that the vermicomposting of aquatic weeds is more efficient and productive as compared to conventional composting of the same substrate. *Lagenandar toxicaria* is the most effective substrate in vermicomposting since it inherited many favourable physical, chemical and biological properties needed for plant growth.

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Study of weed management practices on weed, crop root nodulation and yield of vegetable cowpea

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Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the most important legume vegetables in North East India. It is grown for its long, green vegetable pods, seeds and foliage for fodder. Weeds are a permanent constraint to crop productivity in agriculture. In cowpea, yield losses due to weeds ranges from 10-82% depending upon the density and species of weed, duration of infestation and competing ability of crop plants under different agroecological regions. Hence, the present investigation was undertaken to determine the most economical method of weed control in vegetable cowpea.

METHODOLOGY

A field experiment was conducted at College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh during 2013. The soil of the experimental site was sandy loam with a pH of 5.5. Eight weed control treatments (T_1: weedy check, T_2: Weed free, T_3: pendimethalin 1 kg/ha, T_4: pendimethalin 1 kg/ha + one hand weeding, T_5: quizalofop-ethyl 0.05 kg/ha, T_6: quizalofop-ethyl 0.05 kg/ha + one hand weeding, T_7: black polyethylene mulch and T_8: slashed grass mulch) were evaluated in a randomized complete block design with four replications. Bush type cowpea variety '*VRCP-4*' was sown on 6th August with recommended package of practices. Recommended dose of fertilizers (20 kg N, 50 kg P_2O_5 and 30 kg K_2O/ha) were applied to crop at the time of sowing through di-ammonium phosphate and muriate of potash. The observations on weeds (dry weight, and weed control efficiency) and crop were recorded. Weed control efficiency was calculated using weed dry weight data at 60 DAS.

RESULTS

The crop was infested with *Cynodon dactylon*, *Ipomoea* sp., *Echinochloa crusgalli*, *Cyperus rotundus*, *Urena lobata*, *Cyperus esculentus*, *Murdani akiosak*, *Commelina benghalensis*, *Ageratum coinzoides*, *Euphorbia hirta*, *Setaria glauca*, *etc.* All the weed control treatments proved effective in significantly reducing the number and dry weight of weeds as compared to weedy check at 60 DAS (Table 1). Black polyethylene mulch was quite effective in reducing the number and dry weight of weeds, which could be attributed to poor light conditions and physical suppression of the weeds (Kumar and Singh 2013). Weed free plot resulted in higher weed control efficiency followed by black polyethylene mulch, quizalofopethyle 0.05 kg/ha + hand weeding and slashed grass mulch. Maximum number of nodules per plant was recorded in plots treated with slashed grass mulch while minimum number of nodules was observed in weedy check. All weed control treatments were significantly superior to weedy check in influencing pod yield. Slashed grass mulch treated plot recorded 61.18% higher pod yield over weedy check. Higher net return among with BCR was recorded in slashed grass mulch plot whereas the lowest net return was noted in weedy check.

Table 1. Weed growth, root nodulation, yield and economics as influenced by weed management practices

Treatment	Weed count (no/m²)	Weed dry weight (g/m²)	WCE (%)	Root nodules perplant	Pod yield (t/ha)	Cost of production (Rs/ha)	Net income (Rs/ha)	BCR
T_1	8.9 (79.8)	3.2 (10.0)	0	5.22	5.77	22,000	35,700	1.62
T_2	0.7 (0.0)	0.7 (0.0)	100	10.07	8.96	29,500	60,100	2.04
T_3	5.4 (29.5)	2.1 (3.9)	60.5	8.91	7.07	23,420	47,280	2.02
T_4	4.5 (19.7)	1.9 (3.3)	66.4	9.43	8.47	25,920	58,780	2.27
T_5	4.6 (20.9)	1.9 (3.2)	67.1	9.25	7.39	23,500	50,400	2.14
T_6	3.8 (14.1)	1.7 (2.4)	75.3	10.05	8.91	26,000	63,100	2.43
T_7	1.0 (0.5)	0.7 (0.09)	99.1	10.28	9.07	26,500	64,200	2.42
T_8	4.3 (18.2)	1.7 (2.6)	73.3	11.25	9.29	24,500	68,400	2.79
CD (P=0.05)	0.14	0.06	2.3	0.89	0.79	-	-	-

*Data in parentheses are original value

CONCLUSION

It is concluded that application of black polyethylene mulch is most effective for controlling weeds and improving the pod yield while slashed grass mulch is effective in improving the profitability of crop.

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diseases, causing phyto-sanitary problems. The aphid (*Aphis gossipi*) which is known to transmit a viral disease called potato leaf roll and potato mosaic has been found to live in *Eleusine indica* as ahost. Removal of such a weed has been found to reduce the incidence of this pest on potatoes. *Commelina* sp. has been found to serve as a host for banana virus diseases and also harbours the banana root nematode (*Meloidogyne incognita*). Weeds also act as carry overs of pests from season to season. Some weeds have shown allelopathic effects on some crops. *Centrosema* sp. has allelopathic effects on banana. Weeds have also been observed to interfere with farm operations like harvesting, making movement difficult. In crops like potatoes with underground structures, they result in a number of tubers being left in the ground during harvest. In case of tree plantation, weed control is most essential in rings and in continuous 1.5 to 3.0 m strips down the tree rows. Here the weeds, in addition to competing with the trees, interfere with fruit picking, tree pruning and other horticultural operations. Also, they increase damage to the surface tree roots by diseases and rodents. Further, weeds in orchards may lead to a more severe frost bite in fruits because of reduced radiation from the soil. Ultimately, the fruit trees may be crowded out by the weeds. Densely planted tall trees may smother weeds but they are no more acceptable in modern horticulture. Today's orchards are very much open type in which control of weeds is essential.

Chemical control: This method involves the use of herbicides for weed control. It has been widely adopted nowadays in fruit, vegetable and flower production. A number of pre-emergence herbicides of different selectivity are being used. In fruits a number of herbicides are being used, the choice depends on the prevailing weed species. Where perennial weeds are the major problem, systemic herbicides are used. For example, dalapon and glyphosate have been widely used to control perennial weeds like *C. dactylon, D. scalarum, Cyperus* spp. and *P. Clandestinum*. Other herbicides in use include the growth regulator types (2, 4-D, 2, 4-DB, MCPA), paraquat, simazine, atrazine and diuron (Table 1). These are used to control annual broad-leaved and grass weeds as well as perennial weeds depending on their selectivity. For example, 2, 4-D has been effectively used to control broad-leaved weeds as post-emergence applications. Chemical control is relatively poorly developed in vegetable crops as they tend to be grown on relatively small areas. But, if used with care, herbicides destroy weeds with minimal disturbance to the soil and less adverse effects on crops. Thus, they offer a good weed control alternative to cultural/ mechanical methods in horticultural crop production. With this method, less labour is required; this allows transfer of labour to other activities since horticulture industry is labour intensive. This reduces the drudgery experienced in hand weeding by women who are mainly involved in weed control operations.

Weed management practices for orchards/tree plantation area, tree bases, where freedom from weeds is most essential, are not easily accessible to mechanical cultivation. It may cause injury to the lower fruiting branches and shallow feeding roots of the trees. For this reason, herbicidal control is important for ring weeding under the fruit trees. In between the tree rows, both cultivators and herbicides could be used with similar results, depending upon their economic viability. Also, suitable cover crops and sods may be grown in between the tree rows for weed suppression. Such sods should be kept low by mowing. Some gardeners like to grow vegetables in orchards, which indirectly induces them to maintain weed free conditions. But intercropping of any kind in orchards may be undesirable in part of the year when the demand of orchard trees for mineral nutrients and water is high. At this time, black polythene mulches of 400 gauges can be used more effectively in smothering the weeds in orchards.There has been considerable progress in the development and use of herbicides in orchards, particularly around the tree bases. The selectivity of herbicides to orchard trees may be achieved in any of the following four ways.

i. The inherent tolerance of the plant to the herbicide; instance apple to simazine.

ii. Failure of herbicides such as paraquat and diquat to penetrate the bark of trees

iii. Directed and protected application of herbicides

Use of limited leaching herbicides, such as dichlobenil.

Herbicidal effect on weed density and yield of turmeric

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Turmeric (*Cucurma longa* L.), an herbaceous perennial crop is mostly grown during *kharif*. It is an important commercial spice crop. India accounts for 78% of world's production and 60% in world export (Angels *et al*. 2011). Delayed emergence, slow initial growth, poor development, frequent irrigation makes the crop more prone to weeds mostly during early stage of growth and development and higher yield. Turmeric needs a weed free period of 70-160 days. Jaiswal (1994) reported that weed control efficiency, weed biomass of different treatments ranged from 40-90% and higher WUE was recorded in metribuzin (91%) treatment. This study was taken up to evaluate the effect of different herbicides on weed density and yield of turmeric.

METHODOLOGY

A field experiment was conducted during *kharif* 2014 at Agronomy Main Research Farm, OUAT, BBSR, Odisha. The soil of experimental site was sandy loam with medium N, P, K and organic matter content and slightly acidic to neutral in pH. The experiment involved seven weed control treatments (Table 1) in a Randomised block design with three replications. The Turmeric variety '*Roma*' was grown at a spacing of 60 x 30 cm. Recommended dose of fertilizer 180-90-90 kg N, P, K/ha were applied. The entire dose of FYM (10 t/ha), P and 1/3rd K were applied as basal. N was applied in 3 split doses at 40, 80, 120 days after sowing (DAS) and rest of K were applied at split doses at 80 and 120 DAS. The herbicides were sprayed as per treatments using spray volume of 500 l/ha.

RESULTS

The lowest weed density was recorded under propaquizafop 150 g/ha. Whereas the unweeded control recorded the highest weed density followed by propaquizafop 50g/ha, propaquizafop 62.5g/ha and hand weeding. Propaquizafop 150 g/ha recorded the highest root fresh and dry weight and also fresh and dry rhizome yield, while the lowest yields were obtained in unweeded control. Fresh and dry rhizome yield per plant was highest under Propaquizafop 150 g/ha which was on par with that under Propaquizafop 100g/ha. The lowest rhizome yield/plant was recorded in unweeded control.

Table 1. Effect of herbicides on weed density and yield parameters and yield of turmeric

Treatment	Weed density (no/m^2)		Fresh weight of rhizome (g/plant)	Dry weight of rhizome (g/plant)	Dry weight of root (g/plant)	Fresh rhizome yield (t/ha)	Dry rhizome yield (t/ha)
	At 90 DAS	At harvest					
T_1: Propaquizafop 50g/ha	155.3	171.3	201.3	33.2	7.23	24.3	3.75
T_2: Propaquizafop 62.5g/ha	100.4	121.3	222.7	35.6	7.83	25.2	4.28
T_3: Propaquizafop 100g/ha	45.4	51.7	284.23	43.6	8.83	27.2	5.14
T_4: Propaquizafop 150g/ha	40.4	48.3	301.3	46.7	9.01	29.9	5.54
T_5: Fenoxaprop 100g/ha	71.3	81.6	275.1	40.9	8.71	26.5	4.98
T_6: Two hand weeding	79.3	93.6	198.7	38.7	8.48	23.1	4.67
T_7: Unweeded control	192.6	227.6	89.4	14.1	3.00	13.5	2.05
LSD (P=0.05)	25.5	13.0	21.77	5.6	0.49	2.1	0.30

CONCLUSION

It is concluded that application of propaquizafop 150 g/ha is the most effective in controlling weeds and registering higher turmeric yield.

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Weed control in tomato under agroclimatic condition of Tripura

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In India, tomato is cultivated in 882.0 thousand ha with total production of 187.35 lakh tonnes. In Tripura, the area and production of this crop is 1.58 thousand ha and 39.0 thousand tonnes, respectively. Shadbolt and Holm (1956) concluded that the first four weeks were critical in many vegetable crops, during which time weeds should be removed. This period coincides with the season of peak labour activity leading to scarcity of labour for weeding. This necessitates the use of pre-emergence herbicides for weed control and higher productivity. Use of pre-emergence herbicides would make the weed control more acceptable to farmers, which will not change the existing agronomic practices but will allow for complete control of weeds (Adhikary and Ghosh 2014). Keeping all this in view, the present study was carried out to evaluate the efficacy of pendimethalin as pre-emergence herbicide for weed control in tomato.

METHODOLOGY

The field experiment was conducted during *Rabi* 2013 in the experimental field of KVK, West Tripura located at an altitude of 23 m mean sea level, latitude 23.84° N and longitude 91.27° E. The soil of the experimental site was sandy loam, acidic (pH 5.8) and low in available N (217.7 kg/ha), medium in available P (22.8 kg/ha) and available K (177.7 kg/ha). The variety used in this experiment was Trishul. The pre-emergence herbicide pendimethalin was applied at 3-5 DAT. All the recommended improved package of practices was followed. The data on weed biomass, weed control efficiency and growth and yield parameters of tomato were recorded.

RESULTS

Unweeded control recorded significantly higher weed biomass at all stages of crop growth due to unchecked growth of weeds (Table 1). The weed control efficiency (WCE) gradually decreased over time. The lowest weed biomass and the highest weed control efficiency were recorded at 30, 60 and 90 DAT under pendimethalin 1.5 l/ha + hand weeding at 30 DAT. The herbicide, when used in combination with one hand weeding, was beneficial to keep the crop weed free in the later stages. The yield and yield components of tomato were significantly influenced by different weed control methods. The highest plant height, branches per plant and total fruit yield were recorded under pendimethalin 1.5 l/ha + Hand Weeding at 30 DAT (T_3) followed by hand weeding at 30 DAT (T_1). Whereas, the lowest plant height, fruits per plant, Individual fruit weight and total fruit yield were recorded in unweeded control.

Table 1. Weed biomass, WCE and growth and yield parameters of tomato as influenced by weed control treatments

Treatment	Weed biomass (g/m²)			WCE (%)			Plant height (cm)	No. of branches per plant	Fruit yield (t/ha)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT			
T1: HW at 30 DAT	28.2	12.1	34.5	0	74.1	44.4	75.6	5.34	5.70
T2: Pendimethalin 1.5 L/ha	4.3	17.2	38.0	84.3	60.0	40.6	73.5	5.13	5.54
T3: Pendimethalin 1.5 L/ha+ HW	4.3	10.8	34.1	84.3	73.3	47.5	78.2	6.22	6.69
T4: Control	26.8	42.4	64.3	-	-	-	70.1	3.82	3.12
LSD (P=0.05)	1.6	1.2	1.2				1.7	1.96	2.13

CONCLUSION

It is concluded that pendimethalin 1.5 l/ha as pre-emergence herbicide along with one hand weeding at 30 DAT is the most efficient method of weed control in tomato under the agroclimatic conditions of Tripura.

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Assessment of weed species distribution in different coconut-based cropping systems

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In coconut plantations, recommended doses of fertilizer application, in situ recycling of coconut waste biomass, summer irrigation and intercrops are the major factors which provide platform for growth and multiplication of wide range of weeds. In coconut garden, canopy structure and wider spacing of 7.5 x 7.5 m allows sufficient quantity of sunlight to the ground. Thus, weeds can also enjoy the abundance of sunlight, soil moisture and atmospheric humidity. The nature of crop, cultural practices and cropping pattern/system, soil type, moisture availability, location and season have been reported to cause variation in the abundance or distribution of weed species that are found in a field (Mohlr 2001; Sit *et al.* 2007). Therefore a study was conducted determine the weed distribution, frequency and density in different coconut based cropping systems.

METHODOLOGY

The study was conducted at the CPCRI research farm, Kasaragod, Kerala in already established coconut plantations with various cropping systems. Compositions of weed species in the experimental fields were assessed by throwing 1 sq. m quadrate randomly in 10 different locations in each field. Weed species within each quadrate were pooled and identified. The frequency, abundance, density, relative density, relative frequency, importance of value index and Sorenson's index of similarity were calculated by following standard procedure.

RESULTS

The results showed that twenty three weed species were present in different coconut based cropping system among which, five were monocots/sedges and eighteen were dicots belonging to 13 families. Sit *et al.* (2007) reported presence of 15 weed species in adult coconut garden in plains of Eastern Himalayan region of West Bengal. The number and type of weed varied in different locations of the area under study. Maximum number of weed species was present in High Density Multi Species Cropping System (HDMSCS) (21) followed by cocoa (17), grass (11) and coconut alone plot (7). The frequency, abundance and density of weeds varied considerably in different fields. In coconut alone plot, *Euphorbia* (75%) and *Panicum* (52.8) recorded maximum frequency and density, respectively. In cocoa based coconut farming system (CFS), *Panicum* (100%) and *A. sessilis* (33.5) occurred with maximum frequency and density, respectively. In grass based CFS, a frequency of 100% and density of 73.5 was observed for *Cleome* and *Euphorbia*, respectively. In coconut based HDMSCS *Alternathera* recorded the maximum frequency (81%) while *Cyperus* recorded the maximum density (49.2).

Table 1. Weeds flora in different coconut based cropping systems

Weed species	Family	Different coconut based cropping systems			
		Grass	HDMSCS	Cocoa	Coconut alone
Monocotyledons/sedges					
Cyperus rotandus	Cyperaceae		Y	Y	
Eleucine indica	Poaceae		Y		
Kyllinga brevifolia	Cyperaceae	Y	Y		
Panicum repens	Poaceae	Y	Y	Y	Y
Setaria	Poaceae	Y			Y
Dicotyledons					
A. ficoides	Amaranthaceae		Y	Y	
A. sessilis	Amaranthaceae		Y	Y	Y
Achyranthus aspera	Amaranthaceae		Y		
Ageratum conyzoides	Asteraceae	Y	Y	Y	
Aschylacia			Y		
Biden spilosa	Asteraceae	Y	Y	Y	
Cleome rutidosperma / viscosa	Cleomaceae	Y	Y	Y	
Commelina benghalensis	Commelinaceae	Y	Y	Y	
Emilia sacnhyfolia	Asteraceae		Y	Y	
Euphorbia	Euphorbiaceae	Y	Y	Y	Y
Ludwigia octovalvis	Onagraceae		Y	Y	
Mimosa pudica	Fabaceae	Y	Y	Y	Y
Mulllugo cerviana / verticillata	Mullginaceae		Y	Y	Y
Pepperonia	Piperaceae		Y	Y	
Phyllanthus niruri	Phyllanthaceae		Y	Y	
Tridax procumbens	Asteraceae			Y	
Vernonia cineraria	Asteraceae	Y	Y	Y	
Wadelia sp.	Asteraceae	Y	Y		Y

CONCLUSION

Area covered by different intercrops, management practices, irrigation and light availability affect the variation in the weed species distribution in coconut based cropping systems. Prevalence of dicot weed species was higher in all the cropping systems than that of monocot/sedges.

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Efficacy of different herbicides in controlling weeds in onion

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Weeds happen to be one of the major production constraints in onion fields. Poor competitive ability with its initial slow growth, cylindrical upright leaves and lack of adequate foliage makes onion weak against weeds. In addition to this, frequent irrigation and fertilizer application allows for successive flushes of weeds in onion. The conventional method of weed control is laborious and very expensive. Moreover weeding during critical growth stages is very difficult due to increased cost of human labors and its scarce availability. Use of herbicides may prove as the solution for over dependence on labors in onion weed control, but their proper combination, doses and time of application is more important for better results with low cost. Hence, the present investigation was carried out to find out suitable herbicides in onion for effective control of weeds with higher yield and economical benefits.

METHODOLOGY

An experiment was conducted at Main Agricultural Research Station, Raichur and AEEC, Lingsugur in UAS, Raichur during 2012 and 2013 in a randomized block design with 9 treatments (Table 1) in three replications. The data on weed biomass, yield and economics were recorded.

RESULTS

Post-emergence application of propaquizafop 0.050 kg/ha + oxyfluorfen 0.120 kg/ha recorded significantly higher onion bulb yield as compared to pendimethalin 1 kg/ha or propaquizafop 0.038 kg/ha + oxyfluorfen 0.090 kg/ha, but was at par with propaquizafop 0.044 kg/ha + oxyfluorfen 0.088 kg/ha. Significantly lower weed biomass was recorded with propaquizafop 0.050 kg/ha + oxyfluorfen 0.120 kg/ha as compared to pendimethalin 1 kg/ha but was at par with rest of the treatments. In contrast to this significantly higher weed control efficiency was recorded with propaquizafop 0.050 kg/ha + oxyfluorfen 0.120 kg/ha. Economics analysis indicated that significantly higher economic returns and B:C ratio were obtained with propaquizafop 0.050 kg/ha + oxyfluorfen 0.120 kg/ha.

Table 1. Effect of herbicides on bulb yield and economics

Treatment	Time of applicaiton	Bulb yield (t/ha)	Weed biomass g/m^2	Weed control efficiency (%)	Net returns (Rs/ha)	B:C
T1: Propaquizafop 5% 0.038 kg/ha + Oxyfluorfen 12% EC 0.090 kg/ha	POE	16.70	13.3	75.5	1,03,447	4.16
T2: Propaquizafop 5% 0.044 kg/ha + Oxyfluorfen 12% EC 0.088 kg/ha	POE	17.13	13.2	75.6	1,09,015	4.40
T3: Propaquizafop 5% 0.050 kg/ha + Oxyfluorfen 12% EC 0.120 kg/ha	POE	17.66	11.5	79.2	1,10,840	4.43
T4: Pendimethalin 30 EC 1.0 kg/ha	PE	14.61	17.6	64.0	87,103	3.68
T5: Propaquizafop 10% 0.075 kg/ha	POE	15.64	14.5	72.5	95,081	3.95
T6: Oxyfluorfen 23.5 EC 0.2 kg/ha	POE	15.02	14.6	72.4	90,234	3.76
T7: Farmer practice (HW at 25 and 45 DAT)		13.99	15.1	71.4	80,122	3.32
T8: Weed free check		18.33	0.0	100.0	1,09,948	4.02
T9: Unweeded control		11.19	55.4	0.0	57,295	2.82
SEm±		0.30	1.7	1.2	2,252	0.09
CD (P=0.05)		0.80	5.2	3.8	6,754	0.26

CONCLUSION

It can be concluded that post emergent application of propaquizafop 0.050 kg/ha + oxyfluorfen 0.120 kg/ha is found to be superior in controlling weeds in onion and registering higher yield and income.

Chemical and non-chemical methods of weed control in tomato

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Tomato is one of the most important vegetable crops grown in three seasons at north western agro climatic zone of Tamil Nadu. Favorable weather conditions, wider spacing, frequent irrigations and liberal use of manures and fertilizers promote luxuriant growth of weeds in tomato. Weed competition reduced yield of tomatoes to the tune of 42-71% when weeds compete with the crop from 15-45 days after transplanting. Although manual weeding controls the weeds effectively, it is difficult, time consuming and costly. Singh and Tripathi (1988) found that pre and post emergence application of metribuzin at 0.35 and 0.50 kg/ha respectively produced the tomato yield on par with hand weeding. In recent years, due to weed shift in all types of lands and soils, a complex of weeds poses the problem from transplanting to harvest. Therefore, the present investigation was undertaken with a view to evaluate the performance of chemical and non chemical methods of weed control on yield and economics in tomato.

METHODOLOGY

Field experiments were conducted at Regional Research Station (TNAU), Paiyur in three seasons under irrigated condition in tomato (*cv. 'PKM 1'*) in a randomized block design with three replications. The experiment consisted of 11 treatments (T_1: pendimethalin 1.00 kg/ha, T_2: oxyflurofen 0.125 kg/ha, T_3: metribuzin 0.50 kg/ha , T_4: fluchloralin 1.00 kg/ha, T_5: pendimethalin 1.00 kg/ha + hand weeding, T_6: oxyflurofen 0.125 kg/ha + hand weeding, T_7: metribuzin 0.50 kg/ha + hand weeding, T_8: fluchloralin 1.00 kg/ha + hand weeding , T_9: black polythene mulch (8 m), T_{10}: hand weeding on 25 and 45 DAT and T_{11}: weedy check). The black polythene mulch (8 m) was laid out at one day before transplanting and the tomato seedlings were planted by making holes in the polythene sheet at 60 x 45 cm apart. The recommended fertilizer 150:100:50 kg NPK/ha was applied as urea, single super phosphate and muriate of potash. In all treatments except in polythene mulch plot, the full dose of phosphorus and potassium were applied as basal at the time of transplanting. Nitrogen was applied in two splits, 50% at the time of transplanting and remaining dose at 25 DAT. The full dose of all fertilizes were applied basally before the spread of polythene mulch. The data on weed population and dry weight were transformed using log values and fruit yield were aggregated and analyzed.

Table 1. Weed population and dry weight, yield and economics of tomato as influenced by weed control treatments

Treatment	Weed population (no/ m²)			Weed dry weight (g/ m²)			Fruit yield t/ha	Net income (Rs/ha)	BC ratio
	25 DAT	45 DAT	70 DAT	25 DAT	45 DAT	70 DAT			
T_1	69.8 (1.82)	110.2 (2.02)	133.1 (2.10)	23.60 (1.27)	76.47 (1.70)	84.53 (1.78)	15.15	41,269	2.20
T_2	72.4 (1.85)	104.7 (2.00)	122.6 (2.06)	26.36 (1.34)	78.17 (1.71)	93.80 (1.82)	15.01	40,896	2.20
T_3	70.0 (1.84)	112.0 (2.02)	127.1 (2.08)	22.64 (1.29)	76.50 (1.71)	86.23 (1.79)	15.12	41,381	2.21
T_4	71.7 (1.85)	112.6 (2.03)	126.3 (2.08)	23.70 (1.30)	78.33 (1.74)	92.23 (1.81)	14.79	39,783	2.16
T_5	78.7 (1.88)	110.7 (2.02)	76.2 (1.87)	26.24 (1.36)	71.77 (1.74)	34.70 (1.28)	18.22	55,626	2.57
T_6	78.9 (1.89)	112.6 (2.03)	81.5 (1.90)	24.83 (1.36)	81.63 (1.76)	39.50 (1.33)	17.60	52,867	2.50
T_7	75.1 (1.87)	110.5 (2.01)	82.7 (1.90)	21.67 (1.26)	68.63 (1.66)	37.60 (1.31)	18.32	56,385	2.60
T_8	81.8 (1.91)	112.2 (2.03)	78.0 (1.87)	23.59 (1.29)	72.00 (1.66)	41.13 (1.38)	18.24	56,024	2.59
T_9	7.3 (0.84)	12.2 (1.09)	16.3 (1.20)	0.07 (1.21)	1.10 (0.02)	2.07 (0.32)	24.78	88,258	3.48
T_{10}	106.2 (2.02)	72.2 (1.81)	65.1 (1.79)	34.15 (1.47)	57.27 (1.40)	45.00 (1.58)	17.15	50,583	2.44
T_{11}	131.1 (2.12)	176.7 (2.24)	206.1 (2.30)	41.16 (1.58)	103.3 (1.94)	116.40 (1.90)	10.03	16,983	1.51
LSD (P=0.05)	15.6 (0.14)	35.2 (0.20)	36.5 (0.18)	10.88 (0.14)	44.92 (0.35)	60.58 (0.37	2.76	-	-

Figures in parentheses are log transformed values

RESULTS

Major weed flora of the experimental site were: *Cyperus rotundus* (44.9%), *Parthenium hysterophorus* (23.0%), *Portulaca oleraceae* (8.0%), *Trianthema portulacastrum* (5.3%), *Amaranthus viridis* (0.8%), *Boerhaiva diffusa* (0.6%), *Dactyloctenium aegyptium* (6.4%), *Brachiaria mutica* (3.0%), *Chloris barbata* (1.3%) and *Euphorbia geniculata* (0.1%). Application of herbicides with or without hand weeding and mulching of black polythene sheet significantly reduced the weed population and dry weight over the weedy check and hand weeding twice at all the stages of crop growth. Black polythene mulch resulted in minimum weed count and weed dry weight at all the stages of observation. Pre-emergence application of pendimethalin 1.00 kg/ha, oxyflourfen 0.125 kg/ha, metribuzin 0.50 kg/ha and fluchloratin 1.00 kg/ha also resulted in lower weed population and biomass at 25 DAT as compared to hand weeding. The population and dry weight of weeds was lesser at 70 DAT under herbicide + hand weeding treatments as compared to pre emergence application of herbicides alone. The maximum fruit yield was recorded under polythene mulching (Table 1). Supplementing the herbicide application with hand weeding resulted in higher tomato yield than pre-emergence application of herbicides alone or hand weeding twice. In general, no significant difference was recorded among the difference herbicides tested. The black polythene mulching realized in higher net income and B:C ratio than integrated weed management, pre emergence application of herbicides and hand weeding.

CONCLUSION

It is concluded that black polythene mulching may be recommendedfor better weed control and for higher fruit yield in hi-tech and export oriented tomato production.

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Weed management in rainfed chilli

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Severe weed problems in chilli and huge losses due to weed competition are global problem. Weeds interfere with the development of chilli up to 8 weeks after transplanting by competing for moisture, nutrient, light and space (Amador and Ramirez 2002). Owing to inherent characteristics of chilli such as upright nature of crop, wide spaced, slow initial growth and less canopy, weeds offer severe competition throughout the crop growth. Control of weeds is vitally important not only to check the losses caused by them but also to increase input use efficiency. To get effective control of complex weed flora, integrated approach of weed management is the best choice. In the present investigation, an attempt was made to test the feasibility of herbicides alone at recommended doses and with combination of hoeing and hand weeding to develop an effective and viable weed management practices for chilli

METHODOLOGY

A field experiment was conducted during *Kharif* 2010, 2011 and 2012 at the Agricultural Research Station, Gadhinglaj Dist. Kolhapur (M.S.). The experimental site was medium to deep black and clayey in texture, low in medium in organic carbon (0.64 %), low in available nitrogen (210.2 kg/ha), medium in available phosphorus (20.8 kg/ha) and higher in available potash (474.8 kg/ha) and pH range is 7-7.5. Phule Sai variety of chilli was planted in second fortnight of June at 60 x 45 cm which was used for the study. The experiment was laid out in randomized block design with eight treatments and three replications. The treatments were butachlor 2.0 kg /ha (50 EC) Pre-emergence (two days of transplanting), fenoxaprop-P ethyl 1.0 kg/ha (9.3% w/w) (post emergence at two to three leaf stage), pendimethalin 0.825 kg/ha (30 EC) pre emergence, butachlor 2.0 kg /ha (pre emergence) + one hoeing + one hand weeding, fenoxaprop-P Ethyl (9.3% w/w). EC) + one hoeing + one hand weeding, pendimethalin 0.825 kg /ha (pre emergence) + one hoeing + one hand weeding, weed free check and weedy check. The gross and net plot size were 5.40 x 4.80 m^2 and 4.50 x 3.60 m^2, respectively. Observations on weed counts (number/m^2) and weed dry weight (g/m^2) were taken by sampling randomly at 5 places with the help of 0.25 m^2 quadrants at 60 days and the data were transformed in arcsine values before statistical analysis.

Table 1. Effect of weed control measures on weed density, weed biomass and weed control efficiency in chilli (pooled over 2010, 2011 and 2012)

Treatment	Weed density m^2 Pooled Mean		Weed biomass (kg/m^2)	Weed Control efficiency (%)	Dry chilli yield (t/ha)	Monetary returns (Rs/ha)		B:C ratio
	Broad leaf weeds	Grassy weed	Pooled Mean	Pooled mean	Mean	Gross	Net	Mean
Butachlor at 2 kg/ha	6.32 (40.0)	3.12 (9.44)	1.09 (0.698)	50.2	0.99	67783	25783	1.61
Fenoxaprop-P-ethyl@1kg/ha	6.80 (46.3)	4.55 (20.4)	1.16 (0.835)	40.5	0.90	61603	19603	1.47
Pendimethalin at 0.825kg/ha	5.57 (31.0)	2.46 (5.8)	1.06 (0.63)	55.1	1.14	77672	35672	1.85
Butachlorat 2 kg/ha + 1hoeing+ 1 weeding	4.01 (14.8)	1.83 (3.00)	0.90 (0.312)	77.8	1.46	100422	51422	2.05
Fenoxaprop- P-ethyl at1kg/ha + 1 hoeing + 1 weeding	7.44 (58.6)	2.58 (6.22)	0.96 (0.429)	69.4	1.31	89450	40450	1.83
Pendimethalin at 0.825kg/ha +1 hoeing + 1 weeding	3.32 (10.7)	1.77 (2.66)	0.83 (0.197)	86.0	1.56	106950	57950	2.18
Weed free check	1.85 (03.00)	1.34 (1.33)	0.76 (0.071)	95.0	1.68	115217	45217	1.65
Weedy check	7.06 (101.0)	5.65 (22.6)	1.38 (1.402)	0.00	0.56	38135	2135	1.06
LSD (P=0.05)	0.93	0.50	0.24	-	0.24	14774	14382	-

RESULTS

The prominent weed flora were *Amaranthus spinosus*, *Parthnium hysterophorus*, *Achyranthes Aspers* L., *Alteranthera Triandra*, *Euphorbia hirta* L., *Cynodon dactylon* L. Pers, *Cyperus rotundus* L. Pers, *Digera arvensis*, *Phyllanthus niruri*. Overall, the experiment was dominated by dicot weeds. Significantly lower weed intensity and biomass accumulation were recorded with application of pendimethalin + 1 hoeing + 1 weeding than other treatments and was on par with butachlor + 1 hoeing + 1 weeding. This might be due to effective control of weeds in early stage by pendimethalin and butachlor in combination with one hoeing and one weeding. Weed control efficiency was higher with pendimethalin, butachlor and fenoxaprop-p-ethyl in combination with one hoeing and one weeding and herbicides alone in respective manner.

All the weed control measures resulted in significantly higher dry red chilli yield than weedy check. Weed free check recorded highest values of dry red chilli yield, may be due to least competition on offered by weeds. Application of pendimethalin + 1 hoeing + 1 weeding recorded significantly higher dry red chilli yield over various herbicides and its combination with mechanical method of weed control, while it was on par with butachlor + 1 hoeing + 1 weeding.

Maximum gross returns were obtained in weed free check which was on par with pendimethalin + 1 hoeing + 1 weeding and significantly superior over rest of treatments. However, significantly lower gross returns were obtained from weedy check. Pre emergence application of pendimethalin + 1 hoeing + 1 weeding gave maximum net returns which was on par with butachlor + 1 hoeing + 1 weeding and significantly superior over rest of weed control methods except weed free check. Due to excellent control of complex weed flora without any adverse effect on crop growth weed free treatment registered lower monetary returns B:C ratio due to high cost involved in repeated weedings to keep crop weed free despite of having higher dry chilli yield.

CONCLUSION

The result revealed that pre emergence application of pendimethalin +1 hoeing +1 hand weeding recorded minimum weed density, weed biomass and weed index as compared with all treatments. Gross and net returns were significantly higher with pendimethalin+1 hoeing +1 hand weeding which was on par with butachlor +1 hoeing +1 hand weeding and superior over rest of treatments. Higher weed control efficiency and B: C ratio was recorded by the same treatments.

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Influence of weed management practices on weed dynamics and productivity of fennel

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Fennel (*Foeniculum vulgare* Mill.) generally takes longer time for germination and also has slow initial growth which often leads to heavy infestation of weeds. If not controlled timely, these weeds adversely affect the growth and cause huge losses in yields. The losses in yield could be as high as 91.4 % as reported by Mali and Suwalka (1987). Therefore, weed management is one of the most crucial factors in realising optimum yields. Manual weeding is the common practice in fennel to keep the weeds under check. However, timely availability of labourers and higher costs involved are the major constraints in effective weed management in fennel. Suitable alternatives involving herbicide use is the need of the hour for effective and efficient control of weeds in fennel to ensur optimum yields and reduc the dependence on manual labour. Studies have shown that herbicide application effectively controls the weeds and can increase the seed yield of fennel by 43.2-86.9 % (Voevodin and Borisenko, 1981).

METHODOLOGY

A field experiment on effective and efficient weed control in fennel was conducted at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *Rabi* season of 2011-12, 2012-13 and 2013-14. The experiment comprising fourteen treatments including unweeded check (control treatment) was laid out in randomized complete block design (RCBD) with three replications. Pendimethalin (0.50, 0.75, 1.0 kg/ha and 0.50 kg/ha *fb* one hand weeding at 40 days after sowing), Trifluralin (0.50, 0.75, 1.0 kg/ha and 0.50 kg/ha *fb* one HW at 40 DAS) and Oxyfluorfen (150, 175, 200g/ha and 150 g/ha *fb* one HW at 40 DAS) were tested against two hand weeding (20 and 40 DAS). The crop was sown in the second fortnight of October and harvested in May. Trifluralin was applied as pre-plant incorporation whereas pendimethalin and oxyfluorfen were applied as pre-emergence on the next day after sowing by mixing with 375 litres of water per ha, using knapsack sprayer fitted with flat fan nozzle. The data on weeds, yield attributes and crop yield were recorded at time of harvesting. The weed data were subjected to square root transformation before analysis.

RESULTS

The weed flora mainly consisted of *Rumex dentatus, Rumex spinosus, Medicago denticulata, Chenopodium album, Anagallis arvensis, Malva parviflora, Phalaris minor, Avena ludoviciana etc.* All the weed control treatments significantly reduced the weed infestation (weed dry matter) and increased the yield of fennel when compared with the control (unweeded check). Among different treatments, pre emergence application of pendimethalin 1.0 kg/ha was found most effective in reducing weed dry matter production and significantly better than trifluralin and oxyfluorfen treatments in terms of umbels/plant and seed yield of fennel. The seed yield of fennel with application of pendimethalin 1.0 kg/ha was 1.11, 1.43 and 1.35 t/ha during 2010-11, 2012-13 and 2013-14, respectively. Lower dose of pendimethalin *i.e.* 0.5 kg/ha followed by one hand weeding at 40 day after sowing (DAS) or two hand weedings at 20 and 40 DAS were also found effective and statistically at par with that of pendimethalin 1.0 kg/ha. Meena and Mehta (2009) have also reported similar findings. Though the application of oxyfluorfen (200g/ha or 150g/ha *fb* one HW at 40 DAS) was equally effective as pendimethalin (1.0 kg/ha or 0.5 kg/ha *fb* one hand weeding at 40 DAS) in reducing the weed infestation, it could not increase the yield as it caused phytotoxicity at the initial growth stages of fennel. Thakral *et al.* (2007) have also reported the phytotoxicity of oxyfluorfen in fennel.

Table 1. Effect of different weed control treatments on growth, yield of Fennel and weed dry matter.

Treatment	Plant height at harvest (cm)			Umbels (no./plant)			Seed yield (t/ha)			Weed dry matter at harvest (g/m^2)		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
Pendimethalin 0.5 kg/ha	151.7	144.5	149.7	12.67	15.60	13.17	0.71	0.81	0.79	8.25 (67.40)	9.44 (88.53)	8.94 (79.40)
Pendimethalin 0.75 kg/ha	153.7	145.3	151.2	15.00	20.70	16.93	0.86	1.10	1.03	6.33 (40.80)	7.18 (51.07)	6.79 (45.13)
Pendimethalin 1.0 kg/ha	157.5	146.0	153.5	19.00	26.10	21.57	1.11	1.43	1.35	4.58 (20.37)	5.00 (24.10)	4.55 (19.80)
Pendimethalin 0.5 kg/ha *fb* HW (40 DAS)	160.9	147.5	156.1	18.33	25.80	21.13	1.08	1.42	1.33	4.13 (17.40)	5.47 (29.83)	4.59 (21.27)
Trifluralin 0.5 kg/ha	149.3	144.1	148.4	12.33	14.70	12.53	0.68	0.75	0.74	8.70 (74.80)	10.74 (114.6)	9.91 (97.33)
Trifluralin0.75 kg/ha	150.3	145.5	149.6	14.00	16.20	14.10	0.79	0.84	0.85	7.98 (64.63)	9.52 (89.93)	8.92 (78.70)
Trifluralin 1.0 kg/ha	152.7	150.9	153.6	14.67	17.99	15.37	0.83	0.96	0.94	7.03 (49.27)	8.28 (67.67)	7.70 (58.57)
Trifluralin 0.5 kg/ha *fb* HW (40 DAS)	153.1	151.1	153.9	15.00	19.75	16.87	0.83	1.05	1.04	6.06 (36.07)	7.77 (59.87)	7.09 (49.57)
Oxyflurofen 150 g/ha	148.0	140.3	145.7	12.00	15.30	12.67	0.71	0.80	0.78	7.57 (56.27)	8.57 (72.90)	8.12 (65.10)
Oxyflurofen 175 g/ha	149.9	140.1	146.6	14.67	19.50	16.13	0.87	1.06	1.01	6.08 (38.17)	7.40 (54.10)	7.39 (53.83)
Oxyflurofen 200 g/ha	151.9	140.8	148.0	15.33	20.10	16.77	0.89	1.09	1.04	4.15 (16.67)	4.77 (22.90)	4.21 (16.90)
Oxyflurofen 150 g/ha *fb* HW (40 DAS)	153.2	142.1	149.4	17.33	20.70	18.00	0.99	1.12	1.11	4.09 (16.17)	4.65 (21.63)	4.07 (16.50)
Two HW (20 & 40 DAS)	162.4	151.3	158.8	19.33	24.90	21.47	1.12	1.36	1.35	3.90 (14.27)	5.19 (26.37)	4.07 (15.73)
Control	140.3	134.1	138.7	9.33	10.80	9.13	0.43	0.46	0.45	15.29 (233.3)	17.37 (302.4)	16.81 (282.6)
LSD (P=0.05)	NS	NS	NS	3.30	4.57	3.49	198	244	231	1.78	1.60	1.25

CONCLUSION

Pre-emergence application of pendimethalin 1.0 kg/ha or integration of lower dose of pendimethalin *i.e.* 0.50 kg/ha *fb* one hand weeding (40 DAS) was found most effective in reducing the weed infestation and enhancing the seed yield of fennel.

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Theme 5

Role of biological control in integrated weed management systems

Screening of natural enemies on *Trianthema portulacastrum* - a noxious weed of Andhra Pradesh

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Trianthema portulacastrum L. (horse purselane), a member of Aizoaceae, is indigenous to South Africa but it is widely distributed in tropical and subtropical areas as a noxious weed. It is considered as a major weed in various agricultural and vegetable crops, such as mustard (*Brassica* spp.), corn, pigeonpea, soybean, tomato, potato, onion and cotton. In India, horse purslane has been reported in the states of Uttar Pradesh, Punjab, Haryana, Rajasthan, Tamil Nadu and Andhra Pradesh and considered as a number one problematic terrestrial weed by virtue of its severe infestation in various agricultural and vegetable crops. Horse purslane is a strong competitor, reducing the yield of mung bean by 50-60% when left untreated. Significant losses in maize, soybean, and peanut yield are also attributed to this weed. Up to 60-70% infestation of this weed has been reported in pigeon pea and soybean fields and 80-90% in maize and brassica fields.

METHODOLOGY

A systematic epidemic study was attempted for the screening of natural enemies of the weed plant. From the infected portion of the weed, mycoflora were isolated and various pathenensis of fungal isolates was confirmed by Koch's postulates primarily and the host specificity of the isolates tests on green house plants by spore treatment.

RESULTS

The mycoflora namely *Alternaria alternata* (Fr.) Keissler.,*Colletotrichum capsici* (Syd.) E.J. Butler &Bisby., *Bipolaris maydis*(Y. Nisik. at C. Miyake) Shoemaker., *Curvularia lunata* (Wakker) Boedijin., *Curvularia tuberculata*Sivan. And *Gibbago trianthemae* E.G. Simmons was isolated from highly infected portions of the weed. Among the isolates, Gibbago trianthemae was highly aggressive to weed and it was considered as potential biocontrol agent (mycoherbicidal agent).

CONCLUSION

Among the isolates, *Gibbago trianthemae* was highly aggressive to weed and it was considered as potential biocontrol agent (mycoherbicidal agent).

Effect of *Zygogramma bicolorata* and different fungal isolates on *Parthenium hysterophorus*

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Parthenium hysterophorus also known as Congress grass, is a prolific weed belonging to Asteraceae family, and has now become one of the world's seven most devastating and hazardous weeds. Approximately two million hectares of land in India have been infested with this herbaceous menace. It can only be managed effectively by developing an integrated approach involving many options in combination.

The biological control of Parthenium has been explored through beetle *Z. bicolorata* as well as different fungal isolates at Baru Sahib, Himachal Pradesh. Beetles morphology, different life stages and their egg laying capacity per day were investigated in a 2l beaker containing 10cm layer of soil with Parthenium plant.

One pair of beetles laid about 650-700 eggs in 20-22 days (max. 80 and min. 25) in lab conditions. The laid eggs hatched after 36 to 72 hrs, depending upon the moisture content inside the beaker. The larvae feed on leaves for 12 to 16 days and having 4 instars. After 4th instar, it enters the soil and pupates below (upto 3-5 cm depth). The beetles emerged after 8-10 days and completed their life cycle in 25-28 days. Both the adults and larvae were capable of feeding on the Parthenium leaves but not on the flowers. So florescence remains intact which is one of the major limitations of beetles. Secondly, it was observed that *Z. bicolorata*is having different natural enemies (*Rhodoliacardinalis, Perillusbioculatus, Gryllus, etc*.) that feed on the eggs and larvae of beetles, so the population of beetles was not increasing in the natural environment. Therefore our second approach included the biological control through 5 different strains of fungi, *viz.* two *Alternaria* sp., two *Fusarium* sp., and one *Cladosporium* sp. Isolated strains'pathogenicity wastested individually as well as in combination (both in lab and field) against Parthenium with different control plants. In another approach disc plate technique was used to know the spore germination time and penetration route of fungus. All the strains were showing defoliation of leaves, but two species were completely effective on flowers, whereas one species was infecting both inflorescence and stem inside lab conditions. Out of all, only one *Fusarium* species was showing total defoliation of inflorescence after 25-28 days of spores sprayed in field conditions. Large level of fungal inoculum preparation and spray over the Parthenium in the field will be further explored, as well as studies are also underway to know the effect of *Fusarium* spp. on nearby vegetation.

Biological control of *Parthenium hysterophorus*

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Parthenium hysterophorus L., commonly known as carrot weed or congress grass in India has been considered as one of the worst weeds responsible for causing health problems in human and animals besides loss to crop productivity and plant biodiversity (kumar 2005). The weed has infested about 35 million hectares of land in India since it was first noticed in 1955. Now it has become one of the main weeds in almost all types of agricultural lands besides infesting wasteland, community land, road and railway track sides and forests. Biological control of Parthenium through insects, pathogen and competitive plants gained momentum in India in 1980s with publication of more reports about the indigenous bioagents infesting Parthenium. The classical biological control was started with the introduction of a host-specific leaf-feeding beetle *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) from Mexico (Jayanth 1987).

METHODOLOGY

A huge number of *Zygogramma bicolorata* Pall. (Coleoptera: Cyrysomilidae) insects were collected from natural abode. Three sites were selected randomly in the vicinity of Malinagar High School (Samastipur), Balua Basic School (Muzaffarpur) and Mirapur Middle School (Muzaffarpur) to release in areas heavily infested areas with exotic and noxious weed *Parthenium* and the effectiveness of beetle was as curtained with regard to management of *Parthenium*. Three random samples of $1m^2$ of *Parthenium* density were selected in each from the site. 500 adult battles were released at one site distributed evenly on the entire site during rainy season. Eggs, Larvae and adults were counted from each plant and the data were presented on average basis.

RESULTS

The area as mentioned in Table 1, Mexican beetles were seen emerging from soil after breaking hibernation, cause and defoliate the Parthenium largely from July, increased gradually upto September and drastically decreased thereafter: Similar trends were observed in case of egg, larva and adult population. They remained active between July to September at the three sites under reference. The emergence of beetle was not continuous, as it depends on rain fall, environment and the extent of damage was also not too similar. A critical perusal of data revealed that at site I, damage varied between 11-73%, at site-II between 8.0-76.0% and Site-III between 7.0-46.0 % with an average of 36.87, 39.62 and 21.25%, respectively.

Table 1. Egg, larvae and adult population of *Zygogramma bicolorata* for plant and per cent damage to *Parthenium* of the three sites during *Kharif* 2012

Month	Site I (Mirapur Middle School-Muzaffarpur)					Site II (Malinagar High School-Samastipur)					Site III (Balua Basic School- Muzaffarpur)				
	Eggs	Larvae	Adults	Damage (%)	0-5 scale	Eggs	Larvae	Adults	Damage (%)	0-5 scale	Eggs	Larvae	Adults	Damage (%)	0-5 scale
May, 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June, 12	0	0	2	11	1	0	1	1	8	1	0	0	0	0	0
July, 12	20	0	3	24	1	11	2	3	24	1	0	0	2	7	1
August, 12	37	14	10	63	3	24	10	10	68	3	16	3	8	16	1
Sept. 12	31	20	16	73	3	30	13	14	76	4	12	10	14	46	2
Oct. 12	0	10	13	61	3	0	12	12	63	3	3	6	9	38	2
Nov. 12	0	0	5	43	2	0	6	6	40	2	0	0	6	37	2
Dec. 12	0	0	0	20	1	0	2	2	38	2	0	0	0	26	2
Average	11.0	5.5	6.12	36.87	1.75	8.12	5.75	6.0	39.62	2.0	3.87	2.37	4.87	21.25	1.25

Table 2. Details of *Parthenium* morphology and relation of Mexican beetles at three selected sites for management of *Parthenium* by Mexican beetle in north Bihar

Particulars of *Parthenium* and Mexican beetle	Site I (Mirapur Middle School-Muzaffarpur)	Site II (Malinagar High School-Samastipur)	Site III (Balua Basic School- Muzaffarpur)
Plant population/m^2 area	08-13	09-13	8-12
Plant height (Meter)	0.52-0.82	0.54-0.81	0.47-0.79
Fresh biomass of plant (kg/m^2)	0.65-0.94	0.70-0.92	0.68-0.91
Adult population per plant (average)	6.12	6.00	4.87
Grubs (larvae) (AV)/plant	5.50	5.75	2.37
Eggs (AV)/plant	11.00	8.12	3.87
Per cent damage (%)	36.87	39.62	21.25

CONCLUSION

Mexican beetles were seen emerging from soil after breaking hibernation and defoliate the *Parthenium* largely from July, increased gradually upto September and drastically decreased thereafter.

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Rust fungi species on weeds in agricultural area in South-eastern Anatolia Region of turkey

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Weeds in agricultural crops are one of the essential economic and agronomic problems of plant production. Phytopathogenic fungi are often used for biological weed control. Survey for fungal pathogens of weeds, for application in biological weed control, were carried out in the Southeastern Anatolia Region in Turkey. Diseases of weeds belonging to the families: Alismataceae (1), Apiaceae (1), Aristolochiaceae (1), Asteraceae (12), Berberidaceae (2), Boraginaceae (1), Brassicaceae (1), Caryophyllaceae (1), Datiscaceae (1), Euphorbiaceae (2), Fabaceae (1), Lamiaceae (1), Malvaceae (2), Onagraceae (1), Poaceae (4) and Polygonaceae (3) were found. A first step for the development of biological control of weeds by fungi is that to find agent highly virulent and specific to the target host weed. Hence the present investigation was undertaken.

METHODOLOGY

This study was performed to detect the rust fungi on weeds becoming problem on fields of southeastern Anatolia region in Turkey. Weed specimens were prepared according to established herbarium techniques. Weeds were identified using the Flora of Turkey and East Aegean Islands. Weeds showing symptoms of rust disease was collected from the agricultural fields of different localities of 5 province (Adýyaman, Diyarbakýr, Mardin, Siirt and Þanlýurfa), Southeastern Anatolia Region of Turkey in May and November during 2012-2014. Dried herbarium material was examined under light microscopy and rust diseases identified. All specimens were deposited in the Mycological Collection of the Agriculture Faculty, Dicle University, Diyarbakýr, Turkey.

RESULTS

Totally 34 different species of rust fungi were detected on a total of 34 weed species in the Southeastern Anatolia Region fields (Table 1). Eight rust fungi species vis *Puccinia xanthii* Schwein, *P. phragmitis* (Schum) Koern., *P. montana* Fuckel, *P. bromina* Eriks, *P. calcitrapae* Dc. var. *calcitrapae* Cummins., *P. malvacearum* Mont., *Uromyces glycyrrhizae* (Rab.) Magn. and *U. acetosae* Schroet. were detected on respective hosts vis, *Xanthium strumarium* L., *Phragmites australis* (Cav.) Trin, *Centaurea balsamita* Lam., *Bromus sterilis* L., *Echinops orientalis* Trautv., *Alcea* sp.; *Malva* sp., *Glycyrrhiza glabra* L. and *Rumex crispus* L. These eight rust fungi have been identified as most common species.

Table 1. Weed species influenced by different rust fungi

Rust Fungi	Weed Species	Rust Fungi	Weed Species	Rust Fungi	Weed Species
Aecidium leontices	*Leontice leontopetalum*	*P. cirsii*	*Notabasis syriaca*	*P. recondita*	*Echium italicum*
Albugo candida	*Portulaca oleracea*	*P. coronifera*	*Avena sterilis*	*P. taraxaci*	*Taraxacum officinale*
Coleosporium datiscae	*Datisca cannabina*	*P. crepidicola*	*Crepis alpina*	*P. vagans*	*Epilobium parviflorum*
Melampsora gelmii	*Euphorbia orientalis*	*P. cynodontis*	*Cynodon dactylon*	*P. xanthii* *	*Xanthium strumarium*
Physoderma maculare	*Alisma plantago-aquatica*	*P. dioicae var. opizii*	*Lactuca serriola*	*Uromyces acetosae* *	*Rumex crispus*
Physopella artemisiae	*Artemisia dracunculus*	*P. falcaria*	*Falcaria vulgaris*	*U. bornmuelleri*	*Bongardia hrysogonun*
Puccina acarnae	*Picnomon acarina*	*P. isiacae*	*Cardaria draba*	*U. glycyrrhizae* *	*Glycyrrhiza glabra*
P. aristolochiae	*Aristolochia bottae*	*P. malvacearum* *	*Alcea sp.; Malva sp.*	*U. gypsophilae*	*Vaccaria pyramidata*
P. bromina *	*Bromus sterilis*	*P. menthae*	*Mentha longifolia*	*U. haussknechtii*	*Euphorbia sp.*
P. calcitrapae *	*Echinops orientalis*	*P. montana* *	*Centaurea balsamita*	*U. polygoni-avicularis*	*Polygonum aviculare*
P. calcitrapae	*Serratula cerinthifolia*	*P. phragmitis* *	*Phragmites australis*	*U. vesicatorius*	*Leontice leontopetalun*
P. carduipycnocephali	*Carduus pycnocephalus*	*P. punctiformis*	*Centaurea solsitialis*		

* These (eight) rust fungi have been identified as most common species

Studies of possibilities of phytopathogen fungi application in weed control started about 100 years ago (Hasan, 1983). First success was achieved at the beginning of 1970s, when rust pathogen *Puccinia chondrilliana* was applied in Australia for suppression of *Chondrilla juncea*. Different researches were carried out determination of rust fungi on weed in Turkey and 360 species of rust fungi have been recorded (Bahçecioðlu and Kabaktepe 2012, Ozaslan *et al.* 2015). In addition, *P. xanthii on X. strumarium* and *P. montana* on *C. balsamita* were important pathogens suppressed to development of host plants in field conditions. Some morphological characters based on light microscopes and photographs were given in the poster.

CONCLUSION

Puccinia xanthii on *Xanthium strumarium* and *P. montana* on *C. balsamita* were important pathogens suppressing to development of host plants in field conditions.

Theme 6

Herbicide resistance management

Herbicide weed management in Bt hybrid cotton–soybean cropping system of Central India

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Ten percent of Indian cotton is herbicide treated). India produces 11 million tonnes of soybean with 4 per cent usage of total herbicides during 2014-15. Post emergence herbicides usage is 35% in cotton followed by soybean crops due to changed climatic conditions, introduction of new herbicides and higher labour wages. The cost of the herbicides based integrated weed management (IWM) in cotton/ soybean is 50% less than to conventional practice and was more effective with least drudgery (Gianessi 2013). Present research objective is to test the tolerance in cotton and herbicidal activity against weed species. Herbicide group rotation as well as integrated weed management approach are also highly effective in preventing/ delaying resistance evolution.

METHODOLOGY

Field experiments were conducted during 2011, 2012, 2013 monsoon in *vertisol* associated series sites in Bunny Bt hybrid cotton spaced at 90x 60 cm by spraying pendimethalin 1.0 kg/ha + glyphosate 1.0 kg/ha as PPF method in stale seed bed followed by early post emergence application (20 DAS) of imazethapyr 0.070 kg/ha and pyrithiobac Na 0.070 kg/ha in soybean (45 x 10cm) and cotton, cotton + pigeon pea (90 x 60 cm) cropping systems at 0.5, 1.0, 1.5, 2.0 times of recommended dose. Crops and herbicides were rotated in subsequent two years to find out any shift in weed flora and weed intensity as influenced by crop and herbicide rotation. Protected spray of glyphosate 2, 3, 4, 5, 6, 8 ml and imazethapyr 0.070 kg/ha was done with restriction soybean rotated annually to find out the spectrum of weed control and bring additional herbicides or intercultures to make the IWM packages more effective. Glyphosate, imazethapyr, pyrithiobac, quizalofop, fenoxaprop, propquizafop were tested during 2012, 2013 for cotton and weed tolerance by fortnightly applications. In another field experiment, quizalofop ethyl 0.035 kg/ha, fenoxaprop methyl 0.035 kg/ha, propaquizafop ethyl 0.035 kg/ha, cyhalofop butyl 0.5 ml/l, chlorimuron ethyl 0.075 g/l and combination of 35 per cent each of imazethapyr +imazamox 0.2 g/ml spreader 1.5 g $NH_4(SO_4)_2$ /l were sprayed to find out the crop tolerance and explore the possibility to bring them under crop/ herbicide rotation during 2014-15 season. Herbicides were applied with LOK sprayer with an average water requirement of 413 l/ha. Herbicide toxicity was recorded 2 to 3 days after spray on 0-10 scale. Weeds killed, yellowed and remained green or stunted were also recorded after 8 to 12 DAA of herbicide. A weed free plot and unweeded control was also maintained to compare normal healthy cotton and yield adequacy and reductions.

RESULTS

Glyphosate resistant weeds identified from station and on farm trials at Nagpur after repeated applications of glyphosate were *Merremia emarginata* and *Cynotis axillaris*. *Setaria viridis* was found resistant to pendimethalin over 20 years' continuous application against *Celosia argentia*. Pyrithiobac sodium and imazethapyr at 0.5-2.5 X had no significant differences among doses, with similar broad leaf control range and minor differences for grasses. Both ALS group herbicides need to be combined with graminicides and interculture operations for effective weed control.

Ideally pendimethalin 1.0 kg/ha pre emergence residual herbicide alone or in combination with preplant foliage (PPF) active herbicides like glyphosate 1.0 kg/ha kill all the existing germinated weeds without disturbing the soil in heavily weed infested fields under moist ecosystems. This must be followed by early post emergence herbicide chlorimuron ethyl mixed with quizalofop ethyl in soybean. Propaquizafop + pyrithiobac is the best combination for early post emergence application in cotton. One month old *Sorghum halepense* could be managed by OTT application of glyphosate/post emergence graminicides such as quizalofop ethyl, propaquizafop and fenoxoprop methyl at respective recommended doses.

Table. 1. Weeds controlled by herbicides/ combinations (1 indicates kill, 0 indicates no kill)

Broad-leaved weeds	Glyphosate	Pyrithiobac	Imazethapyr	Quizalofop	Fenoxaprop	Propaquizafop	Pyrithiobac		
							Quizalofop	Fenoxoprop	Propaquizafop
Acalypha indica	1	0	0	0	0	0	0	0	0
Celosia argentia	1	0	0	0			0	0	0
Digera arvensis	1	0	0	0	0	0	1	1	1
Euphorbia sp.	1	0	0				0	0	
Merremia emarginata	0	0	0				1	1	1
Parthenium ysterophorous	1	0	0				0	0	0
Phyllanthus niruri		0		0		0	0	0	
Tridax procumbense	1	0	0		0	0	0	0	0
Sub total	100	0	0	0	0	0	33	33	33
Commelina benghalensis (wide)	1	1	1		0		1	1	1
Cynodon dactylon	1								1
Cynotis auxillaris (Narrow)	1	0	0	0	0	0	0	1	0
Cyperus rotundus	1	0	0		0	0	1	1	0
Eriochloa polystachia							1	1	
Lonegawat		0		0		0			
Phutanegawat		0							
Setaria intermedia (sawa)	0	1	0	0		0	0	1	0
Shirput		0	0						
Sorghum halepense	1	0	0				1	1	1
	50	20	10	0	0	0	40	60	30

CONCLUSION

Pendimethalin 1.0 kg/ha (pre-emergence) residual herbicide alone or in combination with glyphosate 1.0 kg/ha kill all the existing germinated weeds without disturbing the soil in heavily weed infested fields under moist ecosystems. This must be followed by early post emergence herbicide chlorimuron ethyl mixed with quizalofop ethyl in soybean. Propaquizafop + pyrithiobac is the best combination for early post emergence herbicides for application in cotton.

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Control and cross-resistance of barnyardgrassto ALS- and ACCase-inhibitors in rice field in Korea

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Sulfonylurea (SU)-resistant weeds comprised of annual weeds like, *Monochoria vaginalis*, *Scirpus juncoides* and *Cyperus difformis*, and three perennial weeds like, *S. planiculmis*, *Sagittaria pigmaea* and *Eleocharis acicularis*as in 2010 since identification of *M. korsakowii* in the reclaimed rice field in 1998. And the resistant *Echinochloa oryzoides* to ACCase and ALS inhibitors has been confirmed in wet-direct seeding rice field of the southern province, Korea in 2009. In the beginning, the SU-resistant *M. vaginalis*, *S. juncoides* and *C. difformis* were rapidly and individually spread in different fields, however, theses resistant weeds have been occurring simultaneously in the same filed. The resistant biotypes demonstrated about 10-1,000-fold resistance, based on GR_{50} values of the SU herbicides tested. The top ten herbicides by applied area were composed of all SU-included herbicides by 2008.Barnyardgrass(*Echinochloa crus-galli* var. *crus-galli*) is the most difficult-to-control weed that infests rice fields in Korea. The concentrated and successive treatment of ACCase and ALS inhibitors for control of barnyard grass in direct-seeded rice led to the resistance of *E. oryzoides*. Also, SU-herbicides like pyrazosulfuron-ethyl and imazosulfuron effective against barnyard grass can be bound up with the resistance of *E. oryzoides*. The objectives of this research were to confirm ALS (acetolactate synthase) and ACCase(Acetyl-CoA carboxylase)- inhibiting herbicide-resistant barnyard grass in Korea and to determine sensitivity and efficacy of rice herbicides applied for control of resistant and susceptible barnyard grass biotypes.

METHODOLOGY

The putative seeds of ALS- and ACCase-resistant barnyard grass biotype were collected from rice fields in fall 2010. The fields had been treated with ALS and ACCase inhibitors-included mixtures for many years. The response of barnyard grass biotypes to 10 rates (0-10) of ACCase inhibitors, cyhalofop-butyl and metamifop, and ALS inhibitors like, priminobac-methyl, penoxsulam and flucetosulfuron, was evaluated in a dose–response bioassay in a greenhouse. At 20 days after herbicides treatment, dry weights of the treated plants were determined. All treatments for each measurement were triplicated.

RESULTS

On the basis of the values at GR_{50} (concentration of respective herbicides required for 50% inhibition of dry weight), the analysis showed about 19-42-fold resistance depending upon the type of ALS- and ACCase-inhibiting herbicides being investigated and susceptible biotype used for comparison. The resistant biotype had a reduced sensitivity to ALS- and ACCase-inhibiting herbicides.

Table 1. GR_{50} value of ALS- and ACCase-inhibiting herbicide-resistant(R) and susceptible(S) *Echinochloa crus-galli* var. *crus-galli* in greenhouse

Herbicide	GR_{50}(g/ha)		
	R	S	R/S
Priminobac-methyl	107.1	6.5	16.6
Penoxsulam	273.2	1.2	40.3
Flucetosulfuron	20.8	40.5	41.6
Cyhalofop-butyl	81.7	4.3	19.0
Metamifop	69.0	1.9	36.3

These results suggested a cross-resistance between ALS- and ACCase-inhibiting herbicides that resulted in effectiveness for control of barnyardgrass. Barnyardgrass biotypes were effectively controlled 90% with mefenacet, and fentrazamide by 2 leaf stage, whereas oxadiazon, thiobencarb and butachlor provided over 90% control by l leaf stage of the resistant biotype.

Table 2. Efficacy to ALS- and ACCase-inhibiting herbicide-resistant *Echinochloa crus-galli* var. *crus-galli*in greenhouse

Herbicide	Leaf stage			
	0.5	1	2	3
	---- Control Efficacy (%) --			
Oxadiazon	100	91	-	-
Thiobencarb	97	93	-	-
Butachlor	100	95	-	-
Mefenacet	100	100	93	35
Fentrazamide	100	100	92	31

CONCLUSION

The barnyardgrass biotype collected from the paddy fields in Korea showed resistance to ALS- (cyhalofop-butyl and metamifop) and ACCase-inhibitors (priminobac-methyl, penoxsulam and flucetosulfuron) tested.

Accelerating the sustainable control of *Phalaris minor* in wheat in Fathegarh Sahib district of Punjab

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Phalaris minor, an epidemic weed, posed a major threat to the wheat production in the Indo-Gangetic Plains. Sometimes its population is so high (2000-3000 plants/m^2) that farmers are forced to harvest the wheat crop as fodder. The crop suffers a yield loss of 25-30% due to infestation of this weed (Yadav and Malik, 2005). Isoproturon remained effective against this weeds effective for almost a decade. Sole dependence on this herbicide at higher doses resulted in the development of resistance to isoproturon in *P. minor*. Alternative herbicides belonging to group I [(acetyl co-A carboxylase (ACCase) inhibitors] and group II [acetolactate synthase (ALS) inhibitors] were recommended for its management during 1997-98 (Yadav *et al.* 1997). Thus emergence of multiple herbicide resistance in *P. minor* is an emerging threat to wheat production in north-western India. Pendimethalin a pre-emergence herbicide is a vital option to manage the herbicide-resistant *P. minor* population.

METHODOLOGY

Ten on farm demonstrations to accelerate the technology of pre-emergence control of *P. minor* were conducted at farmer's field in Fatehgarh Sahib district during *Rabi* 2013-14 and 2014-15. The soil types of the different locations varied between clay loam to loamy sand. The performance of pendimethalin 30 EC was compared with the recommended post-emergence herbicides of substituted ureas/ clodinafop/ sulfonyl ureas groups, *etc.* The pendimethalin was applied at the rate of 2.5 l/ha within two days after sowing using 500 litres of water per hectare. Plant height, effective tillers/m² and grain yield at the time of harvest of wheat crop was recorded. The data on weed count, crop growth and yield was analysed on average basis.

RESULTS

The results revealed that the application of pre-emergence pendimethalin 30 EC effectively controlled the *P. minor* population. The *P. minor* population of 3.6 and 2.8 units was recorded in the pre-emergence pendimethalin application as compared to post-emergence herbicides (20.5 and 45.6 units), which was 83% and 93% less during 2013- 14 and 2014 -15, respectively. This showed that pendimethalin controlled the resistant population of *P. minor* very effectively. Further, farmers can opt for one hand pulling or post-emergence spray of herbicides to control a late flush of *P. minor* (Dhawan *et al.* 2012). Application of pre-emergence pendimethalin recorded taller plants (80.5 cm and 80.1 cm), more number of effective tillers/m² (364.7 and 362.5), which led to higher grain yield (5.32 and 4.93 t/ha) during both the years as compared to post emergence herbicides. The weed control efficiency of pendimethalin was more during 2014-15 because there was a heavy rain at the critical crop weed competition stage so the farmers were unable to control weeds at that time which led to yield losses and more number of post-emergence sprays at higher doses that added to their cost of cultivation (Table 2) was clearly depicted from the benefit cost ratio. So the crop weed competition for nutrients, light space and moisture was less which resulted in luxurious crop growth in the pendimethalin-treated plots.

Table 1. Bio-efficacy of pendimethalin 30 EC for the control of *P. minor* in wheat

Weed control Treatment	Average *P. minor* count (no./m^2) at 40 DAS		Plant height (cm) at harvest		Effective tillers/m²		Grain Yield (t/ha)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Pre-emergence	3.6	2.8	80.5	80.1	364.7	362.5	5.32	4.93
Post- emergence	20.5	45.6	79.3	76.4	360.2	355.8	5.26	4.57

Table 2. Effect of different weed control treatments on the economic benefits of the farmers

Weed control Treatment	Gross Cost (Rs/ha)		Gross Returns (Rs./ha)		Net Returns (Rs./ha)		B:C Ratio	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Pre-emergence	30,000	30,500	74,620	70,048	44,620	39,548	1.5	1.3
Post- emergence	32,000	33,800	73,640	65,768	41,640	31968	1.3	0.9

CONCLUSION

It is concluded that pre-emergence of *P. minor* control is the low cost method, which is sustainable in terms of weed control and wheat production. Utmost care should be taken before selecting a particular herbicide for weed control, depending upon the type of weed flora, soil type, cropping system and cultivar.

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Tolerance of rice varieties to early post-emergence herbicides

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Rice is the staple food crop occupying 75.6% of the total cropped area of 15.03 million ha in Bangladesh (BBS, 2012). Weed is a great menace causing serious yield reduction in rice. The present experiment was initiated with a view to examine the tolerance of rice varieties to higher rates of two early post-emergence herbicides.

METHODOLOGY

The experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. Five rice varieties and seven herbicide treatments consisting of two early post emergence herbicides (orthosulfamuron and metamiphop) at three rates (at 12 days after transplanting, DAT) and one pre-emergence pendimethalin at 750 g ai/ha (3 DAT) were included in the trial using strip-plot design with three replications. Twenty-five day old rice seedlings of all the varieties were transplanted at 25 x 15 cm spacing on 3 August 2013. The chlorophyll content of rice leaf (SPAD value) was recorded five times at seven days interval starting at 10 DAT. Data on crop characters, yield attributes and yield were recorded at harvest. Grain yield was adjusted at 14% moisture level. The collected data were analyzed statistically following ANOVA technique and means were compared by DMRT using statistical package program MSTAT-C.

RESULTS

The result showed that the leaf chlorophyll content (SPAD values) of all rice varieties increased with increasing the dose of both the herbicides (Table 1). The recommended rate of application of both the herbicides showed the highest grain yield in most of the varieties although double the recommended rate did not show significant decline in grain yield. On the other hand, the three times higher dose caused significant grain yield reduction in all the varieties. However, Cv. BRRI dhan39 gave higher grain yield at 2X dose of metamifop (150 g/ha) as compared to other varieties, perhaps due to similar SPAD values even at higher dosage. Further, Cv. BRRI dhan33 gave similar yield at all doses of metamifop due to similar SPAD values. All five rice varieties gave lower yield with increase in the dosses of orthosulfamuron. Thus, differential response of rice varieties for higher doses of metamifop was observed in the present study. The present result could be supported by Bari (2010) who found yield reduction in rice with three times' higher rate of MCPA application.

Table 1. Leaf chlorophyll content (SPAD values) and grain yield of five transplanted rice varieties as affected by rate of application of two early post emergence herbicides

Treatment	BRRI dhan33	BRRI dhan39	BRRI dhan56	BRRI dhan57	Binadhan-7
Leaf chlorophyll content (SPAD value) at 24 DAT					
Control	41.63 kl	43.73 h-l	41.37 l	42.47 i-l	44.20 h-l
Orthosulfamuron at 150 g/ha	48.23 b-h	45.63 f-l	42.57 i-l	41.87 jkl	44.03 h-l
Orthosulfamuron at 300 g/ha	53.03 a	50.37 a-f	44.70 h-l	48.20 b-h	46.53 d-j
Orthosulfamuron at 450 g/ha	47.50 b-h	51.80 ab	50.13 a-g	51.60 abc	46.27 e-k
Metamifop at 0.75 L/ha	47.93 b-h	47.73 b-h	46.10 f-l	51.07 a-d	47.00 c-i
Metamifop at 1.50 L/ha	50.90 a-e	47.87 b-h	45.53 g-l	51.37 abc	42.63 i-l
Metamifop at 2.25 L/ha	52.10 ab	53.30 a	44.87 h-l	53.10 a	44.20 h-l
LSD (P=.0.5)			1.406		
Grain yield (t/ha)					
Control	3.88 c-h	4.05 c-f	3.38 ijk	3.967 c-g	4.04 c-f
Orthosulfamuron at 150 g/ha	4.91 ab	4.76 b	3.32 ijk	3.59 g-j	4.13 c-f
Orthosulfamuron at 300 g/ha	4.07 c-f	3.47 h-k	3.10 k	3.56 g-j	3.88 c-h
Orthosulfamuron at 450 g/ha	3.98 c-g	3.30 ijk	2.62 l	3.26 jk	3.86 c-h
Metamifop at 0.75 L/ha	4.26 c	4.05 c-f	3.34 ijk	3.81 d-h	4.66 b
Metamifop at 1.50 L/ha	4.15 cde	5.167 a	3.26 jk	3.73 e-i	4.24 cd
Metamifop at 2.25 L/ha	4.15 c-f	3.36 ijk	2.41 l	3.70 f-i	3.51 h-k
LSD (P=.0.5)			0.1304		

CONCLUSION

The study revealed that significant yield reduction of rice varieties occured due to application of higher than double of the recommended rate of early post emergence herbicides like orthosulfamuron and metamifop.

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Status of sulfonylurea resistance in *Sagittaria trifolia* - a perennial paddy weed in Japan

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Sagittaria trifolia L. is one of the most noxious weeds in paddy fields, Japan. Since the late 1990s, severe infestations of *S. trifolia* after applications of sulfonylurea herbicides have been observed in Akita prefecture in Japan. Two biotypes (R1 and R2) of these populations were investigated in relation to sulfonylurea resistance, and both of them showed resistance to bensulfuron-methyl at recommended dose of paddy fields (Iwakami *et al*. 2014). Acetolactate synthase (ALS) is the target site of sulfonylureas such as bensulfuron-methyl and pyrazosulfuron-ethyl. The analysis of ALS gene in R1 and R2 indicated the base of resistance is target site resistance (TSR) in R1 and non-target-site resistance (NTSR) in R2 (Iwakami *et al.* 2014).In pot experiment, R1 showed cross-resistance to pyrazosulfuron-ethyl but R2 did not show the resistance to pyrazosulfuron-ethyl. Thus, two types of resistance were found in *S. trifolia* in Japan; TSR biotype with cross-resistance to pyrazosulfuron-ethyl and NTSR biotype without the cross-resistance. In this study, we surveyed the resistance of *S. trifolia* in four prefectures of Japan, and evaluated the ratio of the two biotypes in the resistant *S. trifolia*in Japan.

METHODOLOGY

Plants of *S. trifolia* were collected in paddy fields with severe infestations of the weed. in 1997-2014. In Akita, Yamagata, Ibaraki and Nagano Prefectures. They were checked for herbicide resistance by pot experiment, shoot-regeneration method (Ohno *et al.* 2004), and/or sequencing of ALS gene. In pot experiment, germinated tubers were transplanted into the pots and grown outdoors or growth chamber. Bensulfuron-methyl and/or pyrazosulfuron-ethyl were applied at young leaf stages with recommended doses of paddy fields. In shoot-regeneration method, the bases of mature plants were transplanted into the pots after cutting off the leaves and roots leaving 3-5 cm from the base, and the herbicides were applied into the pots after regrowth of one leaf. Growth or shoot regeneration was evaluated at about one month after herbicide application in the pot experiment and shoot-regeneration method, respectively. The sequences of ALS gene were determined according to the method described in Iwakami *et al.* (2014).

RESULTS

TSR biotypes were distinguished by cross-resistance to bensulfuron-methyl and pyrazosulfuron-ethyl or the presence of amino acid substitution in deduced amino acid sequences of ALS that are known to cause ALS inhibitor resistance. The rest of bensulfuron-methyl resistant biotypes that showed high susceptibility to pyrazosulfuron-ethyl or have no amino acid substitution in ALS were assumed as NTSR biotypes.

In Akita prefecture, eight accessions were TSR and four were NTSR. In Yamagata, thirteen accessions were TSR and ten were NTSR. In Ibaraki, two NTSR accessions were found. In Nagano, three were TSR and three were NTSR. Totally, 24 accessions were TSR and 19 were NTSR.

CONCLUSION

Both TSR and NTSR biotypes were found in three prefectures of Japan. The ratio of NTSR was 44% in our survey.

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Biochemical characterization of *P. minor* resistance to isoproturon in Uttarakhand

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Phalaris minor is a highly competitive weed of wheat crop in India and can cause yield reductions up to 100% (Chhokar *et al*. 2008). Isoproturon was recommended against *P. minor* in late 1980s. However, extensive use of isoproturon over many years led to the evolution of resistance in *P. minor* in north-west India and resulted in total crop failure (Malik and Singh 1995). In Punjab and Haryana, its recommendation was withdrawn in 1997. However, in Uttarakhand it was still being used for quite a long time. But again it failed to control the weed. The present study reports the possible biochemical causes of isoproturon resistance in Uttarakhand state.

METHODOLOGY

The present study was carried out in pot culture in the Department of Plant Physiology, G.B. Pant University of Agriculture and Technology, Pantnagar as part of the experiments under AICRP on Weed Control. Seeds collected from farmers' fields were used in the experiment. Based on results of previous experiments, seeds from five sources were used. Isoproturon was applied at 0.5, 1.0 (recommended dose, x) and 2.0 kg (2x dose) /ha at 2-3 leaf stage. All the treatments were replicated thrice. Confirmation of resistance in *P. minor* was cross checked by the application of PBO, a mono-oxygenase inhibitor, at 2kg/ha sprayed along with all the three doses of isoproturon. Observation on per cent mortality of *P. minor* plants was recorded at 20 days after spray.

RESULTS

Effect of different doses of isoproturon on mortality of *P. minoris* shown in Table 1. When used alone, isoproturon at all the doses failed to control the weed from all the sources except S1 and S4 sources where mortality rates were higher at double doses of the herbicide. When PBO was applied along with isoproturon, mortality percentage of *P. minor* plants from all the sources recorded higher mortality rates (Fig. 2). Among the sources, plants collected from the sources S1 and S4 recorded highest mortality rates.

Table 1. Effect of different doses of isoproturon on mortality (%) of *P. minor* collected from five different sources.

Sources	Control	ISO I	ISO II	ISO III
S1	0.00	28.67	58.89	84.78
S2	0.00	26.67	35.56	50.33
S3	0.00	13.33	48.33	46.22
S4	0.00	32.56	71.11	77.44
S5	0.00	15.56	42.44	56.67
LSD (P=0.05)	-	15.05	11.71	14.68

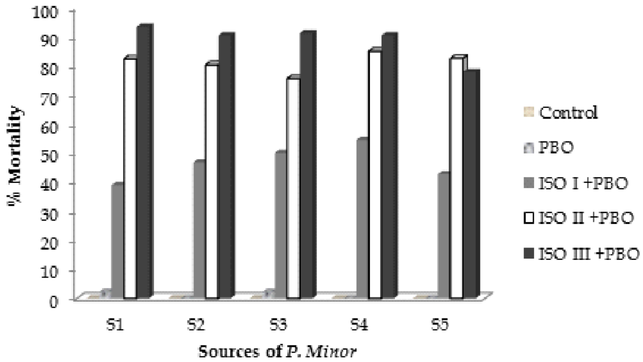

Fig. 1. Effect of different doses of isoproturon along with PBO on mortality (%) of *P. minor*

CONCLUSION

Increased mortality of *P minor* at different doses of isoproturon due to addition of PBO indicated that the resistance observed could be due to enhanced metabolism of the herbicide by the resistant population of *P. minor.*

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Establishment of *Lolium* species resistant to acetolactate synthase-inhibiting herbicide at grain-importation ports in Japan

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Human-mediated seed dispersal has the potential to spread herbicide resistant genes much farther and faster than natural migration. Many herbicide resistant weed seeds are contaminants in commercial grain (Michael *et al*. 2010; Shimono *et al*. 2010). If herbicide resistant weeds were to escape from grain commodities and establish in grain-importing countries, gene flow via pollen or seed movement from the resistant plants could provide a source of resistant alleles in previously herbicide susceptible populations. Therefore, the study on the establishment and expansion of resistant weeds spilled from imported grain in grain-importing countries provides a useful benchmark for future weed-control programs.

METHODOLOGY

Investigation was carried out on the contamination of seeds of *Lolium* species with target-site mutations conferring resistance to acetolactate synthase (ALS)-inhibiting herbicides in wheat imported from the U.S., Canada, and Australia into Japan and the establishment of ALS-inhibiting herbicide resistant *Lolium* species in 11 seaports in Japan that are major entry points for international commodities. Leaves were sampled from 120 plants at each port and total DNA was extracted, then resistance-endowing ALS mutation were identified. In parallel, changes in the frequency of resistant individuals over three years in and around one major port, Kashima port. Every year 500 plants were surveyed (details in Shimono *et al*. 2015).

RESULTS

Herbicide resistant *Lolium* seeds were found from all classes of wheat samples, ranging from 29-85%. Resistant individuals became established at six out of eight ports where more than 50 kt of imported wheat was unloaded every year. In contrast, resistant individuals were not found in the populations at three ports where the amount of wheat being unloaded was less than 50 kt. Monitoring over 3 years at Kashima port revealed that the frequency of resistant individuals did not fluctuate among years. Many resistant individuals were distributed in the close vicinity of the entrance of a fodder company, but a few resistant individuals were found in areas 2-km away from the port. The results indicated that gene flow is minor through pollen or seed movement from resistant plants to surrounding populations.

CONCLUSION

The establishment of resistant *Lolium* individuals was common at major grain landing ports. Although gene flow was probably limited within local area, further extensive and long-term monitoring is required to perform a comprehensive risk assessment of herbicide resistant plants entering Japan through commercial grain trade.

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Development of resistance in weeds against Bipyribac sodium

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Many Provincial Technical Working Group Meetings (PTWG) held on 2014 *Yala* season complained that certain herbicides were unable to kill certain weed species such as *Cyperus iria*, *Cyperus pulcherimus*, *Echinochloa crusgalli* and *Ischaemum rogosum*. To see whether the above mentioned weeds have developed herbicide resistance, four pot experiments using Completely Randomized Design (CRD) were conducted in 2014 and 2015 *Maha* season at Rice Research and Development Institute, Batalagoda. Weed seeds were collected from Anamaduwa and Batalagoda fields. Field history of previous herbicides application was recorded. Pots were filled with fried soils and equal portion of weed seeds were sown. Pot were frequently watered and kept under direct sun light. Each pot experiments consisted of four treatments as zero herbicide treatment, recommended herbicide dosage (300 ml/ha), 25% Increased herbicide dosage (375 ml/ha) and 50% Increased herbicide dosage (450 ml/ha).Water was pounded three days after herbicide application. Remaining weeds root uprooted 10 days after herbicide application and oven dry weights were taken. Data were analysed using SAS package employing ANOVA. Weed Controll Efficacy (WCE) was calculated using the standard formula.

In the case of *Cyperus iria, WCE* was 32% at recommended herbicide dosage. *Cyperus pulcherimus* showed a WCE of 56% at recommended herbicide dosage whereas *Echinocloa crusgalli* and *Ischaemum rogosum* showed a maximum WCE (100%) at recommended herbicide dosage. Results revealed that *Cyperus iria* and *Cyperus pulcherimus* of selected locations have developed to Bispyribac sodium100 g/l herbicide at the recommended dosage of 300 ml/ha.

Cytochrome P450 CYP81A12 and CYP81A21 are associated with resistance to two acetolactate synthase inhibitors in *Echinochloa phyllopogon*

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A multiple-herbicide resistant biotype of *Echinochloa phyllopogon* has been found in California, USA. Incremental activities of cytochrome P450s are assumed to the basis for its resistance to different classes of ALS inhibitors such as bensulfuron-methyl (BSM) (Osuna *et al.* 2002)and penoxsulam (PX)(Yasuor *et al.* 2009). In this study, we characterized P450s of the CYP81A subfamily in *E. phyllopogon* and found that two CYP81A P450 genes were associated with BSM and PX resistance in *E. phyllopogon* (Iwakami *et al.* 2014).

METHODOLOGY

A multiple-herbicide resistant and a susceptible line of *E. phyllopogon* were collected in California in 1997 and selfed for three successive generations. The amount of BSM and its metabolite, O-demethylated BSM were compared between the resistant and sensitive plants after 24 hours BSM treatment. P450 genes were isolated through degenerate RT PCR using cDNAs synthesized from total RNA of the resistant line of *E. Phyllopogon*. The transcript levels of the P450 genes were compared in seedlings between the resistant and susceptible lines using real-time PCR. BSM and PX sensitivities of *Arabidopsis thaliana* introduced with P450 genes of *E. phyllopogon* were examined. BSM was added to culture solution of yeast expressing either of the P450 genes. The culture solution was analyzed for BSM metabolism using LC-MS/MS. Association of expression level of P450 gene and herbicide resistance was analyzed using F6 progenies of the susceptible and resistant lines of *E. phyllopogon*.

RESULTS

Enhanced BSM metabolism into O-demethylated BSM was observed in the resistant line. Two P450 genes, *CYP81A12* and *CYP81A21*, were more highly expressed in the resistant than in the susceptible line. Transgenic *A. thaliana* expressing either of the genes survived in media containing BSM or PX while the wild type died. The peak corresponding to O-demethylated BSM was detected in the culture solution of the yeast expressing either of the genes whereas no such peak occurred in the vector control. Resistance to BSM and PX were correlated with higher transcript levels of the two P450 genes in the F6 lines.

CONCLUSION

The results suggested that the resistant line-specific highly expressed P450 genes are involved in BSM and PX resistance in the multiple-herbicide resistant *E. phyllopogon*.

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Underlying causes for poor control of *Crassocephalum* and *Erigeron* byglyphosate

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Crassocephalum crepidioides (Benth) S. Moor and *Erigeron sumatrensis* Retz are commonly found weeds in tea lands at high elevations of Sri Lanka. There are complaints that the two weeds are not properly controlled by glyphosate.The poor response to herbicides at the mature phase(Gupta 1984), the use of a very low dosage of glyphosate,and developing resistance to glyphosatein these weeds due to the continuoususe of itmay be the factors those attribute for suchpoor control. The following investigations were therefore undertaken to elucidate the underlying causes for poor control of both weeds by glyphosate.

METHODOLOGY

A series of investigations was undertaken at the Tea Research Institute of Sri Lanka, Talawakelle (Altitude 1382 m amsl), during the period of 2010-2011.The bio-efficacy of three different dosages (0.72, 1.08, and 1.8 g/l) and commercial products of glyphosate ('Round up', 'Weedol' and 'D dash') in the control of two weedsat a 6-8 leaf stage was first investigated. In another study, mature seeds of both weeds were collated from two adjoining estates in Maskeliya, *i.e.* 'Norwood' and 'Venture', where the tea lands have been sprayed with glyphosate for more >10 years and hasnot been sprayed for >10 years, respectively and both seed types were named as 'R'and 'S' biotypes, respectively. The effect of maturity level of two weeds on their control by glyphosate was also studied in 2011. *C. crepidiodes* at three different growth phases i.e. tender (1-5 cm tall), young (6-11 cm tall), and mature (12-18 cm tall) and *E. sumatrensis* at 2-4, 5-8, and 8-10 leaf stageswere sprayed with two glyphosate products at 1.08 and 1.8 g/l, separately. All experiments were assigned to a completely randomized design (CRD) with three replicates and anon-treated control was also included.

RESULTS

Effect of the dosage and the product of glyphosate

Among three dosages of glyphosate tested, *C. crepidiodes* was poorly responded to 0.72 g/l compared to 1.08 and 1.8 g/l. A majority of tea stakeholders also use to apply a very low dosage such as <1.2 l/ha (0.78 g/l) to their tea fields. Anderson (1984) also stated that a fast action of glyphosate could be expected with higher dosages. 'Round up and 'Weedol' performed better than 'D dash' indicating that the old formulations were found to be more promising than the new formulations.

Impact of maturity stage of weeds

Table 1: Mean dry weight of *C.crepidiodes* and *E. sumatrensis* at different growth phases as affected by two dosages of two glyphosate products at 3 WAA

Treatment	*C. crepidiodes* (g/plant)			*E.sumatrensis* (g/plant)		
	(1-5 cm height)	(6-11 cm height	(12-18 cm height)	(2-4 leaves)	(5-8 leaves)	(8-10 leaves)
Round up at 1.08 g/l	0.16	2.75 b	4.17	12 b	43 b	39 b
Round up at 1.8 g/l	0	0.58 c	1.92	8 b	38 b	35 b
Weedol at 1.08 g	0.15	2.27 b	3.56	18 b	48 b	45 b
a.i./L	0	0.71 c	2.71	11 b	29 b	41 b
Weedol at 1.8 g/l	0.31	3.96 a	6.16	52 a	80 a	91 a
Untreated Control LSD (P=0.05)	ns	-	ns	-	-	-

All the mature plants of *C. crepidiodes* at 12-18 cm height did not respond to glyphosate either at 1.08 or 1.8 g/l (Table 1). Whereas, the young plants at 5-11 cm height were significantly controlled with both dosages compared to above mature plants and; tender seedlings (1-5 cm height) were most susceptible for glyphosate. Gupta (1984) also indicated the phase of maturity an important factor that attributes for proper killing of a weed by a given herbicide.In contrast, significantly lower dry weight (50-77%) was reported inglyphosate-treated *E. sumatrensis* at all growth phases, compared with that of control.

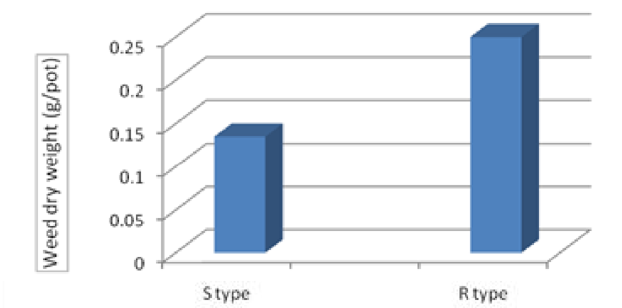

Fig 1: Mean dry weight of two biotypes of *C.crepidiodes* as affected by glyphosate @ 1.8 g a.i/L at Venture and Norwood Estates, Maskeliya

Development of resistance in two weeds for glyphosate

The germination percentage of 'S' biotype weeds was significantly higher than that of 'R' biotype weeds. This may be attributed to the phytotoxicity occurred in mother plants due to systemic mode of action of glyphosate. The mean dry weight of 'S' biotype of *C. crepidiodes* seedlings was significantly lower than ($p<0.05$) that of 'R' biotype seedlings of Maskeliya area at 21 DAA of glyphosate at 1.08 and 1.8 g/l (Fig.1). These results indicate that resistance has been developed for glyphosate in 'R' biotype seedlings of *C.crepidiodes* inMaskeliya area.

Owing to regular use of glyphosate over many years. Valverde (2000) also reported that continuous use of herbicides imposes selection pressure for increased resistance within species that were formally susceptible. Well answering to glyphosate by 'R' biotype of *E sumatrensis* implies that no any resistance has been developed yet in it to glyphosate.

CONCLUSION

*E. sumatrensis*and *C.crepidiodes*weeds are difficult to control at mature phase of growth and with a very low dosage of glyphosate but in addition a low level ofresistance has also been developed in *C. crepidiodes*weed for glyphosate.

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Evaluation of herbicide and insect resistant in transgenic stacked corn hybrids (TC 1507 x NK 603) for higher productivity

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Weeds cause considerable yield loss due to competition of resources with maize crop. Herbicide-resistant corn plants confer tolerance to glyphosate by production of the glyphosate-resistant CP4 5-enolpyruvyl shikimate-3 phosphate synthase (*CP4 EPSPS*) proteins. Transgenic stacked hybrid maize (TC1507 X NK 603) was developed for preventing yield losses in maize crop due to pests and weeds and to improve productivity.

METHODOLOGY

A field experiment was carried out during the *Kharif* season of 2011 at Tamil Nadu Agricultural University, Coimbatore. Sixteen treatments consisting of two transgenic hybrids (30V92 & 30B11 HR) resistant to glyphosate, treated with two doses of post-emergence glyphosate at 900 and 1800 g a.e/ha and were compared with non-transgenic maize hybrids like 30V92, 30B11, BIO9681 and COHM5 treated with pre-emergence application of atrazine at 0.5 kg/ha followed by hand weeding at 40 DAS in a randomised block design with three replications followed with recommended package of practices.

RESULTS

Broad leaved weeds (86%) dominated the weed flora followed by sedge (8%) and grass (5.4%). Among the herbicidal treatments, lower weed density and dry weight were observed under transgenic maize hybrid 30V92, with post emergence applications of glyphosate at 1800 g/ha was 2.04 plants/m^2 and 1.58 g/m^2 (40 DAS), which was comparable with other non-transgenic corn hybrids with same herbicidal treatment which resulted in effective control of broad leaved weeds, grasses and sedge due to its broad spectrum action was stated by Kogger and Reddy (2005). Transgenic corn hybrid 30V92 at 1800 g/ha recorded higher grain yield of 12 t/ha which was 36% higher than the non-weeded check plot of transgenic 30V92. Lower weed index was recorded with 9 and 10% in transgenic hybrids of 30V92 and 30B11**.** Higher weed index was observed in the non-weeded check plots due to non- elective, translocated herbicide, provided the favourable crop growth environment at the establishment stage of the crop (Tharp *et al.*1999). Higher B:C ratio of Rs. 3.42 was found maximum with transgenic hybrids of 30V92 followed by 30B11 hybrid (Rs.3.21).

Table 1. Weed density, dry weight, yield, and economics of maize influenced by different weed control methods

Treatment	Weed density (No/m^2)		Weed dry weight (g/m^2)		Weed index (%)	Grain yield (t/ha)	B:C ratio
	20 DAS	40 DAS	20 DAS	40 DAS			
30V92 POE Glyphosate at 900 g/ha	15.43 (236.22)	2.78 (5.75)	7.61 (55.94)	1.88 (1.52)	9.09	11.10	3.21
30V92 POE Glyphosate at 1800 g/ha	15.33 (233.08)	2.04 (2.15)	7.37 (52.37)	1.58 (0.49)	0.00	12.21	3.42
30V92 POE Glyphosate (Weedy check)	15.74 (245.60)	14.3(202.93)	7.66 (56.62)	10.39 (106.03)	27.60	8.84	2.67
30B11 POE Glyphosate at 900 g/ha	15.78 (246.89)	3.31(8.98)	7.40 (52.79)	2.16 (2.68)	10.15	10.97	3.17
30B11 POE Glyphosate at 1800 g/ha	16.06 (256.07)	2.55(4.50)	7.71(57.41)	1.79 (1.20)	1.88	11.98	3.36
30B11 POE Glyphosate (Weedy check)	15.81 (248.10)	14.5 (209.43)	8.18 (64.92)	10.94 (117.59)	25.30	9.12	2.76
30V92 PE atrazine 0.5 kg/ha + HW+ I C	7.99 (61.85)	7.81(59.00)	3.68 (11.57)	5.78 (31.43)	16.21	10.23	2.48
30V92 No Weed control and only I C	15.45(236.55)	13.64(183.99)	7.08 (48.17)	9.99 (97.79)	31.77	8.33	2.37
30V92 No Weed and Insect Control	16.05(255.75)	14.37 (204.37)	7.79 (58.70)	10.80 (114.59)	38.41	7.52	2.27
30B11 PE atrazine 0.5 kg/ha + HW+ IC	7.55 (55.00)	8.14(64.34)	3.88 (13.04)	6.12 (35.48)	20.06	9.76	2.37
30B11 No Weed control and only IC	15.51 (238.44)	13.5 (182.38)	7.41 (52.92)	10.3 (105.35)	32.84	8.20	2.33
30B11 No Weed and IC	16.25(262.00)	15.05(224.47)	8.13 (64.14)	11.03 (119.61)	39.80	7.35	2.22
BIO9681 PE atrazine 0.5 kg/ha + HW+ IC	7.15 (49.14)	7.52(54.58)	3.74 (11.98)	6.23 (36.77)	34.47	8.00	1.94
BIO9681 No Weed and IC	14.69(213.70)	13.8 (189.93)	7.40 (52.71)	10.94 117.62)	49.87	6.12	1.85
CoHM5 PE atrazine 0.5 kg/ha + HW+ IC	7.83 (59.37)	8.32 (67.3)	4.08 (14.61)	6.75 (43.55)	39.96	7.33	1.78
CoHM5 No Weed and IC	16.38(266.19)	15.24(230.37)	8.52 (70.54)	11.8 (138.52)	58.39	5.08	1.53
LSD (P=0.05)	2.74	2.27	1.34	1.70	-	0.84	-

Values in parentheses are original. Data transformed to square root transformation; *HW- Hand weeding ; * IC- Insect control;

CONCLUSION

Post emergence spraying of potassium salt of glyphosate at 1800 g/ha in transgenic hybrid of 30V92 enhanced the control of broad spectrum weeds by keeping the weed density and dry weight reasonable at lower levels and increased productivity with higher grain yield

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Genetic variability in chickpea for tolerance to Imazethapyr

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In India, chickpea occupied an area of 9.51 m ha with a production of 8.83 mt during 2012-13 recording a productivity of 929 kg/ha. In recent years, production of chickpea is concentrated in central and southern parts of India. In Andhra Pradesh, the area under chickpea has increased dramatically from 71,000 ha in 1992-93 to 6.81 lakh ha during 2012-13. The success story of chickpea cultivation in Andhra Pradesh can be attributed to cultivation of high yielding varieties, matching production technologies coupled with mechanization of most of the field operations. However, in order make chickpea cultivation more profitable there is need to reduce cost of cultivation which increases net returns in chickpea cultivation. Manual weeding is currently the only option for weed control. If left uncontrolled, weeds can reduce chickpea yield significantly. Herbicide-tolerant cultivars offer opportunity of controlling weeds through need-based applications of herbicides. A study conducted at University of Saskatchewan in Canada identified several chickpea accessions tolerant to imidazolinone class of herbicides (Imazethapyr and Imazamox) (Taran *et al.* 2010). Hence present investigation was taken up to study extent of genetic variability for tolerance to Imazethapyr, a post emergence herbicide in chickpea.

METHODOLOGY

A field experiment was conducted during *Rabi* 2014-15 at Regional Agril. Research Station, Nandyal in collaboration with ICRISAT with 21 chickpea genotypes which were identified based on preliminary screening at ICRISAT-Patancheru, IIPR, Kanpur and PAU, Ludhiana. These genotypes were evaluated in randomized block design with three replications. A set of these entries were also grown in the adjacent block as untreated control plots. All the recommended management practices were followed for raising a healthy chickpea crop. Imazethapyr, a post emergence herbicide was sprayed at 75 g/ha on thirty days old crop and the herbicide tolerance was scored in a 1-5 scale at 10, 20 and 30 days after spraying and the average herbicide tolerance score was calculated. Highly tolerant genotypes with excellent plant appearance, no burning/ chlorosis of leaves were rated as 1. Genotypes with good plant appearance with minor burning/chlorosis of leaves were categorized as tolerant with score 2. Moderately tolerant genotypes with fair plant appearance with moderate burning/chlorosis of leaves were rated as 3. Sensitive genotypes (score 4) had poor plant appearance with severe burning/ chlorosis of leaves. Genotypes with complete burning of leaves were rated as highly sensitive (score 5)

Table 1. Tolerance to Imazethapyr, yield and yield attributes of ten chickpea genotypes

Entry no.	Entry	Herbicide Scoring	Days to 50% flowering	Days to maturity	No of Pri. Branches	No of Sec. Branches	Plant Height (cm)	100-seed weight (g)	Seed yield (t/ha)	
									Sprayed	Control
1	ICCIL 01034	2.5	52	91	4.7	15.4	46.8	36.8	4.64	4.59
2	ICCIL 01031	2.8	52	90	3.8	23.2	47.8	34.3	3.33	4.00
3	ICCV 10114	2.9	54	93	3.5	22.6	39.8	22.8	3.33	2.59
4	ICCIL 04016	2.7	56	95	4.2	23.8	41.4	18.8	3.31	2.39
5	ICCIL 04021	2.2	53	93	3.7	21.8	46.0	28.8	3.26	3.42
6	ICC 16141	2.7	55	94	4.0	23.6	38.4	16.5	3.14	2.67
7	ICCIL 04007	2.4	55	94	3.7	22.6	39.9	19.0	3.06	2.13
8	ICCV 08109	2.6	55	93	4.2	23.4	49.0	19.8	3.03	3.50
9	ICCV 08102	3.2	61	100	3.9	18.0	52.2	22.3	2.98	3.96
10	ICCIL 01026	2.6	53	91	4.6	17.5	44.9	35.3	2.77	4.36
Grand Mean		2.7	57	97	4.0	20.0	44.5	22.3	2.49	2.69
LSD (P=0.05)		-	3.6	2.3	NS	5.7	5.1	1.3	843	827

RESULTS

Variability was observed among 21 chickpea genotypes for herbicide tolerance score, yield and yield attributes. The herbicide tolerance score ranged from 2.2 (ICCIL 04021) to 3.2 (ICCV 08102) (Table 1).

Entries ICCIL 04021, ICCIL 04007, ICCV 97105, ICCV 10 and ICCIL 01034 were moderately tolerant to herbicide with scores ranging from 2.2-2.5. Entries ICCIL 01034 (4.64 t/ha), ICCIL 01031(3.33 t/ha) and ICCV 10114 (3.33 t/ha) and ICCIL 04016 (3.31 t/ha) and ICCIL 04021 (3.26 t/ha) were top yielding genotypes in herbicide sprayed plot with ~~a~~ herbicide sensitivity score of 2.5, 2.8, 2.9, 2.7 and 2.2, respectively. Among these, ICCIL 01034 ranked top (4.59 t/ha) in control plots. The performance of genotypes ICCIL 01031 (rank 3; 4.00 /tha) and ICCIL 04021 (rank 6; 3.42 t/ha) was also encouraging in control plots.

CONCLUSION

This study on screening of chickpea lines for tolerance to post emergence herbicide Imazethapyr has revealed the lines ICCIL 01034, ICCIL 01031 and ICCIL 04021 as moderately tolerant to the herbicide. Further screening over years and locations is suggested for standardizing the time and dosage of herbicide application.

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Cross-resistance of littleseedcanarygrassagainst alternativeherbicides in wheat and options for its management

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Littleseed canary grass (*Phalaris minor* Retz.) is a major weed of wheat in rice-wheat cropping system in north-western Indo-gangetic plains of India, which had evolved resistance against phenyl-urea herbicides like isoproturonin early 1990s.Alternative herbicides (clodinafop, fenoxaprop, sulfosulfuron and tralkoxydim) were recommended in 1998 for management of resistant *P. minor*. However, it was speculated well in advance that if newly introduced herbicides were not used properly, they could cause evolution of resistantbiotypes more rapidly than isoproturon. Dhawan*et al*. (2009) reported increase in GR_{50} values from 1999-2000 to 2006-07 in fenoxaprop, sulfosulfuron and clodinafopin a long term trialin Karnal. Hence, monitoring of cross-resistance in *P. minor* biotypes is essential to formulate our strategies for management of *P. minor*.

METHODOLOGY

Biotypes of *P. minor* were collected every year starting from 2007-08 and continued till 2014-15 from different parts of Haryana under rice-wheat cropping system. These biotypes were grown in potculture in the succeeding season at CCS Haryana Agricultural University, Regional Research Station, Karnaland were subjected to bioassay studies with graded doses of clodinafop, fenoxaprop (up to 2011-12), mesosulfuron + iodosulfuron (2012-13 onwards), sulfosulfuron and pinoxaden, at 2-4 leaf stage. Observations on per cent control were recorded at 30 days after treatment. Field experiments were also undertaken with different herbicides and their combinations at research farm of Regional Research Station, Karnaland at farmers' fields in Karnal district of Haryana during 2008-09 to 2012-13 to evaluate the herbicidal options.

RESULTS

The bioassay studies indicated that fenoxaprop was the least effective herbicide against highest number of biotypes, and it showed low efficacy (< 80% control) against all biotypes during 2009-10 (Fig. 1). Clodinafop was the second after fenoxaprop showing low efficacy against highest number of biotypes over the years, with all biotypes showing <80% control during 2010-11. However, its efficacy has been fluctuating over different seasons. Sulfosulfuron was the third herbicide in sequence showing poor efficacy against a number of biotypes, though its efficacy was also fluctuating over the years. Pinoxaden has been effective against most of the biotypes over the years, indicating its suitability in managing the resistant populations.Mesosulfuron + iodosulfuronwas also found effective against 75-90% biotypes during 2012-13 to 2014-15, and also be used against biotypes showing resistance against FOPs. Highest number of biotypes (60-100% biotypes) showed poor efficacy against one or more herbicides. It was followed by biotypes with low efficacy totwo or more (31-91%) and three or more (6-91%) herbicides. There were no biotypes showing low efficacy to all the four herbicides over the years, except two biotypes in 2008-09 and one in 2014-15.

The field experiments indicated that sequential application of pendimethalinor trifluralin1000 g/ha (pre-emergence) followed by clodinafop 60 g/ha orsulfosulfuron 25 g/ha (post-emergence) improved the control of *P. minor* over clodinafop or sulfosulfuron alone. Tank-mix of metribuzin105 g/ha with clodinafop 60 g/ha or sulfosulfuron 25 g/ha also provided effective control of *P. minor*. Pinoxaden 50 g/ha was also quite effective against *P. minor* in wheat.

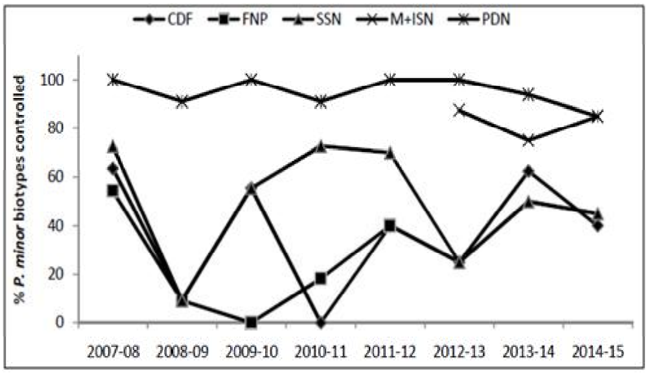

Fig. 1. *Phalaris minor* biotypes (% of total biotypes) controlled effectively (>80% control) by different herbicides (Clodinafop, CDF; Fenoxaprop, FNP; Sulfosulfuron, SSN; Mesosulfuron+iodosulfuron, M + ISN; Pinoxaden, PDN) under bioassay studies

CONCLUSION

Phalaris minor biotypes have evolved cross resistance against one or more herbicides under rice-wheat cropping system in Haryana. For management of this problem, sequential or tank-mix combination of herbicides is a viable alternative.

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Theme 7

Herbicide persistence and its impact in different ecosystems

Herbicidal effects on soil and crop health in cotton

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Use of herbicides has promised better weed management in cotton. But, in other hand, their indiscriminative use negatively correlates with the crop as well as soil health. Herbicidal spray may cause injury on the crop canopy leading to reduced crop growth and development. Similarly, herbicidal spray on the soil surface may hinder the soil microbial population and thus decreases the microbial activity in the soil. The study of herbicidal influence on these parameters gives an idea about compatibility of herbicide with crop, its lethal effect on soil microbes, and thus helps in herbicidal selection for better weed management. Crop phytotoxicty and soil dehydrogenase activity were evaluated as crop and soil health test parameters to understand compatibility of herbicides with cotton.

METHODOLOGY

The field experiment was conducted during *Kharif* 2012-13 at Agricultural College Farm, Bheemarayanagudi, Shahapur (Karnataka) under UKP Command area. The soil was medium deep black soil, medium in organic carbon (0.7%), low in available nitrogen (252 kg/ha), medium in available phosphorus (33 kg/ha P_2O_5) and high in potash (297 kg/ha K_2O). The experiment comprised of 14 treatments, *viz*. unweeded check (T_1), weed-free check (T_2), diuron 1 kg/ha pre-emergence (PRE) *fb* interculture (IC) and hand weeding (HW) at 30, 45 and 60 days after sowing (DAS) (T_3), pendimethalin 0.68 kg/ha PRE fb IC and HW at 45 DAS (T_4), propaquizafop 10 EC 0.1 kg /ha post-emergence (POE) at 20 and 40 DAS fb IC at 60 DAS (T_5), quizalofop-p-tefuryl 4.41 0.044 kg/ha POE at 20 and 40 DAS fb IC at 60 DAS (T_6), fenoxaprop-p-ethyl 9.3,0.1 kg/ha POE at 20 and 40 DAS *fb* IC at 60 DAS (T_7), quizalofop ethyl 0.05 kg/ha POE at 20 and 40 DAS fb IC at 60 DAS (T_8), pyrithiobac sodium 0.125 kg/ha POE at 20 and 40 DAS *fb* IC at 60 DAS (T_9), pendimethalin PRE *fb* propaquizafop 0.1 kg/ha POE at 30-35 DAS fb IC at 60 DAS (T_{10}), pendimethalin PRE *fb* quizalofop-p-tefuryl 4.410.044 kg/ha POE at 30-35 DAS fb IC at 60 DAS (T_{11}), pendimethalin PRE fb fenoxaprop-p-ethyl 9.30.1 kg/ha POE at 30-35 DAS fb IC at 60 DAS (T_{12}), pendimethalin PRE fb quizalofop-ethylkg/ha POE at 30-35 DAS fb IC at 60 DAS (T_{13}), and pendimethalinfb pyrithiobac sodium0.125 kg/ha POE at 30-35 DAS fb IC at 60 DAS (T_{14}). The experiment was laid out in a randomized complete block design with three replications. Cotton (cv. Arya *Bt*BG II) was sown on 10th July of 2012 with a spacing of 90 × 60 cm. The phytotoxicity injury ratings (Rao 1986) and dehydrogenase activity (Cassida *et al*. 1964) were analysed to study the effect of herbicides on crop and soil.

RESULTS

At 15 DAS, diuron1 kg/ha PRE recorded higher crop phytotoxicity (3.33) compared to pendimethalin 0.68 kg/ha (2.00) which progressively receded at 25 DAS. The effects still persisted with diuron than with pendimethalin, however from 35 DAS onwards there was more recovery and by 60 days none of such impacts were noticeable.

At 25 DAS, unweeded check and weed free check recorded the highest (21.34 µg and 21.07µg/g soil/day) amount of TPF formed. These were on par with all other treatments except treatments followed with pre-emergence herbicides. The least soil dehydrogenase activity (16.30 and 17.20 µg TPF/g soil/day) was noticed in recommended practice *i.e*. diuron1 kg/ha and pendimethalin 0.68 kg/ha. The highest soil dehydro-genase activity (22.96 µg TPF/g soil/day) was again noticed in weed free check at 45 DAS and it was on par with all other treatments. So no significant differences were observed among the treatments. The same trend was continued at 60 DAS and at 90 DAS with reduced activity.

Table 1. Crop phytotoxicity and soil dehydrogenase activityin cotton field as influenced by weed control treatments

Treatment	Crop phytotoxicity					Soil dehydrogenase activity (µg TPF formed /g soil/day)				
	15 DAS	25 DAS	35 DAS	45 DAS	60 DAS	25 DAS	45 DAS	60 DAS	90 DAS	At harvest
T_1 Unweeded Check	0.00	0.00	0.00	0.00	0.00	21.34	22.77	25.49	17.73	9.41
T_2 Weed free Check	0.00	0.00	0.00	0.00	0.00	21.07	22.96	25.04	17.28	8.32
T_3 Diuron fb IC and HW	3.33	2.00	0.00	0.00	0.00	16.33	21.88	24.14	17.11	9.61
T_4 Pendimethalin fb IC and HW	2.00	1.00	0.00	0.00	0.00	17.55	21.80	24.24	17.14	9.28
T_5 Propaquizafop (Twice) fb IC	0.00	1.00	0.33	0.33	0.00	20.80	21.77	21.59	17.05	8.75
T_6 Quizalofop p tefuryl (Twice) fb IC	0.00	0.67	0.33	0.00	0.00	20.57	22.30	24.03	17.05	8.39
T_7 Fenoxaprop p ethy (Twice) fb IC	0.00	1.00	0.67	0.33	0.00	20.75	21.88	24.15	17.23	9.41
T_8 Quizalofop ethyl (Twice) fb IC	0.00	1.00	0.67	0.33	0.00	20.12	22.06	25.29	17.37	8.26
T_9 Pyrithiobac sodium (Twice) fb IC	0.00	1.33	0.33	0.00	0.00	20.08	22.96	25.08	17.42	8.88
T_{10} Pendimethalin fb Propaquizafop fb IC	2.00	1.33	0.67	0.33	0.00	17.56	22.07	24.75	17.01	9.10
T_{11} Pendimethalin fb Quizalofop p tefuryl fb IC	2.00	1.33	0.33	0.33	0.00	17.62	21.84	24.88	17.48	8.25
T_{12} Pendimethalin fb Fenoxaprop p ethyl fb IC	1.67	1.33	0.67	0.00	0.00	17.80	22.04	24.21	17.38	8.63
T_{13} Pendimethalin fb Quizalofop ethyl fb IC	1.67	1.33	0.67	0.33	0.00	17.34	22.35	23.91	17.24	8.60
T_{14} Pendimethalin fb Pyrithiobac sodium fb IC	1.67	1.33	0.00	0.33	0.00	17.20	21.94	24.32	17.21	8.62
LSD (P=0.05)						1.51	1.27	1.46	1.36	1.00

CONCLUSION

Herbicides did not show any recognizable phytotoxicity symptoms on cotton. Only pre-emergence herbicides had little injurious effect initially below the threshold level from which the crop recovered later. Similarly, soil dehydrogenase activity was also not affected by post-emergence herbicides, while only pre-emergence herbicides initially caused temporary decrease in the activity and was recovered in later days.

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Determination of herbicide persistence by bioassay technique in garlic

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Garlic (*Allium sativum* L.) is the most important spice & condiment crop of Saurashtra region of Gujarat in India. Yield losses in garlic were up to 94.8% due to weed competition during the whole crop cycle (Anonymous 2009). Day by day weed control through herbicides is increasing and popularizing among farmers. Bioassay is a major tool for quantitative and qualitative determination of herbicide persistence/residues where the indicator plant is grown in a field and pot and is compared with that of similar plant grown in untreated soil.

METHODOLOGY

A field experiment was carried out during *Rabi* seasons 2007-08 and 2008-09 at Junagadh Agricultural University on medium black clayey soil. The experiment comprising of 10 weed management treatments (Table 1) was laid out in a randomized block design with four replications. Pre-emergence (PE) and post-emergence (POE) application of herbicides were made using spray volume of 500 l/ ha on the next day of sowing and at 60 days after sowing (DAS), respectively. In bioassay, plastic pots of (20 cm dia x 10 cm ht) were used for raising sorghum[a] and cucumber as indicator plants. Pots were filled with 500 g soil sample taken from each plot at 0-15 cm depth. Counted seeds were sown in each pot for different tests. Water was applied as and when required. Numbers of plants were counted at 10 DAS from each pot and converted in to the per cent basis. The randomly selected five plants from each pot were dried in the oven at 65 $\pm$ 5^{0}C till the constant weight.

RESULTS

The weed flora of experimental site was mainly consisted of *Echinochloa colona* L**.** Beauv., *Brachiaria* sp., *Chenopodium album* L., and *Cyperus rotundus* L. As compared to unweeded check, the magnitude of reduction in weed density varied from 81% under 1 HW at 25 DAS + oxadiargyl 90 g/ha POE at 60 DAS to 93% under oxyfluorfen 240 g/ha PE + 1 HW at 40 DAS, while, reduction in dry weight of weeds was from 24% under oxyfluorfen 240 g/ ha PE + oxadiargyl 90 g/ha POE at 60 DAS to 47% under oxyfluorfen 240 g/ ha PE + 1 HW at 40 DAS.

Application of herbicides significantly increased the bulb yield as compared to unweeded check. The magnitude of increase in bulb yield was 386% under 1 HW at 25 DAS + oxadiargyl 90 g/ha POE at 60 DAS to 869% under oxyfluorfen 240 g/ha PE + quizalofop-ethyl 40 g/ ha POE at 60 DAS. This increase in bulb yield was 979% under weed free check over unweeeded check.

Table 1. Effect of t herbicides on bioassay parameters of sorghum and cucumber at 30 DAS as well as weed and yield of garlic (Pooled over two years)

Treatment	Sorghum		Cucumber		Weed density (no.s/m^2)	Dry weight of weeds (g/m^2)	Bulb yield (t/ha)
	Germi nation (%)	Dry matter (g/five plant)	Germi-nation (%)	Dry matter (g/five plant)			
Oxyfluorfen 240 g/ha PE + 1 HW at 40 DAS	47.50	0.17	55.00	0.21	5.89 (41)	246	6.06
Oxadiargyl 90 g/ha PE+ 1 HW at 60 DAS	75.00	0.36	50.00	0.16	9.02 (96)	304	5.76
1 HW at 25 DAS + Oxadiargyl 90 g/ha POE at 60 DAS	83.75	0.39	83.75	0.53	10.59 (116)	350	4.63
1 HW at 25 DAS + Quizalofop-ethyl 40 g/ha POE at 60 DAS	81.25	0.40	83.75	0.55	9.79 (98)	309	5.32
1 HW at 25 DAS + Fenoxaprop-p-ethyl 75 g/ha POE at 60 DAS	83.75	0.42	82.50	0.54	10.07 (115)	329	5.14
Oxyfluorfen 240 g/ha PE + Oxadiargyl 90 g/ha POE at 60 DAS	43.75	0.18	52.50	0.20	8.59 (79)	354	5.28
Oxyfluorfen 240 g/ha PE + Quizalofop-ethyl 40 g/ha POE at 60 DAS	46.25	0.19	53.75	0.19	6.92 (56)	306	6.53
Oxyfluorfen 240 g/ha PE + Fenoxaprop-p-ethyl 75 g/ha POE at 60 DAS	43.75	0.18	53.75	0.20	7.50 (61)	319	5.48
Weed free	85.00	0.43	87.50	0.58	0.71 (0)	0	7.27
Unweeded check	82.50	0.38	82.50	0.51	24.12 (606)	465	0.67
LSD(P=0.05)	8.36	0.03	7.05	0.03	5.55	45	0.54

Data of weed density have been transformed to x =05 and figures in parenthesis are original values

The results of bioassay study revealed that there was significant persistence effect of oxyfluorfen 240 g/ha pre-emergence on sorghum as well as cucumber at 30 DAS and oxadiargyl 90 g/ha pre-emergence on cucumber at 30 DAS. However, persistence effect of these pre-emergence herbicides on sorghum and cucumber were disappeared at 60 DAS. The results also showed (data not given) that there was no any persistence effect of post emergence herbicides application done at 60 DAS.

CONCLUSION

Pre-emergence application of oxyfluorfen 240 g/ha and oxadiargyl 90 g/ha showed significant persistence effect up to 30 DAS, though it disappeared at 60 DAS. Post-emergence application of oxadiargyl 90 g/ha, quizalofop-ethyl 40 g/ha and fenoxaprop-p-ethyl 75 g/ha at 60 DAS did not show any significant persistence effect in garlic as indicated from sorghum and cucumber bioassay.

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Impact of low-dose herbicides on soil enzyme dynamics in dry direct-seeded rice

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In response to the problem of acute water scarcity and labour shortage at the peak time of crop establishment, dry direct seeding of rice (DDSR) has emerged as a viable option to combat the rising production costs and shortage of water and labour. However, weeds are the major biological constraints in dry seeded rice because of the absence of stagnant water and use of low doseherbicides isbecoming prevalent. This necessitates the need to assess the risk of herbicide persistence in soil. Soil enzyme activity is an indication of microbial activity which is an integral part of soil environment. The dehydrogenase enzyme activity is commonly used as an indicator of biological activity in soils and this enzyme is considered to exist as an integral part of intact cells but does not accumulate extra cellular in soil. The present study was conducted to find out the effect of low dose herbicides on soil enzymes.

METHODOLOGY

The field experiment was conducted during *kharif* 2014 by dry direct seeding of rice (var. Uma) in randomized block design with three replications. The herbicides used were bensulfuron methyl + pretilachlor, pyrazosulfuron ethyl (pre-emergence) and azimsulfuron (post-emergence) along with a traditional herbicide oxyfluorfen. Pre-emergence herbicides were applied one day after sowing on to the surface of soil using knap-sack sprayer with flood jet nozzle while post-emergence herbicides were applied at 25 DAS on the weed flora. The soil samples were taken before and 15, 30, 45 and 60 days after sowing (DAS) for determining dehydrogenase and urease enzyme activity. Soil samples (0-15cm depth)were taken at 15 and 30 DAS. Procedure of Casida*et al.* (1964) was used for the determination of dehydrogenase.Urease in soil was determined following the method described by Broadbent *et al.* (1964). The dehydrogenase and urease enzyme activities expressed as triphenylformazanhydrolysed (µg)/g of soil per 24 hr as influenced by herbicide treatments are presented in Table 1.

RESULTS

The dehydrogenase activity was significantly higher at 45 DAS compared to other time of plant growth viz., 15, 30 and 60 DAS. This might be due to the spurt in microbial population

Table 1. Dehydrogenase enzyme activity as influenced by herbicide treatments

Treatment	Dehydrogenase enzyme activity (TPF (µg)/g soil per 24 hr)			
	15 DAS	30 DAS	45 DAS	60DAS
T_1: Bensulfuronmethyl + Pretilachlor at 60 + 600 g/ha	129.64	182.58	205.83	198.69
T_2 : T_1 + hand weeding at 40 DAS	136.18	179.84	354.69	282.27
T_3: T_1 + Azimsulfuron at 30 g/ha as (post- emergence)	150.09	233.97	232.99	127.13
T_4: Pyrazosulfuron ethyl at 25 g/ha as (pre – emergence)	172.96	246.96	567.84	256.58
T_5: T_4 + hand weeding at 40 DAS	174.11	131.67	540.68	370.24
T_6 : T_4 + Azimsulfuron at 30 g/ha	180.14	83.49	159.93	242.19
T_7 : Oxyfluorfen at 0.15 kg/ha	275.47	155.94	230.45	295.82
T_8 : T_7 + hand weeding at 40 DAS	239.88	123.69	429.05	336.46
T_9: T_7 + Azimsulfuron at 30 g/ha	290.94	99.45	236.50	316.12
$T_{10:}$ hand weeding at 20 and 40 DAS	229.61	177.39	326.52	313.35
$T_{11:}$ weedy check	168.99	235.8	410.29	294.92
LSD (P=0.05)	5.43	30.52	9.27	9.86

with the addition of exudates or rhizodeposition during the growth stages *i.e.* up to 45 days. Since dehydrogenase is an endoenzyme,its activity is maximum at the active growth stage of plant. The highest activity of dehydrogenase recorded at 45 DAS irrespective of the treatment may be due to the fact that it corresponds to the active growth stage of the crop and there is enhanced rhizosphere activity coupled with higher moisture content of soil after commencement of flooding from 40 DAS in semi dry rice. The urease enzyme activity was not inhibited by any of the herbicide treatments. Higher values of urease activity was recorded at both 15 and 30 DAS and the higher urease enzyme activity might be attributed to the higher amount of substrate availability during these stages.

CONCLUSION

Study revealed that herbicides either used as pre-emergence or post-emergence remains in the active top soil and cause alternations in soil enzyme activities on different days after treatments.The treated herbicides affect the soil enzyme activity but none of them registered highly negative effect on soil enzyme activity.

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Transformation products of 2,4-D ethyl ester in rice field and potential for environmental contamination

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Herbicide use in agriculture particularly in rice (*Oryza sativa* L.) production is connected with the soil and water source contamination and have been studied exhaustively for the past two decades in order to find out the contamination potential of different herbicides. Until recently, the research is mostly concentrated at the active parent compounds, though transformed products may also be toxic and has potential to pollute the environment. 2,4-D is the dominant herbicide used across the globe and in India which is commercialized as salt, amine and ester formulations and has post-emergence action. Due to its high solubility in water,it is easily transferred to the groundwater and might contaminate the water sources under rice ecosystem (Primel *et al.* 2005). Hence, periodical and continuous monitoring of the active compoundand its degradation products in the rice ecosystem is vital to evaluate the risk to the soil environment.

METHODOLOGY

A field experiment with rice as a test crop was conducted during *kharif* 2012 and the herbicide 2,4-D 38% EC was applied at two different levels as post-emergence on 14 days after transplanting. Soil and water samples were collected from the field at periodic intervals from 0 day after herbicide application (DAHA) until harvest to study the transformation of 2,4-DEE to 2,4-D-acid and metabolites. The residues were extracted using acetonitrile + distilled water+acetic acid (80+19+1: v/v), partitioned with 50% aqueous Na_2CO_3 and hexane; and cleaned up using anhydrous Na_2SO_4. Extracted solvent was evaporated to dryness and residuesredissolved in acetonitrile for HPLC-DAD analysis.The metabolites were confirmed by the GC-MS.

RESULTS

The results of the study are presented in Table 1. While the residue of 2,4-D acid was detected in the field water on 0 DAHA onwards, it was detected in soil from 1 DAHA only. Owing to the very rapid degradation of the 2,4-D esters in water by hydrolysis, the primary breakdown product detected in soil on 1st day is 2,4-D acid. While 2,4-D acid was detected in soil up to 7 days, 2,4-Dichlorophenol (2,4-DCP) was detected only up to5thday. This might be due to the easy breakdown of 2,4-DCP by anaerobic aquatic metabolism into carbon dioxide. Unlike the soil, the 2,4-D was detected in field water from 0 to 7 day and similar result was found with the 2,4-DCP also, however it was not detected on 0 day.The maximum quantity of 2,4-D was detected on 3rdday in soil (0.053-0.067 mg/kg) while it was on 1st day in field water. Similarly the highest concentration of 2,4-D was recorded on 1st and 3rd day after application in field soil and water respectively.

Table 1. Residues of 2,4-D and metabolitein rice grown field soil and water

Days after herbicide application	Residue in field soil (mg/kg)				Residue in field water (mg/L)			
	2,4-D		2,4-Dichlorophenol		2,4-D		2,4-Dichlorophenol	
	1 kg/ha	2 kg/ha	1 kg/ha	2 kg/ha	1 kg/ha	2 kg/ha	1 kg/ha	2 kg/ha
0	BDL	BDL	BDL	BDL	0.112	0.132	BDL	BDL
1	0.0076	0.0122	0.0178	0.0251	0.018	0.046	0.015	0.019
3	0.0533	0.0670	0.0123	0.0153	0.016	0.028	0.027	0.036
5	0.0230	0.0235	0.0074	0.0091	0.011	0.019	0.019	0.021
7	0.0072	0.0091	BDL	BDL	0.003	0.014	0.011	0.014
10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Halflife (d)	1.73	1.74	2.71	2.73	1.77	2.16	2.79	2.94
R^2	0.984	0.960	0.999	0.991	0.716	0.793	0.999	0.979

Tomlin C D S 2006.The Pesticide Manual: A World Compendium, 14th ed.; British Crop Protection Council: Surrey, UK.

BDL: Below detectable level Give figure of detection Limit Dissipation of both the metabolites were studied from the highest concentration and found that it followed first order reaction kinetics with the significant correlation in soil only (Table 1). The mean half- life of 2,4-D in field soil and water is 1.7 and 2.7drespectively which is lower than that for 2,4-DCP (2.0 and 2.9 d respectively for field soil and water). Similar half- life of 1 day for 2,4-D acid was reported by the Tomlin (2006) , who also reported the half-life in hrs when pH of the water is 8.0 or more. Higher half- life of 2,4-DCP than 2,4-D acid shows that the side chain cleavage of 2,4-D to form 2,4-DCP is a continued process until the availability of source and 2,4-DCP is the major metabolite of 2,4-DEE applied in rice grown soil with pH of 8.0 and above.

CONCLUSION

The present study suggests that the 2,4-dichlorophenol is the major persistent metabolite of 2,4-DEE in rice grown soil and field water with pH of 8.0 and above. Hence, its monitoring in environment is vital to circumvent the contamination of surface and ground water.

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Persistence of penoxsulam in soil and its terminal residues in rice

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Rice (*Oryza sativa* L.) is the most important staple food for about 50 per cent of the world's population that lives in Asia and a worldwide research on rice is continuing to enhance the production and productivity of the crop. A major production constraint in rice cultivation is the weed control and is managed with chemicals. Asia accounts for vast majority of the global rice herbicide market and this share will continue to grow, since the multinational agrochemical companies will be looking to take advantage of a more liberal trading climate in Asia. Hence, the inappropriate and indiscriminate use of herbicides may cause the environmental contamination through longer persistence. With this background, the present study was undertaken to study the persistence of penoxsulam in soil and its terminal residues in rice as influenced by the time of application.

METHODOLOGY

Field experiment with rice (var. ADT 43) was conducted during *Kharif* 2013 and the herbicide Penoxsulam 21.7% SC was applied at two different doses as post emergence on 14 days after transplanting. Soil and plant samples were collected from the field at harvest for persistence and residue study. Extraction of penoxsulam residue was done using acidified acetonitrile: methanol (1:1 v/v) in an ultrasonic apparatus for 30 min. After sonication, 1.8 g $MgSO_4$ and 2 g of Na acetate was added and mixed well using vortex mixer and the sample suspension was centrifuged 5000 rpm for 5 mins. The supernatant was decanted, filtered and dried in rotary vacuum evaporator and the residue was re-dissolved in HPLC grade acetonitrile for LC-DAD analysis at λ_{max} 280 nm. Recovery studies were made using spiked samples of soil and water samples collected from control treatment. The blank soil and plant reference was used to establish the limit of quantification.

RESULTS

The results of the study are presented inTable 1.The average recovery of penoxsulam from soil, rice straw, grain and husk was 88.8, 85.7, 87.9 and 86.0 per cent, respectively. Limit of detection and quantification of penoxulam is 0.008 and 0.01 µg/g respectively in all the matrices. Irrespective of the quantity of application, the penoxsulam residues were not detected in the rice straw, grain and husk at the time of harvest. The residue were below the detection limit of 0.01 µg/g, which is within the tolerance level (0.01 µg/g) proposed for penoxsulam in rice (EFSA, 2008). Though the residue of penoxsulam was not detected in the soil at 22.5 g ai ha^{-1}, it was detected in field soil (0.041µg/g) at harvest when it was applied at 50.0 g/ha. Since the penoxsulam is broken down in the water by light and microbes and has a half-life ranging from about 12 to 38 days (USEPA, 2004), its residue detected in the field soil is below 0.05 µg/g. Since, the penoxsulam doesn't bind to soil sediments, leaching[a] to ground water through soil is likely, the continuous and indiscriminate use of this herbicide may be circumvented which otherwise could lead to accumulation of penoxsulam residues in the soil environment.

Residual effect of imidazolinone herbicides applied in greengram on succeeding Indian mustard

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Among the main features of imidazolinone group of herbicides, the residual activity in soil is highlighted, and its persistence in soil depends on several environmental and edaphic properties (Kraemer *et al*. 2009). Persistence is undesirable, when it results in injury to crops planted in succession or rotation, or when there is risk for the residues to cause environmental contamination.Imidazolinone herbicides*viz*. imazethapyr, premix of pendimethalin + imazethapyr, premix of imazethapyr+imazamoxare are able to check the emergence and growth of annual weeds in greengram(*Vigna radiata L.*) [Chhodavadia*et al*. 2013]. This study was undertaken to find out the residual effect of imidazolinone herbicides on succeeding mustard/raya (*Brassica juncea L.)* crop when applied alone or as ready-mix/ pre-mix in greengram.

METHODOLOGY

The experiment was conducted at Punjab Agricultural University, Ludhiana (Punjab) during *rabi* 2013-14. The soil was loamy sand with normal pH and E.C., low in O.C. and available N; and high in available P and K. Treatments applied to greengram crop included pendimethalin 1000 g/ha, pre-mix of imazethapyr + pendimethalin 800, 900 and 1000 g/ha both as pre-emergence; imazethapyr 50, 70 g/ha, pre-mix of imazethapyr + imazamox 60, 70 g/ha both applied at 20 DAS; weed free (hoeings at 20, 40 DAS) and weedy in RCBD with 3 replications. Raya cv. RLC 1was sown with hand drill at 30 cm row to row spacing with seed rate of 3.75 kg/ha after seed bed preparation. Recommended package of practices for crop cultivation was followed. The data on weed dry matter, crop growth, yield attributes and yield was observed and analysed using statistical measures.

RESULTS

Phalaris minor, Avena ludoviciana, Rumex dentatus, Medicago denticulata, Coronopus didymus, Chenopodium album, Malva parviflora, Oenotherala ciniata were the major weeds in the experimental field. All pre- and post-emergence herbicides, *viz*. imazethapyr, imazethapyr + imazamox, imazethapyr + pendimethlain and pendimethalin, applied to preceding green gram at variable doses, did not show any residual effects on any of grass and broadleaved weeds in succeeding Indian mustard crop. All the weed control treatments used in green gram did not show any residual effects on germination, growth and seed yield of succeeding Indian mustard crop, indicating that all these herbicides could be adopted for weed control in greengram-Indian mustard based cropping sequences. Application of pendimethalin 1.0 kg/ha as pre-emergence and imazethapyr + imazamox 60 g/ha as post-emergence to preceding greengram recorded the highest B:C ratio in the succeeding mustard crop.

Table 1. Residualeffect of herbicides applied in greengram on weed dry matter, growth, yield attributes and yield of succeeding *raya*crop (*rabi* 2013-14)

Treatment (applied to preceding green gram crop)	Dose (g/ha)	Weed dry matter (g/m^2) at 40 DAS[a]		Plant height at harvest (cm)	Branches / plant	Seed yield (t/ha)	B:C[b]
		Grasses	BLW				
Pendimethalin	1000	6.4 (41)	12.2 (150)	227.7	6.7	1.750	2.518
Imazethapyr	50	6.6 (43)	12.7 (160)	225.0	7.0	1.416	2.074
Imazethapyr	70	6.9 (48)	14.3 (205)	227.7	6.7	1.484	2.222
Imazethapyr + pendimethalin	800	8.0 (66)	12.2 (153)	226.7	6.7	1.609	2.370
Imazethapyr + pendimethalin	900	7.9 (62)	13.1 (172)	230.7	7.3	1.366	2.074
Imazethapyr + pendimethalin	1000	6.8 (46)	12.0 (145)	219.3	6.6	1.572	2.370
Imazethapyr + imazamox	60	7.0 (48)	13.3 (178)	236.0	7.7	1.691	2.518
Imazethapyr + imazamox	70	8.1 (64)	11.8 (139)	227.0	6.7	1.576	2.370
HW at 20, 40 DAS	-	8.6 (72)	13.2 (177)	223.0	6.3	1.384	2.074
Weedy check	-	7.4 (54)	14.3 (209)	226.0	7.0	1.591	2.370
LSD (P=0.05)	-	NS	NS	NS	NS	NS	-

a- Figures in parenthesis are original means. Data is subjected to square root transformation; b- MSP of raya:Rs. 30/kg

CONCLUSION

Application of imazethapyr alone or its pre-mix with pendimethalin/imazmox in greengram is safe to succeeding crop of raya. Kraemer AF, Marchesan E , Avila LA, Machado SLO and http://dx.doi.org/10.1590/S0100-83582009000300025

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Residual effect of pre- and post- emergence herbicides on succeeding crops of soybean

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Weeds are the foremost biotic constraints in enhancing productivity of soybean and take yield losses ranging from 20-89% (Dubey 2002). Presently a number of herbicides are commercially available for weed control in soybean. Under chemical method of weed management, the rotation of herbicides is more essential to prevent the weeds to develop resistance to herbicides.Currently soybean accounts for 4 percentage of total herbicide consumption. In India, the average usage of herbicide is 40 g/ha per year compared to 675-1350 g/ha per yearin many advanced countries (Das *et al*. 2012). Residual toxicity of herbicides on the succeeding crops is the main constraint in the use of chemical weed control. Keeping above facts in views, the present work was done to study the residual effect of herbicides on succeeding crops of soybean.

METHODOLOGY

Field experiments was conducted at the Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University, during *kharif* 2012 to evaluate the new formulation of sulfentrazone 48% F and clomazone (FMS) 50 EC on weed control in soybean and their residual effect on succeeding crops. Fourteen treatments consisting of pre-emergence application of sulfentrazone at 240, 300, 360, 480 and 720 g/ha and clomazone at 750, 1000, 1250 and 2000 g/ha were compared with recommended PE pendimethalin at 750 g/ha and POE imazethapyr at 100 g/ha, hand weeding and mechanical weeding by twin wheel hoe weeding. For all herbicidal treatments, hand weeding was given on 40 DAS. The experiment was laid out in randomized block design and replicated thrice without disturbing the plot, the same layout was used for raising the subsequent residual crops. Soybean variety CO (Soy) 3 released by TNAU was used for the study. The possible residual toxicity of the herbicides used was studied by raising the commonly grown garden land crops *viz*., sunflower (CO 4) and pearl millet (CO(Cu 9)) as succeeding crops during *Rabi* 2012-13.The effect of herbicides was observed by studying the growth characters such as germination, DMP and yield.

RESULTS

The succeeding residual crop of sunflower and pearl millet exhibited residual effect for the applied herbicide in soybean. This indicated that the residual amount of herbicides which remains in soil had adverse effect on germination of succeeding crops. Lower dry matter production and seed yield of sunflower (Table 1) was recorded with sulfentrazone at 720 g/ha and clomazone at 2000 g/ha applied as pre emergence Pre- emergence application of pendimethalin at 750 g/ha recorded higher germination per cent, dry matter production and seed yield and it was comparable with sulfentrazone at 240 and 300 g/ha.

Table1. Residual effect of herbicides on germination, dry matter production and yield of succeeding crops

Treatment (g/ha)	Germination (per cent) at 10 DAS		DMP (t/ha) at 60 DAS		Sunflower	Pearl millet
	Sunflower	Pearl millet	Sunflower	Pearl millet	Seed yield (kg/ha)	Grain yield (kg/ha)
PE Sulfentrazone - 240	84.1	80.8	3.23	1.28	1.51	2.21
PE Sulfentrazone - 300	85.5	78.6	3.17	1.27	1.45	2.13
PE Sulfentrazone - 360	78.5	75.8	3.15	1.26	1.39	2.10
PE Sulfentrazone - 480	74.1	74.7	3.13	1.26	1.33	2.06
PE Sulfentrazone - 720	64.9	62.7	2.80	1.03	1.14	1.59
PE Clomazone - 750	86.4	86.4	3.36	1.40	1.56	2.57
PE Clomazone -1000	85.9	84.3	3.28	1.39	1.47	2.54
PE Clomazone - 1250	81.2	81.6	3.20	1.24	1.43	2.04
PE Clomazone - 2000	69.3	61.3	2.83	1.13	1.23	1.68
POE Imazethapyr - 100	88.0	85.8	3.39	1.42	1.63	2.55
PE Pendimethalin - 750	86.7	84.2	3.38	1.36	1.59	2.57
HW on 20 and 40 DAS	85.2	86.9	3.37	1.35	1.62	2.67
TWH on 20 and 40 DAS	86.4	83.5	3.37	1.35	1.55	2.54
Unweeded control	83.3	82.1	3.31	1.35	1.55	2.53
LSD (P=0.05)	-	-	0.29	0.15	0.17	0.26

Pre emergence application of sulfentrazone at 240 to 720 g/ha registered lesser grain yield (Table 1) of pearl millet whereas, clomazone at higher dose (2000 g/ha) alone affected the yield of succeeding pearl millet. This might be due to higher concentration of sufentrazone and clomazone persist in the soil for a long time causing injury to succeeding sunflower and pearl millet. Higher grain yield (2.67 t/ha) of pearl millet were recorded in hand weeding plot. This result is in line with the outcome of Jelena *et al*. (2012) who found thatsulfentrazone affected millet and oat development.

CONCLUSION

It can be concluded that pre emergence application of of sulfentrazone at 480 g/ha with one HW on 40 DAS showed residual effect on succeeding pearl millet and not affected by the sunflower.

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Effect of herbicides application on dehydrogenase activity

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Herbicides are one of the important monitory input in the crop production. These are using in large quantities in modern agriculture to control undesirable plant community in the field. Increased application of herbicides leads to increased chemical concentrations in soil, altered soil reactions, and potential adverse effects on non-target organisms [Perucci and Scarponi, 1994]. Research suggests that repeated and high quantity of herbicide application may involve a risk of reduced or altered soil microbial and enzyme activities. Under this circumstance, the present study was undertaken to identify the effect of herbicide application on soil enzyme activity.

METHODOLOGY

Field experiment was conducted during *Kharif* 2012 to study the effect of herbicide application on soil enzyme activity. The experiment was laid out in randomized block design with three replications. The treatments comprised of different herbicides and manual weeding, *viz*. Early Post-emergence (EPOE) bispyribac-sodium 25 g/ha,pre emergence(PE) pretilachlor 1000 g/ha, Post-emergence (POE) admixture of chlorimuron ethyl 10% + metsulfuron methyl 10% 4 g/ha, POE ethoxysulfuron (750/18.75) g/ha, manual weeding and unweeded control. These herbicides were applied in different combinations as shown in the Table 1. The soil enzyme, *viz*. dehydrogenase was estimated using dry soil, $CaCO_3$, 2, 3, 5 - triphenyl tetrazolium chloride and methanol. The concentration of dehydrogenase in the sample was obtained from the standard graph drawn by using Tri Phenyl Formazan (TPF) as standard, and expressed as µg of TPF released per g soil on dry weight basis (Casida *et al.* 1964).

RESULTS

Results The experimental results revealed that the dehydrogenase enzyme activity in the rice soil had significant variations in the weed control treatments adopted .The highest dehydrogenase enzyme activity was recorded in unweeded control treatment (118.80 µg) and it was comparable with hand weeding twice (111.54 µg) and closely followed by PE pretilachlor 750 g/ha *fb* POE admixture of chlorimuron ethyl 10% + metsulfuron methyl 10% at 4 g/ha (Table 1). Among different herbicide treated plots, PE pretilachlor 750 g/ha *fb* POE admixture of chlorimuron ethyl 10% + metsulfuron methyl 10% (4 g/ha) recorded maximum dehydrogenase activities (93.16 µg). This might be due to less toxicity of herbicide molecules to microbes. Dehydrogenase is thought to be an indicator of overall microbial activity, because it occurs intercellular in all living microbial cells and is linked with microbial oxydo reduction processes. [Wang *et al.* 2008].

Table 1. Effect of herbicides on dehydrogenase in transplanted rice

Method of Application-HerbicideTreatment	Rate of application (g/ha)	µg TPF released g dry weight of soil at 25 DAT
EPOE - Bispyribac Sodium	25	71.79
PE – Pretilachlor	1000	74.79
POE - Admixture of Chlorimuron and Metsulfuron	4	68.38
PE - Pyrazosulfuron-ethyl	20	55.98
EPOE - Bispyribac Sodium + Ethoxysulfuron (tank mixture)	25 + 18.75	72.65
EPOE - Bispyribac Sodium + Admixture of Chorimuron and Metsulfuron (tank mixture)	20 + 4	64.96
PE - Pretilachlor fb POE Ethoxysulfuron	750 / 18.75	85.47
PE - Pretilachlor fb POE Admixture of Chlorimuron and Metsulfuron	750 / 4	93.16
PE - Pyrazosulfuron-ethyl fb Hand weeding at 25 DAT	20	71.79
PE - Admixture of Pretilachlor + Bensulfuron methyl	660	61.97
Hand weeding twice at 25 and 45 DAT	-	111.54
Weedy check	-	118.80
LSD (P=0.05)		2.67

EPOE - Early post-emergence (15 DAT); POE - Post-emergence (25 DAT); PE - Pre-emergence (3 DAT)

CONCLUSION

Based on the results of experiment, it was concluded that application of PE pretilachlor 750 g/ha *fb* POE admixture of chlorimuron ethyl 10% + metsulfuron methyl 10% (4 g/ha) recorded maximum dehydrogenase activities in different herbicide applied rice soil.

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Effect of weed management practices on soil health under rice-wheat cropping system

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The rice-wheat cropping system of India is vital for food security. It contributes more than 70% of total cereal production in India (Singh and Kaur 2012). The weed management practices could hardly affect the soil health but may brought changes in soil (Pandey *et al.* 2007) when applied in rice- wheat cropping system. The information on effect of weed management practices on soil health are rather meagre. Thus, an attempt was made to find out the"effect of weed management practices on soil health of rice and wheat under rice-wheat cropping system".

METHDOLOGY

The field experiment was conducted during *Kharif* and *Rabi* season of 2013-14 at Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) to study the "effect of weed managementpractices on soil health of rice and wheat under rice- wheat cropping system". The soil at the test site was silt loam with pH 8.12,EC 0.23 dS/m, OC 0.32% , bulk density 1.45 g/cc, available N, P and K 180.4 17.5 and 262 kg/ha, respectively. The experiment was laid out in split plot design, keeping kharif season treatments in main plot (weedy check, 2HW, butachlor at 1.5 kg/ha) and *Rabi* season in sub plot (weedy check, 2 HW, isoproturon 0.1 kg/ha + 2,4D Na salt 0.5 kg/ha). The rhizospheric soil samples were collected randomly from each plot at harvest stage of crop and analyzed for various physico-chemical and microbial parameters as influenced by various treatments.

RESULTS

Weed control treatments applied during rabi and kharif season did not show any significant effect on bulk density, pH, EC and organic carbon in the soil at harvest stage (Table 1). However, on microbial properties i.e. free living N fixing bacteria (FLNB), phosphate solubilizing bacteria (PSB), soil respiration (SR), alkaline-P, acid-P and dehydrogenase activity (DHA) showed significant effect between the treatments at harvest stage during rabi and kharifseasons. At harvest maximum FLNB (15.5 and 16.3 cfu × 10^4/g), PSB (11.5 and 13.0 cfu × 10^4/g), SBC (125.5 and 131.3), SR (0.30 and 0.35 mg CO_2/ 100 soil.d), acid-P (105 and 90.6 µgp-NP/h/g), alkaline-P (175 and 165.8 µp-NP/h/g) and DHA (0.37 and 0.35 µg TPF/h/g) were recorded under two hand weeding treatment (K_1 and R_1) during Kharif and Rabi seasons, respectively. This was mainly due to hand weeding, sunlight and aeration effect. Hand weeding also allowed to facilitate the growth of micro organism. Further results revealed that butachlor and isoproturon applied in rice and wheat,respectively, did not causeany harmful effect on soil health.

Table 1. Effect of different treatments on soil health of rice and wheat under rice –wheat cropping system at harvest stage

Treatment	Soil health										
	BD (g/cc)	pH (1.25)	EC (dS/m)	OC (%)	FLNFB	PSB	SBC	SR	Acid-P	Alk-P	DHA
Kharif											
K_0 = Weedy	1.47	8.30	0.22	0.33	11.3	8.3	120.5	0.25	87.2	167.5	0.25
K_1 = HW (2)	1.47	8.30	0.21	0.35	15.5	11.5	125.5	0.30	105.0	175.0	0.37
K_2 = Butachlor at 1.5 kg ha^{-1}	1.47	8.30	0.23	0.34	12.5	8.0	117.2	0.22	95.0	170.0	0.34
LSD (P=0.05)	NS	NS	NS	NS	2.19	1.63	4.24	0.042	2.31	12.17	0.44
Rabi											
R_0 = Weedy	1.47	8.30	0.23	0.30	13.7	10.2	123.0	0.32	84.5	155.0	0.23
R_1 = HW (2)	1.47	8.31	0.23	0.33	16.3	13.5	131.3	0.35	90.6	165.8	0.35
R_2 = Isoproturon at 1 kg/ha + 2,4-D Na salt at 0.5 kg/ha	1.47	8.30	0.24	0.30	11.5	9.0	120.5	0.32	84.7	163.7	0.32
LSD (P=0.05)	NS	NS	NS	NS	1.47	1.09	5.99	0.59	1.98	8.68	0.041

FLNFB = Free Living N-Fixing Bacteria (c.f.u. x 10^4/g)
PSB = P - Solubilizing bacteria(c.f.u. x 10^4/g)
SBC = Soilbiomasscarbon (µg)
Acid P = Acid-Phosphate Activity (µgp-NP/h/g)
Alkaline P= Alkaline-Phosphate Activity (µgp-NP/h/g)
DHA= Dehydrogenase activity (µg TPF/h/g)
SR= Soil respiration (µg CO_2 per 100 g soil/d)

CONCLUSION

It can be concluded that two hand weedings recorded positive effect on soil health, while butachlor at 1.5 kg/ha and isoproturonat 1kg/ha + 2,4D Na salt at 0.5kg/ha applied in rice and wheat crop, did not leave any harmful effect on soil health in rice-wheat cropping system.

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Performance evaluation of granular carbon for removal of sulfonylurea herbicides from water

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Million tones of pesticides are used worldwide to protect crops from pests, weeds and pathogens. Excessive mobility and persistence of herbicides in soil may cause ground water contamination. Transport and degradation processes depend upon the properties of herbicides and soils. Sulfonylurea herbicides are the largest major group of soil applied herbicides. This group includes chemicals that are ionisable, persistent and frequently found in ground and surface waters worldwide. Herbicide adsorption on activated carbon was studied by a number of researchers. Keeping this in view the adsorption-desorption of four sulfonylurea herbicides *i.e.* metsulfuron, sulfosulfuron, chlorsulfuron and chlorimuronwas studied on granular carbon.

METHODOLOGY

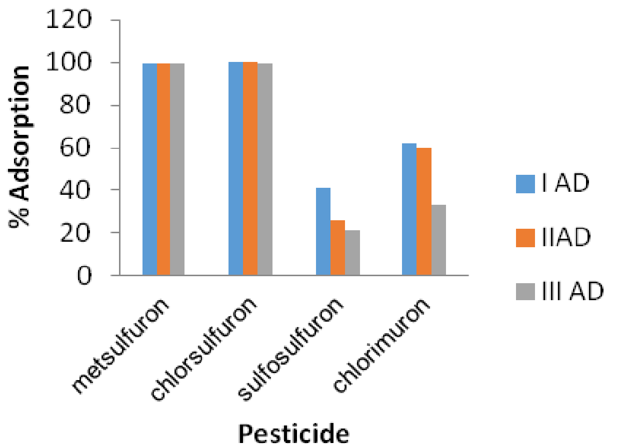
The adsorption- desorptionexperiment was conducted using the batch method at 1:400 (w/v) granular carbon:water ratio. To granular carbon 100 mL of aqueous solution of the desired herbicide was added and shaken on a mechanical shaker. After equilibration for 24 hrs the suspension was centrifuged at 10,000 rpm for 10 min and herbicide residues were quantified in the supernatant. The adsorption studies were carried out at initial concentrations of 1, 2.5, 5, 7.5 and 10 µg m/l for each individual herbicide. The amount of herbicide adsorbed on granular carbon was calculated from the difference between initial and equilibrium concentration in solution after adsorption following the equation:

$$q_e = (C_0\text{-}C) \times V/M$$

Where, q_e is the concentration of herbicide sorbed (µg/g), C_o is the initial concentration of herbicide in solution (µgm/l), C is the equilibrium solution concentration of the herbicide (µg m/l), V is the volume of solution (ml) and M is the mass of the granular carbon (mg). After adsorption the supernatant was decanted and was replaced with the equal volume of distilled water and suspension was equilibrated for desorption. To study the cumulative adsorption capability of granular carbon for individual herbicide sequential adsorption and desorption studies were performed.

RESULTS

Adsorption studies were conducted with two triazinyl (metsulfuron, chlorsulfuron) and two primidinyl (sulfosulfuron, chlorimuron) sulfonyl urea herbicides at five different concentrations i.e. 1, 2.5, 5, 7.5 and 10 µg/l. Adsorption data was fitted to the Freundlich equation and the parameters and the isotherm indicated that the values of correlation coefficients for all the cases were very high (R^2> 0.96), indicating that the Freundlich adsorption equation satisfactorily explained the results of herbicide sorption by the granular carbon. Cumulative studies were conducted using three adsorption cycles for each herbicide.The adsorption and desorption data of metsulfuron, sulfosulfuron, chlorsulfuron and chlorimuron on granular carbon is presented in Fig.1. Results suggest that metsulfuron and chlorsulfuron were highly adsorbed compound showing 97-98% adsorption followed by chlorimuron and sulfosulfuron.



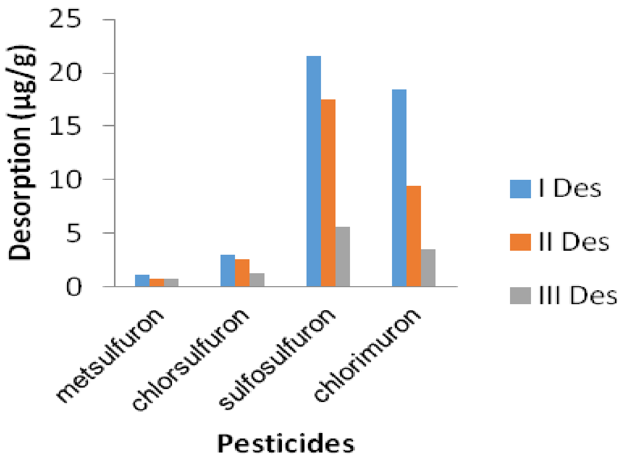


Fig. 1. Adsorption and desorption of four herbicides on granular carbon

All the four sulfonyl ureas are highly soluble in water (1.2-3.18 g/l). Results of sequential adsorption and desorption studies indicate that adsorption of two triazinyl herbicides (metsulfuron and chlorsulfuron) on GAC was more than 95% in each cycle. Sulfosulfuron and chlorimuron (pyrimidinyl herbicides) could be adsorbed only 40-60% and there was a decrease in adsorption after each cycle.Metsulfuron and chlorsulfuron have very high water solubility (2.8 and 3.18g/l) than sulfosulfuron and chlorimuron however desorption of metsulfuron and chlorsulfuron was very less (1-2µg/g) in each cycle while other two desorbed significantly in each cycle (5-23µg/g).

CONCLUSION

Inspite of higher water solubility triazinyl sulfonylureas were strongly adsorbed and least desorbed by GAC thus can be removed from water.Primidinyl sulfonyl ureas were least adsorbed and more desorbed by GAC thus may not be completely removed from water using GAC.

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Changes in soil microflora with herbicides application in autumn sugarcane-based intercropping systems

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Intercropping in autumn sugarcane is quite common and an economical approach for higher unit productivity from same piece of land. Intercropping of gobhi sarson (*Brassica napus*) and raya (*Brassica juncea*) in autumn sugarcane has been found to be one of the viable option to augment the production and income (Singh *et al.* 2007). In agricultural systems, weeds often pose a major threat to crop yields and in intercropping systems, manual weed control is not always feasible. Weeds can reduce sole sugarcane yield by 12-83 % in tropical conditions of western India (Pawar *et al*. 2004). Hence, it necessitates the use of herbicides for timely weed control. However, little is known about the effect of these herbicides and intercropping on soil microbial population in autumn sugarcane. Soil health and microbial diversity have become vital issues for the sustainable agriculture and safe environment. The present study investigate how agronomic practices of herbicides application in autumn sugarcane intercropped with gobhi sarson and raya would affect soil microbial population.

METHODOLOGY

The effect of herbicide application in intercropping systems on major soil microbial population was studied at Punjab Agricultural University, Ludhiana, 2011-12 on loamy sand soil, low in O C andavailable N and medium in available P and K. The treatments consisted of 3 cropping systems {sole sugarcane, sugarcane + gobhi sarson (1:1) and sugarcane + raya (1:2)} in the main plots and six weed control treatments {pendimethalin 0.56 kg and 0.75 kg/ha pre-emergence, alachlor 1.25 1.88 kg/a pre emergence, hand weeding and weedy check} in sub plots replicated thrice in a split plot design. The effect of herbicide application on soil microbial population (bacteria, actinomycetes and fungi) was studied at 0, 15 and 30 days after spray. The viable microbial counts were analyzed by using serial dilution and pour plating technique.

RESULTS

The population of bacteria did not vary amongst cropping systems at same day of spray and 15 DAS. After 30 DAS, significantly lower bacterial count was observed in the rhizosphere of raya than gobhi sarson and sole sugarcane. Bacterial population declined from 48.9 x 10^6 cfu/g in sole sugarcane to 40.5 x 10^6 cfu/g in sugarcane intercropped with raya (Table 1). The population of actinomycetes did not differ significantly amongst the cropping systems on the same day of spray than sole sugarcane. Contrary to bacteria, the actinomycetes count increased with intercropping of *Brassica* crops at 15 and 30 DAS. The differential chemical reaction in the rhizopshere under different crops might be responsible for differences in microbial population under the intercropping systems. Fungal population was significantly lower in sole sugarcane after four weeks. Bacterial population declined significantly with application of pendimethalin and alachlor at their respective doses on the same day of spray at both the sites than unsprayed plots. Higher bacterial populations observed in the unsprayed treatments. However, on the contrary, actinomycetes and fungal count did not differ significantly with herbicide application at 0, 15 and 30 DAS. There has been a general rise in microbial count treated with herbicides reaching maximum around four weeks indicating that the microbial population started building up as the herbicides got degraded to undo the inhibition of microbial growth.

Table 1. Soil microbial population (cfu/g) as influenced by cropping systems and weed control treatments

Treatment	Bacteria (x10^6)			Actinomycetes (x10^4)			Fungi (x10^3)		
	0 DAS	15 DAS	30 DAS	0 DAS	15 DAS	30 DAS	0 DAS	15 DAS	30 DAS
Cropping systems									
Sugarcane sole	29.5 a	39.5 a	48.9 a	25.8 a	29.2 b	30.3 b	23.8 a	22.0 a	24.4 c
Sugarcane + gobhi sarson	29.7 a	39.9 a	44.9 ab	26.3 a	30.0 b	31.1 b	24.0 a	22.9 a	26.0 b
Sugarcane + raya	30.0 a	44.5 a	40.5 b	29.8 a	33.5 a	35.0 a	24.3 a	24.3 a	26.9 a
LSD (P=0.05)	0.91	0.13	0.002	0.07	0.05	0.02	0.90	0.06	0.19
Weed control treatments									
Pendimethalin 0.56 kg/ha	28.5 b	40.3 a	46.5 a	24.5 a	30.0 a	31.7 a	24.0 a	22.1 a	24.1 a
Pendimethalin 0.75 kg/ha	28.1 b	40.3 a	45.1 a	27.2 a	31.3 a	32.3 a	22.3 a	22.8 a	26.1 a
Alachlor 1.25 kg/ha	28.3 b	39.3 a	46.6 a	28.3 a	31.3 a	30.0 a	23.6 a	22.6 a	27.0 a
Alachlor 1.88 kg/ha	27.0 b	44.5 a	46.5 a	27.8 a	29.2 a	31.7 a	23.8 a	23.5 a	27.3 a
Hand weeding	32.3 a	41.8 a	44.3 a	28.2 a	32.5 a	32.8 a	24.8 a	23.5 a	25.5 a
Weedy check	34.5 a	41.6 a	39.6 a	27.5 a	31.0 a	34.7 a	25.8 a	23.8 a	24.5 a
LSD (P=0.05)	0.003	0.32	0.15	0.66	0.81	0.64	0.39	0.79	0.47

Treatment means superscripted by different alphabets are statistically different

CONCLUSION

The autumn sugarcane intercropped with *gobhi sarson* and *raya* had differential effect on population of different soil microbes during four weeks of study. After 30 days bacterial population declined in sole sugarcane, while actinomycetes increased with intercropping of *Brassica* crops. Pre emergence application of pendimethalin and alachlor at varying doses was not showing any detrimental effect to soilbacteria, actinomycetes and fungi. However, a temporary reduction in number of bacteria was observed immediately after herbicide application and later it was recovered within four weeks.

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Dissipation of ethofumesate in soil and residue analysis in sugarbeet at harvest

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Pesticides play an important role in the production of rice but their residues may cause numerous environmental problems. They may contaminate surface and groundwater through leaching and run-off. Efficient weed control in sugarbeet could increase yield by 25-40%. Ethofumesate [(*RS*)-2-ethoxy-2,3-dihydro-3,3-dimethylbenzofuran-5-yl-methane sulfonate] is used as pre-and post-emergence herbicide for controlling a wide range of grasses and broad-leaved weeds. It inhibits the lipid synthesis in sensitive plants. It is available as EC, SC, SE and OD for use in agriculture. Ethofumesate may be co-formulated with phenmedipham, bromoxynil, ioxynil, desmedipham or metamitron. Residues studies of ethofumesate in sugarbeet crop are lacking hence dissipation studies were taken to understand in sugarbeet crops grown under field conditions.

METHODOLOGY

Three treatments consisting of control and ethofumesate (50 SC) were applied as post-emergent herbicide at 2 leafed stage herbicide at 2 kg/ha and 4 kg/ha, respectively. Soil samples were collected from all the plots at different time intervals *i.e.* 0 (1 hr.), 1, 3, 5, 7, 15, 30, 45, 60, 75 and 90 days after herbicide application and finally on the harvesting day. Sugarbeet roots and leaves samples were collected at harvest time.

Ehofumesate was extracted from soil by mixture of acetone: methanol. The extracts reduced to dryness under reduced pressure, partitioned with dichloromethane: water system. The organic layer evaporated to near dryness. Cleanup was done with silica SPE using hexane: dichloromethane. The residue was dissolved in methanol for HPLC analysis. Chopped and macetared beet root / leaves was extracted with methanol: acetone mixture and concentrated to 1 ml and subjected to cleanup with silica SPE. The eluted sample was dried under steam of nitrogen and residue was dissolved in HPLC grade methanol. The operating chromatographic conditions for ethofumesate residue were HPLC system, C-18 HPLC column, methanol: water (70:30 v/v) mobile phase, 228 nm wavelength.

RESULTS

Validation of the extraction procedure in terms of the percent recovery of ethofumesate from fortified samples of soil, beet root and leaves samples were found between 77.01-86.03, 78.22-86.15, and 80.26-86.50 at 0.5-5.0 ppm fortification levels. Limit of detection for ethofumesate was 0.005µg/ml, and limit of quantification for soil, beet root and leaves was 0.02, µg/g, respectively

Percent dissipation values at different time intervals were calculated considering the amount of herbicide recovered on 0th day as 100%. Percent persistence of herbicide in soil treated at 2 kg/ha decreased from 100-63.40% from 0th day to 3rd day and fall up to 59.32% till 7th day. After 10 days of application it gradually falls at almost constant rate and decreased to 16.82 on 60th day after application. However, no detectable residue (<0.02 mg/g) was found after 90th day of application. At 4 kg /ha application rate, herbicide in soil decreased from 100-79.4% from 0th day to 3 day and fall up to 44.33% till 10th day. No detectable residue was observed on 120th day of application. Dissipation of ethofumesate occur through a two phase conforming to first-order kinetics. In soil, the half-life values at 2 and 4 kg/ ha of etofumesate were 12.69 and 51.88 days and 15.12 and 55.72 for early and late phase respectively (Table 1).

Table 1. Dissipation of ethofumesate in soil

Incubation interval	Percent dissipation	
	2.0 kg/ha	4.0 kg/ha
0 day	0.00	0.00
1 day	8.25	8.75
7 day	40.68	46.72
0 day	51.78	55.67
15 day	58.66	62.87
60 day	83.18	89.34
90 day	96.66	97.66
105 day	BDL	99.18
Harvest day (152 days)	BDL	BDL

Mean value of 3 replicates; BDL= Below detectable limit, (LOQ < 0.02 mg/g$^-$)

Kucharski (2007) found residues of ethofumesate in roots of sugar beet did not exceed EU acceptable limits if applied for continuous for three year. At harvest time, ethofumesate residue analysis was done on beet root, and leaves and no detectable amount of residue was observed at both application rates.

CONCLUSION

Ethofumesate undergoes rapid dissipation in soil and follows first-order degradation kinetics in soilIn beet root and leaves, no detectable amount of ethofumesate was observed under sub-humid and subtropical conditions at the time of harvesting.

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Determination of rice herbicides in soil: A comparison of sample preparation techniques MSPD and LSE

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Herbicides, constituting 20% of India's consumption for rice crop, are widely utilized for improving crop health, maintaining agro ecosystem, food supply and economical advantages. However, the intensive application of herbicides has also resulted in unintentional exposure of the ecosystem by entering into food chain and polluting the soil, air and ground and surface water. Considering low concentration levels of herbicide residues in soil and food matrices, the determination of these residues often requires extensive sample extraction and purification prior to the analysis. The development of sensitive, selective and reproducible analytical methods has always been a prerequisite for the achievement of high-quality results in enforcement and monitoring programmes abandoning energy, time, cost and solvent consumption. For estimating residues of five rice herbicides namely anilophos, butachlor, fenoxaprop-p-ethyl, oxadiargyl and pendimethalin the efficiency of matrix solid phase dispersion (MSPD) and liquid solid extraction (LSE) methods was evaluated in the present study.

METHODOLOGY

Stock solution of herbicides (1000 µg m/l was prepared by dissolving appropriate amount of anilophos, butachlor, fenoxaprop-p-ethyl, oxadiargyl and pendimethalin in 10 ml HPLC grade acetonitrile. Working standards were prepared from this stock solution in range of 0.001 to 10 ìgm/l by dilution with acetonitrile.

LSE- extraction

Spiked sample was shaken with solvent for 1 hr and then filtered using activated charcoal. To this, 5% NaCl solution was added and it was partitioned thrice with 25 mL of dichloromethane (DCM). The combined organic layers were passed through activated sodium sulphate and concentrated. The residues were re-dissolved using 2 mL acetonitrile for analysis. No cleanup was required for soil samples. Rice grain extracts were cleaned on glass adsorption column packed with silica-gel and activated charcoal between anhydrous sodium sulphate at each end. The concentrated extract was added at top after pre-washing with DCM and eluted with (90:10) DCM and acetone mixture. Eluents collected were evaporated on rotary vacuum evaporator and reconstituted in 2 mL acetonitrile.

MSPD- extraction

MSPD method reported by £ozowicka *et al.* 2012 was used to extract herbicides from soil/rice samples. Briefly, spiked soil/rice was grounded with florisil activated at 200 p C for 8 hr. After homogenization, blend was quantitatively transferred with spatula to a glass column packed with sodium sulphate and charcoal. The column was eluted with the eluting solvent and the eluent was evaporated using rotary vacuum evaporator. The sample was reconstituted in 2 ml acetonitrile and was analyzed by HPLC.

RESULTS

Both methods were optimized, considering different parameters and under optimum conditions, the recovery studies were carried out at three levels (0.5, 0.1 and 0.01 µg/g). The percentage recovery of rice herbicides, using LSE procedure, from soil and rice spiked at these levels ranged between 75-89 and 72-85 respectively, which was lower as compared to those obtained from MSPD extraction ranging between 86-103 and 82-99%. Precision values expressed as relative standard deviation (RSD) were <15 for LSE and <10 for MSPD. Correlation coefficient was higher than 0.998 for both the methods.

CONCLUSION

A rapid and efficient method has been developed for determining rice herbicide in soil and rice samples. The results indicate that MSPD is an efficient method and has significant advantages over classical liquid-solid extraction technique. The method based on MSPD is simple, fast and sensitive extraction procedure offering reduction in time, less sample loss and use of smaller amounts of organic solvents for isolation of herbicide whereas LSE is solvent-consuming multistep procedure involving purification, separation and clean-up steps associated with risk of losing analyte at each step. With the extraction efficiency and time expenditure taken into account, MSPD extraction was considered an efficient method.

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Degradability of different herbicides in rice field and their impact on soil microflora

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Among the rice growing countries, India having the largest area under rice in the world and in case of production it is next to China. Weeds are the cause of serious yield reduction problems in rice production worldwide. Herbicide is the appropriate tool to address this problem but it creates two major problems initially by persisting and accumulating in the environment and contaminating numerous plants and animals and secondly they affect human health directly or indirectly. Most of the organic pollutants are herbicides (Dorigo *et al*. 2007), which are used not only in agriculture but also for many other purposes. Microbial action is a major mode of decomposition of herbicides in soils. Many species of micro organisms degrade a variety of organic carbon substances including herbicides to derive energy and nutrients for their metabolism (Cork and Krueger 1991). Many new post and pre emergence herbicides including oxadiargyl and bispyribac are recently been introduced in our country but their fate and persistence in soil are almost unknown. In this experiment an assessment was done to evaluate the existence of different herbicides applied in rice field using microbiological techniques as a tool.

METHODOLOGY

A field study was conducted during *Kharif* 2010-2013 in Instructional cum Research Farm, IGKV, Raipur and in the fourth year degradability of different *Kharif* herbicides were assessed in terms of microbial and biochemical characteristics of herbicide treated soil comparing with hand weeded herbicide free condition. Six different herbicides (oxadiargyl as pre-emergence *fb* bispyribac as post-emergence herbicides at 80 gm and 20 gm/ha, respectively; pyrazosulfuron applied at early post-emergence stage (8DAS) at 25 gm/ha and tank mixed combination of fenoxaprop and chlorimuron-ethyl + metsulfuron-methyl applied at post-emergence stage at 60.00 gm and 25.00gm/ha, respectively) were tested for their environmental suitability compared with hand weeding practice. The experiment was conducted on *Kharif* rice (O*ryza stativa* L.) with test variety MTU-1010. The soil was Inceptisol (pH : 6.75, EC : 0.13 dS/m, organic carbon : 0.48%, available N: 162 kg/ ha, available P: 12.50 kg/ha and available K : 195 kg/ha).The treatments were replicated thrice under randomized block design. Rhizosphere soil samples were collected at a depth of 7.5-15 cm at 30, 50 days after sowing and harvest stage of crop. The soil samples were subjected to analysis for microbial biomass carbon, basal respiration rate, phosphatase & dehydrogenase activity, population of total diazotrophs and phosphate solubilizing bacteria.

RESULTS

The long term study on the degradability of different herbicides on microbial and bio-chemical properties of soil indicated that after application of different pre & post emergence herbicides in single and combined form the above soil properties were affected at different levels. At 30DAS among all the applied herbicides maximum inhibitory effect on soil microflora was visualized due to application of oxadiargyl and bispyribac which significantly reduced basal soil respiration rate (BSR), dehydrogenase enzyme activity (DHA), acid phosphatase activity (AP), microbial biomass carbon content (MBC) and population of nitrogen fixers & phosphate solubilizers in soil (Table 1). At 50DAS, the inhibitory effect of all the applied herbicides was visualized on studied microbiological & biochemical properties except pyrazosulfuron which was applied at early post emergence stage (8 DAS) and did not reduce the values of studied parameters. In this stage of crop growth the effect of pyrazosulfuron was found at par with hand weeding practices. This indicated that pyrazosulfuron degraded before 50 DAS of crop. At harvest stage, the oxadiargyl and bispyribac herbicides started to degrade but existence of oxadiargyl+ bispyribac and fenoxaprop + chlorimuron + metsulfuron was observed in soil in terms of above measured parameters as the values of BSR, MBC, DHA, AP and microbial population were found significantly lower than hand weeding practices. This indicates the persistence of above chemicals in soil at harvest stage of crop growth. In the above study minimum degradability of fenoxaprop + chlorimuron ethyl + metsulfuron methyl was found in comparison to other applied herbicides. Pyrazosulfuron was found safe than other tested herbicides as it was degraded faster than others.

Table 1. Effect of herbicides on basal soil respiration rate (mgCO_2/h/100g soil) and Dehyrogenase activity (µg TPF/h/g soil) in rhizosphere soil of rice

Treatment	0 DAS		30 DAS		50 DAS		At harvest	
	BSR	DHA	BSR	DHA	BSR	DHA	BSR	DHA
Oxadiargyl 80 g/ha *fb* Bispyribac 25 g/ha	0.237	24.73	0.140	10.60	0.106	7.85	0.130	20.64
Pyrazosulfuron 25 g/ha	0.244	26.12	0.202	20.89	0.347	70.25	0.227	22.87
Fenoxaprop 60 g/ha + CME+ MSM 4 g/ha	0.232	24.18	0.205	26.54	0.113	17.00	0.102	15.61
Hand weeding twice	0.247	26.72	0.315	43.07	0.376	75.30	0.235	23.57
Un weeded control	0.249	27.02	0.321	44.29	0.389	82.85	0.241	25.43
LSD (P= 0.05)	N.S.	N.S.	0.024	2.78	0.029	5.06	0.018	2.36

BSR: Basal soil respiration rate; DHA: Dehydrogenase enzyme activity; DAS Day after sowing

CONCLUSION

In the above study minimum degradability of fenoxaprop + chlorimuron ethyl + metsulfuron methyl was found in comparison to other applied herbicides. Pyrazosulfuron was found safe than other tested herbicides as it was degraded faster than others.

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Atrazine degradation in mineral salts medium and soil using an enriched culture

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Atrazine (2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine) is a widely used selective, systemic, pre- and post-emergent herbicide for the control of broad-leaf and grassy weeds. Because of its widespread use over the last thirty years atrazine has emerged as a pollutant of environmental concern mainly due to its low biodegradability. Biodegradation is one of the most cost effective natural remedial approaches to remove xenobiotic chemicals from the environment. Seeger *et al.* in 2010 summarized that microorganisms belonging to *Pseudomonas*, *Arthrobacter*, *Chelatobacter*, *Agrobacterium*, *Rhodococcus*, *Stenotrophomonas*, *Pseudaminobacter* and *Nocardiodes* genera have ability to degrade atrazine and *Pseudomonas sp*. strain MHP41, an efficient *s*-triazine-degrading bacterium, has been successfully applied for bioremediation. Previously, we reported an atrazine degrading enrichment culture,a consortium fromgenera *Bacillus, Pseudomonas* and *Burkholderia*, that could degrade atrazine as sole source of carbon and nitrogen (Dutta and Singh, 2013). Present study was designed to evaluate the potential of this enriched culture to degrade atrazine metabolites and pathway of atrazine degradation was proposed.

METHODOLOGY

Atrazine degrading enrichment culture was used to degrade atrazine in 4 soils having different physico-chemical properties, *viz.* Hyderabad, Andhra Pradesh (soil 1), Almora, Utrakhand (soil 2) , Jhargram, West Bengal (soil 3) and Pantnagar, Uttarakhand (soil 4). Further, the degradation of atrazine metabolites *viz.*hydroxyatrazine, deethylatrazine and deisoproptylatrazine was studied in the mineral salts medium and the metabolites were supplemented as (i) sole source of carbon and nitrogen (-C,-N), (ii) carbon alone(-C,+N), (iii) nitrogen alone (+C,-N) and (iv) none (+C,+N). The ability of the enrichment culture to withstand high concentrations of atrazine and effect of pH was also studied. Atrazine/metabolites were quantified using high performance liquid chromatography.

RESULTS

Degradation studies of atrazine metabolites viz. hydroxyatrazine, deethylatrazine and deisopropylatrazine in mineral salts medium suggested that enrichment culture was able to degrade only hydroxyatrazine and it was used as the sole source of carbon and nitrogen (Fig. 1).

Degradation slowed down when sucrose and/or ammonium hydrogen phosphate were supplemented as the additional source of carbon and nitrogen, respectively. Ability of the enrichment culture to degrade only hydroxyatrazine suggested that the pathway of atrazine degradation was its hydrolysis to hydroxyatrazine and not the dealkylation. Further, the hydroxyatrazine could get metabolized to cyanuric acid by dealkylation and deamination by the formation of deetylhydroxyatrazine, deispropylhydroxyatazine, N-ethylammelide, N-isopropylammelide anddeethyl-deisopropylhydroxyatrazine; though, formation of any of these metabolites was not confirmed in the present study. Cyanuric acid was further degraded by the formation of biuret and an unidentified metabolite, other than urea.Results indicated that the enrichment culture was capable of degrading atrazine upto 110 mg/ml concentration though initial lag period increased as atrazine concentration in the medium increased. Further, it could degrade atrazine in different soil types, except in an acidic soil. However, raising the soil pH to neutral or alkaline enabled the consortium to degrade atrazine suggesting that acidic pH inhibited the atrazine degrading ability of the consortium.

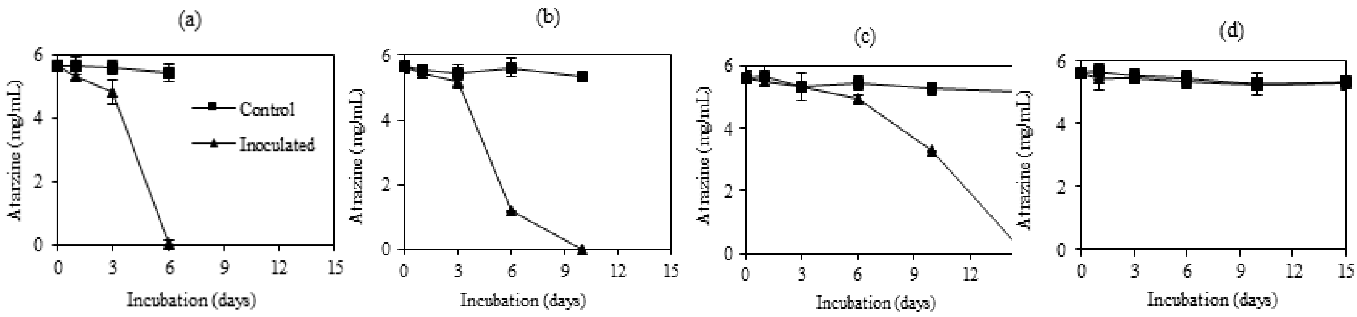

Fig. 1. Degradation of hydroxyatrazine in mineral salts medium under different conditions: (a) -carbon, -nitrogen; (b) +carbon, -nitrogen; (c) -carbon, +nitrogen; (d) +carbon, +nitrogen

CONCLUSION

The enrichment culture can be successfully utilized to achieve complete degradation of atrazine and its persistent metabolite hydroxyatrazine in contaminated soil and water without substantial accumulation of any of its intermediate metabolites.

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Evaluation of leaching behavior of metribuzin under two irrigation levels

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Chemical weed control is a preferred practice due to scarce and costly labour as well as lesser feasibility of mechanical or manual weeding. Herbicide persistence and their fate in the environment are both influenced by the soil processes of adsorption, movement and decomposition. The movement of herbicide by leaching is important to weed management effectiveness, herbicide carryover and the potential for environmental problems. The extent to which a herbicide is leached is determined by adsorptive relationship between the herbicide and the soil, solubility of herbicide in water and the amount of water passing downward through the soil.

Metribuzin is a selective triazinone herbicide that inhibits photosynthesis. It is used for the control of annual grasses and numerous broadleaf weeds in field and vegetable crops. The aim of the present study was to investigate the impact of different levels of irrigation on the leaching behavior of metribuzine

METHODOLOGY

Soil (0-15 cm depth) was collected from surrounding area of, College of Agriculture, Gwalior that was never treated with any herbicide. The soil was sandy clay loam in texture with sand 55.2%, silt 19.4% and clay 25.4%. The experiment was done at ambient temperature in a completely randomized design with three replications in Polyvinyl chloride (PVC) columns filled with soil. Metribuzin was added directly to column at doses equivalent to 0.5 and 1.0 kg/ha with control columns without herbicide. Calculated quantity of water was added to encourage movement of herbicide. In one set water equivalent to 2.5 cm/day irrigation was added to each column while in second set water equivalent to 7.5 cm/day water was added. At the end of the trial presence of herbicides was determined through bioassay by using black gram as sensitive crop. Plant height, fresh weight and dry weight of black gram plant as affected by metribuzin were recorded 21 days after sowing.

RESULTS

The leaching of metribuzin was affected by concentration of herbicide as well as irrigation levels as depicted by growth of black gram plant at different depth (Table 1 and 2). Plant height, fresh weight and dry weight of black gram were reduced up to 25-30 cm and 35-40 cm depth at recommended (0.5 kg/ha) and double the recommended (1.0 kg/ha) doses at 2.5 cm irrigation level. At 7.5 cm irrigation the plant growth of black gram was reduced up to 35-40 cm at 0.5 kg/ha and 40-45 cm at 1.0 kg/ha metribuzin. The close association between leaching and amount of deep-percolating water produced by irrigation treatments was expected because leaching occurs through dissolution of solute in soil solution and, subsequently moves with soil water. Troiano *et al.* (1993) stated that both amount and method of water application are important factors that determine pesticide movement and that, in irrigated agriculture, both must be considered as integral components of pesticide management. Sondhia and Yaduraju (2004) also reported that metribuzin leaches up to the depth of 52 cm in the soil column in sandy clay loam soil under laboratory conditions.

Table 1. Leaching behavior of metribuzin (with 2.5 and 7.5 cm irrigation)

Soil depth (cm)	2.5 cm irrigation						7.5 cm irrigation					
	0.5 kg/ha			1.0 kg/ha			0.5 kg/ha			1.0 kg/ha		
	Pl. Height (cm)	Fresh wt. (g/plant)	Dry wt. (mg/plant)	Pl. Height (cm)	Fresh wt. (g/plant)	Dry wt. (mg/plant)	Pl. Height (cm)	Fresh wt. (g/plant)	Dry wt. (mg/plant)	Pl. Height (cm)	Fresh wt. (g/plant)	Dry wt. (mg/plant)
0-5	10.74	0.094	29	7.99	0.130	27	10.89	0.092	29	8.57	0.091	22
5-10	11.46	0.109	26	8.01	0.102	21	11.34	0.103	23	8.95	0.084	22
10-15	11.08	0.115	29	11.33	0.107	28	11.45	0.115	24	10.11	0.098	25
15-20	13.00	0.145	27	8.53	0.118	21	12.06	0.140	22	10.95	0.113	22
20-25	18.19	0.203	33	12.56	0.124	27	14.78	0.138	25	12.36	0.123	29
25-30	18.51	0.207	36	13.58	0.158	27	16.84	0.180	23	15.06	0.149	32
30-35	21.43	0.241	41	15.50	0.196	34	16.36	0.221	30	16.23	0.205	37
35-40	21.73	0.248	40	18.11	0.213	33	16.61	0.232	38	19.57	0.235	39
40-45	22.89	0.242	39	20.22	0.294	37	20.95	0.292	40	17.83	0.234	39
45-50	20.74	0.231	39	21.50	0.287	40	22.73	0.277	40	20.18	0.277	41
Control	19.91	0.235	40	-	-	-	21.24	0.240	40	-	-	-

CONCLUSION

In sandy clay loam soil metribuzin leaches upto 25-30 cm at 0.5 kg/ha and 35-40 cm at 1.0 kg/ha at 2.5 cm irrigation. At 7.5 cm irrigation the herbicide leaches upto 35-40 cm at 0.5 kg/ha and 40-45 cm at 1.0 kg/ha.

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Long-term effect of herbicides on weed seed bank and population of soil micro-flora in rice-wheat cropping system

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The sustainable agriculture involves optimizing agricultural resources and at the same time maintaining the quality of environment and sustaining natural resources. In achieving this optimization, the soil microbial community composition is of great importance, because they play a crucial role in carbon flow, nutrient cycling and litter decomposition, which in turn affect soil fertility and plant growth, and hence occupy a unique position in biological cycles in terrestrial habitat. A number of herbicides have not only been introduced as pre- or post-emergence weed killer (Ayansina and Oso 2006) but also leave unwanted residues in soil, which are ecologically harmful (Sebiomo*et al*. 2011). Continuous use of herbicides in rice-wheat cropping system may affect the soil physico-chemical properties and continuous application of herbicides in cropping systems may also affect the microbial population. To study relativity of microbial population as affected by cultural methods and herbicide application is therefore, of great importance in agro-ecosystems.

METHODOLOGY

The experiment was conducted at Rajendra Agricultural University during *Rabi* 2011-2012 in wheat crop in AICRP weed management programme.The initial and post harvest surface soil samples (0-15 cm soil depth) were collected from each plot from long term herbicidal trial. The samples were air dried processed and sieved with 2 mm plastic sieve and stored in the polythene bags. The pH and electrical conductivity of the soil were measured in 1:2 soil:water suspension and organic carbon content by standard procedures. A dilution plate count technique was followed to study the total bacteria by Thorntons Agar medium, Kent Ninght's medium for actinomycetes and Martin's Rose Bengal Agar medium for total fungi in the soil. The plates were incubated at 30 ± 1^{0}C for five days.

RESULTS

The effect of different treatments under main and sub plots did not show any significant effects on pH and EC in initial and post-harvest soil. A slight increase in percent organic carbon was recorded in post-harvest soil samples as compared to initial samples. Highest bacterial population (22.89 and 23.80 x 10^6cfu/g of soil) in initial and post-harvest soil samples, respectively were observed with Anilophos 0.5 kg/ha followed by butachlor 1.5kg/ha whereas, the lowest values in main plot were observed with mechanical weeding treatment. The actinomycetes and fungal population in main plot were significantly higher with weedy check followed by anilophos 0.5 kg/ha. The lowest fungal and actinomycetes population in initial and post-harvest soil samples in main and sub plots were recorded in mechanical weeding treatments. A CO_2 evolution of 70.88 and 73.89 mg/100g of soil in main plot was recorded in initial and post-harvest soil samples, respectively with weedy check treatment which was followed by anilophos 0.5kg/ha.

Table 1. Long term effect of herbicides on weed seed bank and population of soil micro-flora in direct seeded Rice - Wheat cropping system

Treatment	Chemical Properties of Soil						Biological Properties of Soil							
	pH		EC		%OC		Total Bacteria (10^6 cfu/ g of soil)		Actinomycites (10^5 cfu/ g of soil)		Fungi (10^4 cfu/ g of soil)		Co_2 Evolution (mg/100g soil)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Main Plot														
Weedy check	8.24	8.45	0.25	0.24	0.50	0.59	20.69	20.96	9.53	10.10	11.38	11.98	70.88	73.89
Mechanical weeding (2)	8.37	8.43	0.33	0.34	0.48	0.45	17.78	18.62	4.94	5.30	8.38	8.76	61.87	64.29
Butachlor 1.5 kg/ha	8.44	8.35	0.24	0.38	0.37	0.48	21.52	22.26	9.86	10.60	11.21	11.74	50.75	58.12
Anilophos 0.5 kg/ha	8.37	8.41	0.18	0.23	0.50	0.51	22.89	23.80	9.01	9.77	11.79	12.40	67.45	71.17
LSD (P=0.05)	0.25	0.032	0.024	3.44	0.05	0.02	0.29	0.40	0.13	0.41	0.16	0.42	1.22	0.25
Sub Plot														
Weedy check	8.36	8.97	0.19	0.24	0.60	0.72	21.56	21.96	5.73	6.10	8.63	9.40	70.56	75.60
Mechanical weeding	8.45	8.52	0.26	0.33	0.56	0.63	19.30	19.50	5.66	6.20	7.30	7.40	53.33	52.93
Isoproturon 1.0 kg/ha	8.32	8.13	0.27	0.21	0.50	0.53	20.46	20.53	4.33	4.60	8.50	8.93	60.70	62.96
Isoproturon 0.75 kg/ha tank mix 1% urea	8.38	8.41	0.27	0.15	0.46	0.54	20.73	21.36	4.66	4.70	8.76	9.16	63.96	65.50
Isoproturon 0.75 kg/ha tank mix 0.1% surfactant/adjuvant	8.26	8.21	0.25	0.26	0.45	0.53	21.40	21.46	4.33	4.93	8.70	8.93	60.80	64.46
LSD (P=0.05)	0.17	0.029	0.02	3.39	0.03	0.015	0.15	0.101	0.16	0.04	0.142	0.09	1.16	0.12

CONCLUSION

Highest microbial population was recorded under weedy check and lowest in mechanical weeding. However, herbicides used in this experiment did not show any adverse effect on the microbial population.

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Bioassay of dissipation pattern of polyoxy-ethylene tallow amine surfactant in water using *Hygrophila polysperma*

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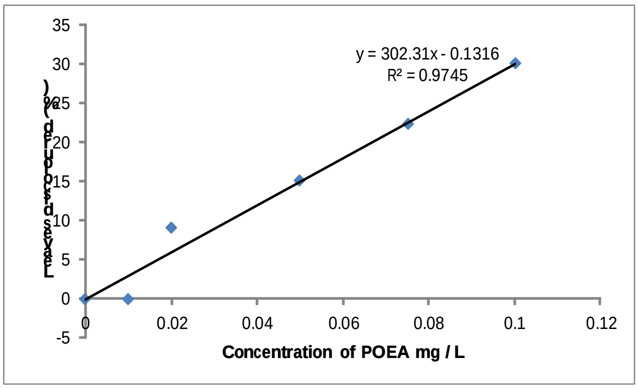
Glyphosate [(N- phosphonomethyl) glycine] formulations contain the surfactant polyoxy ethylene tallow amine (POEA) in the range of 8-15%. Results of several studies indicate that the surfactant POEA is toxic to fish and to aquatic invertebrates (Cox 1995) and the toxicity is about 30 times more than that of glyphosate (Servizi *et al* 1987). Since glyphosate is a widely used herbicide, there is an increasing concern regarding the safety of glyphosate formulations, particularly Roundup® and little information is available on the fate of POEA in water. Because of the structural complexity of POEA, estimation of its residue using the common instrumental techniques such as chromatography and spectrometry is difficult. In view of the above, attempts were made to standardize bioassay method using aquatic plants and its persistence in the aquatic system was estimated.

METHODOLOGY

The surfactant POEA (Rhodameen TA 15 of >99.9% purity), obtained from Rhodia Speciality Chemicals India Ltd., Maharashtra, India, was dissolved in water and the quantity required to give various concentrations was added to the glass containers of 1 litre capacity as per treatments. The preliminary study consisted of two aquatic plants, *viz.* H*ygrophila polysperma* and *Cabomba aquatica* obtained from Sreepadma Aqua Flora, Kochi, India and six concentrations of POEA ranging from 0 to 1000 mg per litre of water (0, 0.1, 1.0, 5.0 , 100, and 1000 mg/l)were used. Based on the visible changes observed in this test, only *Hygrophila polysperma* plant was selected for further tests with additional concentrations of POEA at narrow levels (0, .01, 0.02, 0.05, 0.075, 0.1 and 1.0 mg/l). The two sensitive parameters viz., leaves fallen (%) and leaves discoloured (%) were compared. From the dose response curve, it was possible to determine concentration of POEA in water. In order to study the dissipation pattern of POEA in the aquatic system, POEA was applied on *Salvinia* mat (500.0 g/tank) in an aquarium (40 L water) to give a concentration of 0.15 mg/L water. The aquarium contained fine soil (sediment) from lowland paddy (3.0 kg) as well as a fish population of 10 numbers (var. Gourami). Water samples were collected at 1, 15, 30, 60, 90 and 120 days after application of POEA.

RESULTS

At three days after putting *Cabomba aquatica* in the surfactant (Rodameen TA15) solution, solutions of higher concentrations turned green but no consistent visible effects were noticed on *Cabomba aquatica*. In the case of *Hygrophila polysperma,* the leaves changed color from green to brown after three days, at the highest concentration of POEA (1000 mg/l), but the color of the solution was



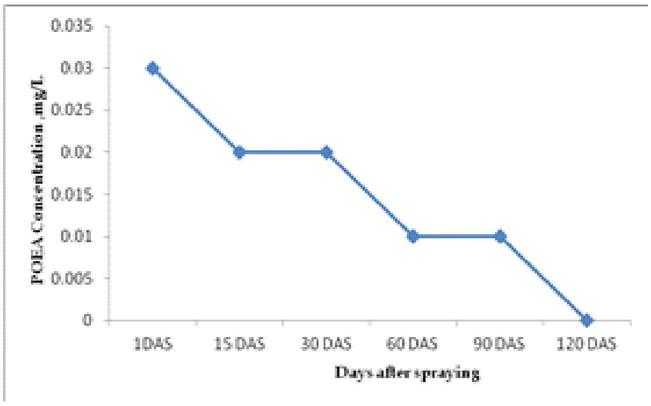


Fig. 1. Effect of POEA on H*ygrophila polysperma* Figure 2. Dissipation pattern of POEA in water

not affected. This is the reason for selecting *Hygrophila polysperma* for further studies. When *Hygrophila polysperma* was exposed to varying concentrations of POEA (0.0, 0.01, 0.02, 0.05, 0.075, 0.1 and 1.0 mg/l) colour of the leaves at the higher surfactant concentration (1.00 mg/l) changed to dark brown in the edges by 3 days. It was found that percentage of leaves discoloured at 7 DAS gave a linear response indicating that *Hygrophila polysperma* could be used as an indicator plant for the bioassay of POEA in the water samples. The pattern of dissipation of POEA in water is presented in Fig 2. It could be seen that POEA persisted in water up to 90 days after application under laboratory conditions.

CONCLUSION

The bioassay using *Hygrophila polysperma* indicated that POEA completely dissipated from the water body in about 120 days.

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Evaluation of imidazolinone herbicides in greengram and their residual effects on succeeding mustard crop

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Weeds in green gram have been reported to offer serious competition and cause yield reduction to the extent of 20-45%. Weed emergence in green gram begins almost with the crop emergence leading to crop-weed competition right from the initial stages. Pre-emergence use of pendimethalin at 1.0 kg/ha has been found effective to control weeds in green gram but a residual herbicide is needed to control second flush of weeds emerging after rains. Keeping it in view, herbicides imazethapyr alone or in combination with imazamox and pendimethalin as pre-mixture with imazethapyr were tested under PPI, PRE and post emergence conditions and were compared with pendimethalin applied alone.

METHODOLOGY

The present studies were conducted during *kharif* and *rabi* seasons of 2014 in the Department of Agronomy, CCS Haryana Agricultural University, Hisar under irrigated conditions. The soil of the experimental field was sandy loam in texture, having pH 8.1, low in organic carbon (0.3%) and nitrogen (182 kg/ha), medium in available phosphorus (18.5 kg/ha) and high in potassium (372 kg/ha) content. The treatments used were pendimethalin at 1.0 kg/ha and pendimethalin+ imazethapyr (RM) at 1000 g/ha as pre-emergence. Post emergence treatments included different doses 70 and 80 g/ha of imazethapyr and imazethapyr + imazamox (RM) and were compared with weed free and weedy checks. Experiment was conducted in randomized block design with three replicates. Post emergence herbicides were applied at 20 DAS (2-3 leaf stage of weeds) by knapsack sprayer fitted with flat fan nozzle using 300 l/ha water. Mustard crop cultivar RH 749 was planted on 21.10. 2014 after harvest of green gram with shallow disking and planking in same layout as in *kharif* 2014. Observations on phytotoxic effects on mustard were recorded at 30 and 45 DAS.

RESULTS

Weed management studies in green gram

Weed flora of the field was dominated by *Trianthema portulacastrum* constituting 82% of total weed flora. All pre-emergence herbicides treatments proved very effective against predominant weed *T. portulacastrum*. (Table 1). Post emergence application of imazethapyr and imazethapyr + imazamox (RM) at 70 and 80 g/haproved less effective in minimizing weed density. Although post emergence application of both these herbicides caused suppression in *Trianthema* growth but pre-emergence treatments of pendimethalin alone or in combination with imazethapyr were very effective to minimize *Trianthema* population as was evident from weed density and WCE% at 30 and 60 DAS. Post emergence use of imazethapyr and its combination with imazamox at 70 and 80 g/ha caused slight toxicity to green gram in which mitigated within 15 days after application but with significant reduction in plant height and seed yield. Punia *et al* (2011) reported that post-emergence application of imazethapyr at 80 and 100 g /ha caused mild injury to clusterbean.

Although, pre-emergence application of pendimethalin proved very effective and gave 90% control of weeds up to 15 DAS

Table 1. Effect of different herbicides on weed control in green gram and their residual carryover effect on succeeding mustard crop

Treatment	Dose (g/ha)	Weed Density (no./m²)				WCE%		Visual weed control%		Crop phytotoxicity (%)		Green gram Seed yield (kg/ha)	B:C	Residual effect on mustard			Mustard seed yield(Kg/ha)
		Trianthema p.		*C. rotundus*										No. of Plants/m.r.l.	Crop phytotoxicity (%)		
		30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	15 DAS	30 DAS	30 DAS	45 DAS				30 DAS	60 DAS	
Imazethapyr (PPI)	70	1.68 (1.22)	1.49 (0.33)	1.97 (2.88)	1.56 (1.55)	93.1	74.6	95	90	90	0	980	2.29	1.73	90	90	1298
Imazethapyr (PPI)	80	2.28 (5.22)	1 (0)	1.50 (1.55)	1.30 (0.77)	93.8	84.8	98	95	95	0	967	2.27	1.26	95	95	1168
Imazethapyr (PRE)	70	1.13 (0.33)	1.13 (0.33)	2.03 (3.22)	1.38 (1)	73.9	50.2	95	15	15	0	919	2.15	5.7	15	7.3	2569
Imazethapyr(PRE)	80	1.29 (0.77)	1(0)	1.74 (2.22)	1.66 (2)	85.7	44.9	100	25	25	0	922	2.15	5.46	25	0	2340
Imazethapyr 3-4 leaf	70	7.54 (62.6)	2.68 (8.11)	2.06 (3.44)	2.10 (3.66)	21.8	30.4	15	70	70	8	603	1.41	3	70	8	2551
Imazethapyr 3-4 leaf	80	5.49 (39.4)	3.91 (15.3)	1.83 (2.44)	1.71 (2)	34.7	27.2	20	85	85	10	657	1.53	2.78	85	10	2180
Imazethapyr + imazamox (RM) (PRE)	70	4.12 (16.1)	2.98 (10.4)	2.04 (3.77)	1.86 (4)	94.2	77.4	60	15	15	0	798	1.85	5	15	0	2687
Imazethapyr + imazamox (RM) (PRE)	80	1.96 (4.22)	1.86 (3.22)	2.37 (5.33)	2.18 (4.44)	95.1	81.5	75	25	25	0	800	1.85	4.66	25	0	2366
Imazethapyr + imazamox (RM)	70	7.79 (67.8)	4.12 (16.2)	2.38 (4.77)	1.42 (1.11)	18.0	9.2	25	10	10	0	492	1.14	5.16	10	0	2573
Imazethapyr + imazamox (RM)	80	4.75 (31.3)	3.32 (11.3)	1.91 (3.55)	1.66 (1.88)	49.1	35.5	40	25	25	0	500	1.16	4.83	25	0	2488
Pendimethalin (PRE)	1000	2.90 (10.8)	2.08 (4.88)	2.05 (3.33)	2.52 (6.55)	86.1	54.4	97	0	0	0	946	2.22	7.13	0	0	2636
Imazethapyr + pendimethalin (RM) (PRE)	1000	1.68 (2.77)	1(0)	2.74 (7.11)	2.07 (3.44)	93.5	76.9	96	0	0	0	983	2.23	6.3	0	0	2499
Weedy check	-	5.67 (48.1)	3.36 (10.5)	2.61 (5.88)	2.12 (3.53)	0	0	0	0	0	0	519	1.29	7.8	0	0	2575
Two hoeings 20 and 40 DAS	-	5.37 (34.7)	2.28 (4.77)	1.84 (2.66)	1.99 (2.96)	84.0	45.16	0	0	0	0	971	1.51	8.93	0	0	2589
Weed free	-	1(0)	1 (0)	1(0)	1(0)	100	100	100	0	0	0	1161	1.45	7.01	0	0	2664
LSD (P= 0.05)		4.18	1.59	NS	NS	-	-					285		1.88			411

Original figures in parenthesis were subjected to square root transformation ("X+1) before statistical analysis DAS= Days after sowing but per cent control decreased with time and it remained 78% up to 45 DAS. Pre emergence use of pendimethalin 30% EC+ imazethapyr 2% (RM) at 1000 g/ha was very effective with 80% control of weeds even up to 45 DAS without any crop suppression. At 30 DAS, visual weed control was more than 95% in all PPI and PRE treatments of imazethapyr at 70 and 80 g/ha but in post emergence use of similar herbicide it was only 15-40% however, at 60 DAS, WCE decreased in all pre emergence treatments due to emergence of second flush of weeds which appeared due to later rains (Table 1). At 60 DAS, maximum WCE (85%) was recorded with PPI use of imazethapyr at 80 g/ha. Weed control treatments had reflection on weed density, WCE% and seed yield of green gram. Seed yield was maximum (1161 kg/ha) in weed free treatment which was significantly at par with all PPI and PRE treatments but was higher than all post emergence treatments. Maximum B:C ratio of 2.27 was obtained with PPI use of imazethapyr at 80 g/ha.

Residual effect on succeeding mustard crop

Residual toxicity on mustard was more in PPI treatments (90-95%) of imazethapyr but less in PRE and POST applications of various herbicides(Table 1). Mustard crop in these treatments showed significant variation in germination percentage and crop phytotoxicity as compared to untreated check, weed free and two hoeings. Hollaway *et al* (2006) reported a persistence of imazethapyr for more than 3 years. Seed yield in imazethapyr as PPI was also significantly reduced as compared to other treatments. Shaner and Hornford (2005) reported that imazamox and imazethapyr applied as early POE, have residual activity. Imazamox dissipates more rapidly than imazethapyr in the soil. Pre-emergence use of pendimethalin and its ready mix combination at 1000 g/ha did not show any residual carry over effect on mustard crop as germination percentage, crop phytotoxicity percentage in these treatments were similar to weedy check.

CONCLUSION

Post emergence use of imazethapyr and its combination with imazamox at 70 and 80 g/ha caused slight toxicity to green gram in terms of yellowing, bud necrosis and crinkling of leaves which mitigated within 15 days after application but with significant reduction in plant height and seed yield. Application of imazethapyr as PPI at 70 and 80 g/ha reduced germination as well as seed yield of mustard. Pre emergence use of pendimethalin 30% EC+ imazethapyr 2% (RM) at 1000 g/ha was very effective with 80% control of weeds even up to 45 DAS without any crop suppression and no residual effect on succeeding mustard crop.

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Effect of integrated weed management on weeds and productivity of greengram

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Green gram, locally known as *moong* is normally grown during *kharif* and summer seasons. High infestation of weeds at the early stages of crop growth poses considerable threat in achieving the desired yield. Full season competition with the weeds has led to 30-80% reduction in grain yield of mung bean during summer and *kharif* seasons and 70-80% during the spring season. Initial 45 days is considered to be critical period with respect to crop weed competition in green gram. Therefore, inhibiting the growth of weeds during initial growth phase of crop is considered essential for better crop yields. The conventional method of weed control (hoing or hand weeding) is laborious, expensive, insufficient and some times causes damage to crop. Chemical weed control certainly has its merit over the existing methods. Hence, this experiment was planned to find out suitable method of weed management.

METHODOLOGY

A field experiment was conducted at Instructional Farm, Navsari Agricultural University, Navsari Campus, Navsari situated between 20º 57' N latitude, 72º 54' longitude and has an altitude of about 10 m from MSL to study effect of integrated weed management on weeds and productivity of *Rabi* green gram (*Vigna radiata*) during the years 2005-06, 2006-07 and 2007-2008. In all eleven treatments, *viz*. unweeded control (W_0), one hand weeding at 20 DAS (W_1), one hand weeding at 20 DAS + hoeing at 40 DAS (W_2), two hand weedings at 20 and 40 DAS (W_3), two hand weedings along with hoeings at 20 and 40 DAS (W_4), pendimethalin as pre-emergence at 1.0 kg/ha (W_5), pendimethalin as pre-emergence at 1.0 kg/ha + one hoeing at 40 DAS (W_6), pendimethalin as pre-emergence at 0.75 kg/ha + 1 hand weeding at 40 DAS (W_7), pendimethalin as pre-emergence at 0.75 kg/ha + 1 hand weeding and hoeing at 40 DAS (W_8), quizalofop ethyl 40 g/ha as post emergence at 20 DAS (W_9), quizalofop ethyl 60 g/ha as post emergence at 20 DAS (W_{10}) and quizalofop ethyl at 40 g/hapost emergence at 20 DAS + hoeing at 40 DAS (W_{11}) were laid out in randomized block design with three replications. The green gram variety CO 4 was sown at 30 cm apart from row during second week of November. The crop was fertilized with recommended dose of 20-40-0 kg NPK/ha as basal only. All the data obtained from greengram crop for consecutive three years were statistically analyzed using the *f* test. The net realization was calculated by deducting the total cost of cultivation from the gross realization for each treatment. The benefit cost ratio (BCR) was calculated on the basis of the formula given below:

RESULTS

The predominant weed species observed in experimental plots were *Cyperus rotundus* L. (Sedge); *Echinochloa colonum* link, *Brachiaria* sp., *Digitaria sanguinalis*., *Eragrosits major*, *Cynodon dactylon* and *Sorghum halepense* (Monocots); and *Amaranthus viridus* L., *Alternenthera sessilis* L., *Digera arvensis, Convolvulus arvensis, Eclipta alba* L., *Vernonia cinerea, Euphorbia hitra* L., *Phylanthus madraspentesis, Physalis minima* L. *and Trianthema portulacastrum* (Dicots).

Two hand weedings along with hoeing at 20 and 40 DAS (W_4) recoded minimum number of weeds (7.68) and remained at par with the treatment having hand weeding at 20 and 40 DAS (W_3). Similarly lowest dry weight of weeds (4.28 g) was observed in the treatment having two hand weedings along with hoeing at 20 and 40 DAS (W_4) which remained at par with treatments having two hand weeding at 20 and 40 DAS (W_3), pendimethalin as pre-emergence at 0.75 kg/ha + 1 hand weeding and hoeing at 40 DAS (W_8) and pendimethalin as pre-emergence at 0.75 kg/ha + 1 hand weeding at 40 DAS (W_7). However, the highest number of weeds and dry weight were observed in the unweeded treatment (W_0). The highest weed control efficiency (WCE) of 77.7% was recorded under the treatment of two hand weeding along with hoeing at 20 and 40 DAS (W_4) followed by two hand weeding at 20 and 40 DAS (W_3), pendimethalin as pre emergence at 0.75 kg/ha + one hand weeding and hoeing at 40 DAS (W_8) treatments.

Table 1. Weed count/m², dry weight of weed (g/m²) at 60 DAS and WCE (%) as influenced by different weed management treatments in *Rabi* green gram (Pooled data of three years)

Tr. No.	Weed count/m²	Dry weight of weed (g/m²)	WCE (%)	Seed yields (kg/ha)	Weed Index (%)	Haulm yields (t/ha)	HI (%)	Net realization (x103 `/ha)	BCR
W_0	11.33 (129.6)	19.25 (795)	38.73	795	38.73	2.33	25.4	10.70	1.69
W_1	10.88 (118.7)	14.93 (871)	32.83	871	32.83	2.42	26.4	11.78	1.72
W_2	10.57 (112.8)	13.65 (832)	35.84	832	35.84	2.67	23.7	10.10	1.42
W_3	8.16 (67.9)	4.90 (1217)	06.17	1217	06.17	3.39	26.4	18.66	2.54
W_4	7.68 (59.7)	4.28 (1297)	-	1297	-	3.72	25.9	19.94	2.54
W_5	9.57 (92.2)	6.92 (1034)	20.29	1034	20.29	3.09	25.0	14.14	1.75
W_6	9.80 (96.3)	7.00 (1048)	19.20	1048	19.20	3.08	25.4	14.15	1.70
W_7	8.90 (79.7)	5.81 (1061)	18.19	1061	18.19	3.26	24.6	14.66	1.79
W_8	8.66 (79.9)	5.24 (1122)	13.49	1122	13.49	3.37	24.9	15.68	1.86
W_9	10.44 (109.6)	11.99 (885)	31.77	885	31.77	2.88	23.5	11.66	1.56
W_{10}	9.78 (96.7)	8.33 (960)	26.05	960	26.05	2.96	24.5	12.70	1.60
W_{11}	10.07 (102.3)	9.27 (888)	31.54	888	31.54	2.84	23.8	11.45	1.48
LSD (P=0.05)	0.86	1.860		195.9	-	0.59	-	-	-

Note: Data in parenthesis indicate actual value and those outside are $\sqrt{x+1}$ transformed value

Significantly higher seed yield (1297 kg/ha) and haulm yield (3720 kg/ha) were recorded with the treatment having two hand weeding along with hoeing at 20 and 40 DAS (W_4) and was found at par with two hand weeding at 20 and 40 DAS (W_3) and pendimethalin as pre emergence at 0.75 kg/ha + one hand weeding and hoeing at 40 DAS (W_8) for seed yield and two hand weeding at 20 and 40 DAS (W_3), pendimethalin as pre-emergence at 0.75 kg/ha + 1 hand weeding at 40 DAS (W_7) and pendimethalin as pre emergence at 0.75 kg/ha + one hand weeding and hoeing at 40 DAS (W_8) for haulm yield. The response of the different treatments was observed in the order of their significance $W_4 > W_3 > W_8 > W_7 > W_6 > W_5 > W_{10} > W_{11} > W_9 > W_1 > W_2 > W_0$. The treatments having two hand weeding at 20 and 40 DAS (W_3) and pendimethalin as pre emergence at 0.75 kg/ ha + one hand weeding and hoeing at 40 DAS (W_8) recorded the lowest weed competition index (WCI) of 6.17 and 13.49%, respectively. Treatment having one hand weeding at 20 DAS (W_1) recorded maximum harvest index of 26.42% followed by two hand weeding at 20 and 40 DAS (W_3) (26.40%) and two hand weeding along with hoeing at 20 and 40 DAS (W_4) (25.85%).

From the economic point of view, maximum net realization (Rs. 19943/ha) with BCR of 2.54 was realized with treatment having two hand weeding along with hoeing at 20 and 40 DAS (W_4) followed by treatments two hand weedings at 20 and 40 DAS (W_3) and Pendimethalin as pre-emergence @ 0.75 kg/ha + 1 hand weeding and hoeing at 40 DAS (W_8) with net realization of Rs. 18665/ha and Rs. 15688/ha with BCR of 2.54 and 1.86, respectively.

CONCLUSION

From the foregoing discussion, it can be concluded that two hand weedings along with hoeing at 20 and 40 DAS or two hand weedings at 20 and 40 DAS are found most appropriate and profitable weed management practices. However, under the situation of shortage of labourers, pre emergence application of pendimethalin @ 0.75 kg/ha coupled with one hand weeding and hoeing at 40 days after sowing seems to be the good weed management practice as it proved effective and economical weed control measure in *rabi* green gram.

Effect of different post-emergence herbicides on biochemical and physico-chemical properties of rice soil

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Weed management integrates preventive, cultural, mechanical, chemical and biological practices in which the use of herbicides is probably the most important component of the system. Generally herbicides are not harmful when they are applied at recommended levels in soil (Selvamani and Sankaran 1993) but reports are there which envisaged that herbicidal application has adverse effects on bacterial, fungal (Shukla 1997) and actinomycetes population (Rajendran and Lourduraj 1999). Different microorganisms are efficient decomposers of herbicides which are generally aliphatic, hydroxyl and aromatic compounds. They easily decompose the aliphatic and hydroxyl group but decompose aromatic substances at a slower rate. The application of several herbicides may lead to accumulation and develop toxic effects hazardous for humans and the ecosystem. In this experiment a new post emergence herbicide was tested comparing with existing herbicides with and without wetting agent with respect to their ultimate effect on soil microflora. Herbicides with soil activity are still an important component of weed control in rice. The problems caused by the increased application of herbicides call for multidisciplinary approach. Incorrect and indiscriminate application of herbicides affects negatively the health of humans, plants and animals. Particularly hazardous are the poorly degradable herbicides like triazines whose persistence may lead to long-term accumulation. In this experiment different herbicidal combinations were compared with respect to their ultimate effect on soil microflora.

METHODOLOGY

A field study was conducted during summer 2013 at Instructional cum Research farm, IGKV, Raipur in an inceptisol with summer season rice to evaluate the degradation of different post emergence herbicides applied alone or/and in combinations in terms of microbiological and biochemical characteristics of rhizosphere soil. Five different herbicides (bispyribac sodium, metamifop, chlorimuron ethyl, metsulfuron methyl and cyhalofop butyl) were applied individually or in combination at post emergence stage (15 DAS). A wetting agent (agrisol) was also used with some herbicides to increase the efficiency of applied herbicides. Combination of two herbicides i.e. bispyribac sodium and metamifop were also tested at different concentration to find out their suitable dose for optimizing rice yield and environmental safety. All the herbicidal treatments were compared with unsprayed control. The experiment was conducted on summer rice (*Oryza stativa L.*) with test variety MTU-1010. The soil was Inceptisol (pH: 6.29, EC: 0.20 dS/m, organic carbon: 22.33%, available N: 238.336 kg/ha, available P: 9.24 kg/ha, and available K: 252.712kg/ha). The treatments were replicated thrice under randomized block design. Rhizosphere soil was collected at a depth of 7.5-15cm from 13 locations at different stages of crop growth from the same plot and were pooled together for the purpose of analysis. Soil sampling was done at 30, 50 days

Table 1. Effect of post-emergance herbicides on dehydrogenase activity (µg TPF/h/g), acid phospatase activity (µg p-NP/h/g), nitrogen minralization (kg/h) of rhizosphere soil at different growth stages of rice

Treatment	0 DAS			7 DAS			15 DAS			30 DAS			50 DAS			At harvest		
	DA	APA	NM	DA	APA	NM	DA	APA	NM	DA	APA	NM	DA	APA	NM	DA	APA	NM
T1	31.21	121.23	76.02	37.30	129.24	84.64	21.28	113.41	69.81	40.31	104.29	62.90	41.79	169.19	143.47	22.64	112.32	75.32
T2	31.05	120.32	75.13	37.09	128.16	83.27	20.79	111.66	67.95	40.03	101.92	60.70	41.46	168.78	141.89	22.46	110.48	74.58
T3	30.72	119.24	74.63	36.82	127.03	82.31	19.84	109.90	66.50	39.71	99.67	58.63	41.29	167.24	139.93	22.27	109.79	73.96
T4	30.54	117.24	73.75	36.63	125.45	81.17	19.27	105.89	65.15	39.52	94.25	57.09	41.23	162.14	136.14	22.16	108.79	73.52
T5	31.18	120.84	75.74	37.24	128.32	84.10	21.11	112.18	69.06	40.14	102.66	61.99	41.58	168.93	142.33	22.59	110.97	74.89
T6	30.23	115.34	72.36	36.16	123.39	80.89	17.43	103.05	63.46	39.34	90.30	55.27	41.05	161.07	136.03	22.07	107.33	73.17
T7	31.25	121.56	76.39	37.35	129.36	85.19	21.47	113.90	70.60	40.53	104.96	63.95	41.93	169.52	144.79	22.79	112.80	76.03
T8	31.32	121.75	76.72	37.46	129.59	85.69	21.79	114.38	71.41	40.76	105.75	65.11	42.06	169.73	145.08	22.83	113.28	76.23
T9	30.85	119.57	74.85	36.94	127.24	82.78	20.42	110.51	67.17	39.86	100.46	59.58	41.39	168.16	140.48	22.35	110.40	74.21
T10	31.37	121.92	76.90	37.53	129.78	86.02	22.01	114.74	71.99	40.92	106.40	65.87	42.57	169.84	145.77	22.95	113.52	76.82
T11	31.40	122.03	77.14	37.59	130.24	86.52	22.24	115.52	72.63	41.06	107.39	66.61	42.84	169.90	146.02	23.13	114.43	77.02
T12	31.52	122.34	78.21	37.65	130.53	87.96	29.17	121.29	81.23	41.17	156.70	121.97	44.63	174.17	150.24	24.26	115.78	79.21
T13	31.56	122.39	79.85	37.70	130.61	89.81	46.96	138.32	108.64	45.94	164.36	128.76	45.98	178.24	153.51	24.49	117.54	81.34
LSD(P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.47	11.34	7.68	4.82	11.71	7.78	4.70	16.98	15.63	N.S.	N.S.	N.S.

after sowing of crop and at harvest. The soil samples were subject to analysis for dehydrogenase activity, acid phosphatase activity, N minralization, soil pH and electrical conductivity.

RESULTS

Dehydroganase activity

All the herbicides including wetter significantly inhibited the DHA after their application *i.e.* 15 DAS of rice crop. The degree of inhibition was noticed at various levels at 15 DAS. The dehydrogenase activity got reduced with the increasing dose of bispyribac sodium + metamifop (T1 to T4). Among different herbicides cyhalofop butyl 10% EC (T6) exhibited maximum inhibition of dehydrogenase activity and minimum by metamifop 10% EC. Cyhalofop butyl reduced the DHA value from 36.16µg (7 DAS) to 17.43 (15 DAS) soon after its application whereas metamifop reduced the value from 37.59-22.24 µg within the same period. Wetting agent (Agrisol) also reduced the above activity significantly at 15 DAS of its application.

At 30 DAS all the herbicide treatments significantly reduced dehydrogenase activity over control, except the wetting agent. At 50 DAS all the herbicide treatments were found to be at par with unsprayed control except for cyhalofop butyl and bispyribac sodium + metamifop (140 g/ha) which started to degrade at 30 DAS but did not completely degrade at 50 DAS, hence showed their presence by reducing DHA in comparison to control.

At harvest stage all the treatments were found to be at par with control. The study showed that the applied herbicides started to degrade at 30 DAS and completely degraded before 50 DAS except for bispyribac sodium + metamifop (at 140 g/ha) and cyhalofop butyl. The wetter degraded completely before 30 DAS. The residual effect of other herbicides excluding bispyribac sodium + metamifop at 140 g/ha and cyhalofop was 35 DAS.

Acid phosphatase activity

Other herbicides including wetter significantly reduced the APA at 15 DAS. The cyhalofop reduced the APA from 123.39µg (7 DAS) to 103.05 µg (15 DAS) which was further reduced to 90.30µg at 30 DAS. The combined application of bispyribac with metamifop have shown higher inhibitory property next to that of cyhalofop at higher concentration i.e. 140, 70, 56 g a.i./ha. The metamifop alone exhibited least inhibition as it reduced the APA from 130.24 (7 DAS) to 115.52µg (15 DAS) and further to 107.39µg. Wetting agent agrisol has shown inhibitory property at 15 DAS but became ineffective at 30 DAS. At 50 DAS the APA value of all the herbicides treated plot was found at par with unsprayed control except for cyhalofop butyl and bispyribac sodium + metamifop (@ 140 g a.i./ha) which indicated their complete degradation. At harvest stage of crop, all the values of APA in different herbicides treated plots were found at par with control which showed the absence of herbicides molecules and their harmful secondary metabolites in rhizosphere. In unsparayed control plot a continous increment of APA was visualized from 0 to 50 DAS which slightly narrowed down at harvest.

Nitrogen Mineralization

The soil treated with cyhalofop butyl was found in a state of low NM rate at 15 DAS (63.46 kg) in comparison to 7 DAS (80.89 kg). Cyhalofop butyl reduced the NM value from 80.89 kg (7 DAS) to 63.46 kg (15 DAS) with a time span of 8 days. However, herbicide metamifop reduced the above value from 86.52 to 72.63 kg within the same duration. Wetting agent also showed significant impact on NM as it reduced the NM values significantly after its application at 15 DAS. At 30 DAS all the herbicide treatment reduced the NM value over control significantly. At 50 DAS all the herbicide treatments were found to be at par with unsprayed control except for cyhalofop butyl and bispyribac sodium + metamifop (140g/ha) which proved their presence in rhizosphere soil. The nitrogen mineralization study showed that all the applied herbicides started to degrade at 30 DAS and completely degraded before 50 DAS except for bispyribac sodium + metamifop (@ 140g/ha) and cyhalofop which were degraded prior to harvest. This study elucidates that nitrogen mineralization process retarted due to herbicides application but due to detoxification of applied herbicides it became normal before harvest.

CONCLUSION

The dehydrogenase activity dropped upon treatment with herbicides which however started to degrade after 30 DAS and were found at par with unsprayed check plots at 50 DAS indicating complete degradation of applied herbicides except two herbicidal treatment i.e. cyhalofop and bispyribac + metamitop. Herbicide application significantly reduced the Phosphatase activity when applied with wetting agent at 15 DAS the wetter degraded quickly and could not affect PA at 30 DAS. The combined effect of bispyrabac and metamifop which applied at higher dose and individual effect of cyhalofop reduced the NM upto 50 DAS, after that the treatments were found ineffective. However, other herbicides and their combinations have shown their complete degradation on or before 50 DAS. Combined application of bispyribac sodium and metamifop @ 70 g/ha was found to be best treatment considering their effect to optimize crop yield and comparatively less detrimental effect on soil microbial activities.

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Herbicide persistence and its effects on soil microbiological and biochemical properties in rice-chickpea cropping system

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Among rice growing countries, India is having the largest area under rice in the world and its production is next only to China. In Chhattisgarh rice-chickpea is the most popular cropping system in rain fed conditions. In general weeds reduce the crop yield by 31.5% (22.7% in winter and 36.5% in summer and *Kharif* seasons). Labor-saving techniques, such as the replacement of transplanting with direct seeding, have become widespread which may cause weed problems leading to rice yield reductions. Further chickpea as a succeeding crop after rice produces lower yields due to improper nutrient management coupled with very poor weed management. Thus, under this situation herbicide-based weed management is becoming the most popular method of weed control in rice and rice based cropping systems. However, the application of several chemicals may lead to synergy and development of toxic effects hazardous for humans and the ecosystem (Michaelidou *et al* 2000). In this experiment an attempt has been made to evaluate the persistence of different herbicides applied in rice-chickpea cropping system using microbiological techniques as a tool.

METHODOLOGY

A field study was conducted during 2010 to 2014 in Instructional cum Research Farm, IGKV, Raipur and in the fourth year degradability of different *Kharif* and *Rabi* herbicides were assessed in terms of microbial and biochemical characteristics of herbicide treated soil while comparing with hand weeded herbicide free condition in chickpea grown field after harvest of rice. Six different herbicides oxadiargyl as pre-emergence *fb* bispyribac as post-emergence herbicides at 80.00 g - 200.00 g/ha, respectively; pyrazosulfuron applied at early post-emergence stage (8 DAS) at 25 g/ha and tank mixed combination of fenoxaprop and chlorimuron-ethyl +metsulfuron-methyl applied at post-emergence stage at 60.00 g and 25.00 g/ha, respectively were applied in rice. Similarly pendimethalin was sprayed at1kg/ha as pre-emergence herbicide in chickpea crop. The experiment was conducted on *Kharif* rice with test variety MTU-1010 and chickpea in *Rabi* with test variety JG-130. The treatments were replicated thrice under split plot design during *Rabi*. Soil samples were collected at a depth of 7.5-15 cm at 0, 30, 50 days after sowing and harvest stage of crop. The soil samples were subject to analysis for microbial biomass carbon, basal respiration rate, phosphatase and dehydrogenase activity, population of total diazotrophs and phosphate solubilizing bacteria.

RESULTS

Application of fenoxaprop-p-ethyal, chlorimuron-ethyl and metsulfuron-methyl which were applied at post emergence stage (22 DAS) of rice crop significantly reduced the basal soil respiration rate (BSR), dehydrogenase and acid phosphatase enzyme activity (DHA and AP), microbial biomass carbon content (MBC) and in rhizosphere soil of succeeding chickpea crop grown in *rabi* up to the time of sowing of chickpea crop (Table 1). From 30 DAS of chickpea, the effect of above applied herbicides on above studied parameters could not observed. The data on population of total free N-fixers, number and biomass of chickpea nodules declined after applied herbicides in rhizosphere of chickpea crop as the number and dry weight of chickpea nodules (recorded at 50 DAS) did not vary significantly due to *kharif* treatments. The study further envisaged that application of pendimethalin in chickpea significantly reduced the values of BSR, DHA,AP, MBC and population of total free N-fixers in rhizosphere soil of chickpea crop after its application and the effect was found up to 30 DAS. No residual effect of above applied herbicide was observed on the above studied parameters at 50 DAS in comparison to farmers' practice. Application of pendimethalin did not affect the number and biomass of chickpea nodules which was recorded at 50 DAS.

Table 1. Effect of long term herbicidal trial in direct seeded rice-chickpea cropping system on basal soil respiration rate (mgCO_2/h/100g soil) and Dehyrogenase activity (µgTPF/h/g soil) of rhizosphere soil of Chickpea

Treatment	0 DAS		30 DAS		50 DAS		At harvest	
	BSR	DHA	BSR	DHA	BSR	DHA	BSR	DHA
Main plot background in Kharif								
Oxadiargyl fb Bispyribac	0.148	38.32	0.225	63.52	0.346	83.14	0.152	39.21
Pyrazosulfuron (EPOE)	0.154	39.16	0.229	64.17	0.355	84.43	0.158	41.96
Fenoxaprop-p-ethyalandChlorimuron-ethyl + Metsulfuron-methyl	0.115	34.37	0.223	62.83	0.338	82.13	0.148	38.76
Hand weeding twice	0.157	39.76	0.234	65.24	0.359	87.23	0.163	42.63
Unweeded	0.169	40.12	0.236	65.42	0.361	90.17	0.165	43.36
LSD (P= 0.05)	0.013	3.92	0.011	2.55	N.S.	N.S.	N.S.	N.S.
Sub-plot (Weed control)								
Farmer's practice	0.148	38.34	0.274	80.92	0.355	85.29	0.157	41.05
Pendimethalin @ 1.0 kg/ha	0.148	38.15	0.132	30.59	0.332	81.24	0.153	40.66
Control	0.151	38.56	0.281	81.21	0.369	89.73	0.161	41.83
LSD (P=0.05)	N.S.	N.S.	0.020	5.76	0.034	7.19	N.S.	N.S.

BSR: Basal soil respiration rate DHA: Dehydrogenase enzyme activity; DAS = Days after sowing

CONCLUSION

Residual effects of Fenoxaprop-p-ethyl, Chlorimuron-ethyl and Metsulfuron-methyl, (applied in *kharif* rice) were observed during *rabi* experimentation up to sowing time of chickpea. Application of herbicides did not affect the number and biomass of nodules which were recorded at 50 DAS. Farmers' practice was found to be better as it increased dry weight of nodules over weedy check recorded at 50 DAS.

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Efficacy of herbicides on survival of *Bradyrhizobium japonicum in-vitro*

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Soybean (*Glycine max* (L.) Merrill.) is commonly grown in Vidarbha region of Maharashtra and farmers are using biofertilizers to reduce the cost on cultivation. Herbicide use is an integral part of soybean production for controlling weed infestation because of scarcity of labour. It may influence nodulation and biological nitrogen fixation in legumes by affecting rhizobia. There is a need to study possibility of the direct effect of herbicides on *Bradyrhizobium japonicum*. Reduction in nodulation can be due to herbicidal injury to the plant from direct action of the herbicides on *Bradyrhizobium japonicum* population in the soil. Therefore, the present investigation was undertaken to examine the effect of different concentrations of the herbicides on survival of *Bradyrhizobium japonicum.*

METHODOLOGY

Three day old culture of *Bradyrhizobium japonicum* was used for inoculation. Yeast Extract broth was prepared and autoclaved at 121^0C for 15 minutes. Herbicides solutions were made in autoclaved distilled water and inoculated with *Bradyrhizobium japonicum*. Broth with no inoculation with herbicides was served as control. The flask was then put in rotary shaker at 27 ± 2^0C. The growth of rhizobia was measured after incubation for optical density at 650 nm with a spectrophotometer.

RESULTS

Bradyrhizobium japonicum was evaluated for tolerance to herbicides, *viz.* Fluchloralin, Pendamethalin,Imazethapyr and Alachlor at three concentrations. The data generated during the experiment is tabulated in Table 1. It was revealed from the data that there were significant differences on survival of *Bradyrhizobium japonicum* at 24, 48 and 72 hrs after inoculation over untreated control. At 24 hrs maximum 96.33 x 10^7/ml CFU population was recorded by the treatment pendamethalin (10µ/l) and was found significantly superior over all other treatments. However, at 48 hrs fluchloralin (10 µ/l) was significantly followed by pendamethalin (20µ/l) which recorded 16.7 x 10^7 CFU and was at par with pendamethalin (10µ/l) recording 16.6 x 10^7 CFU. There was a reduction in rhizobial colonies from 24-72 hrs linearly. This may have occured due to death of bacteria. Mishra and Bhanu (2006) reported severe reduction and alteration in protein and toxic assimilation variation in cells of harmful strains due to herbicides variation in rhizobial cell. Similarly significant changes in optical density were recorded and highest optical density of 1.30 was observed with fluchloralin (10µ/l) followed by fluchloralin (20µ/l). These results are in conformity to the findings of Yadav *et al* (1990).

Table 1. Effect of different herbicides on survival of *Bradyrhizobium japonicum*

Treatment	CFU(x10^7) after			Optical density
	24 Hrs.	48 Hrs.	72 Hrs.	
Fluchloralin (10/µl)	95.66	13.50	16.7	1.31
Fluchloralin (20/µl)	94.60	12.30	15.5	1.30
Fluchloralin (30/µl)	90.33	11.36	15.2	1.24
Pendamethalin (10/µl)	96.33	11.23	16.6	0.71
Pendamethalin (20/µl)	87.33	12.63	16.3	0.69
Pendamethalin (30/µl)	75.66	11.96	14.6	0.66
Imazethapyr (10/µl)	93.66	11.70	14.2	0.66
Imazethapyr (20/µl)	87.66	11.96	13.4	0.66
Imazethapyr (30/µl)	78.00	11.76	13.0	0.66
Alachor (10/µl)	80.66	12.30	12.8	1.04
Alachor (20/µl)	74.33	11.20	11.7	0.89
Alachor (30/µl)	71.33	10.70	10.7	1.06
Untreated control	61.66	7.90	8.66	1.33
LSD (P=0.05)	9.50	1.38	0.83	0.10

CONCLUSION

It is concluded from the present investigation that fluchloralin (10µ/l) was found beneficial for *Bradyrhizobium japonicum* survival *in-vitro*.

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Leaching behaviors of oxyfluorfen and oxadiargyl in red and black soils

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Movement of pesticides through soil is an important process that determines their fate in both soil and aquatic environment and has a direct implication on ground water contamination and pollution. Information pertaining to leaching potential of oxyfluorfen and oxadiargyl in red and black soils is scanty. Hence, the present experiment was conducted.

METHODOLOGY

Leaching studies were done under simulated field conditions with PVC pipes (diameter 10 and 65 cm length) and using them as soil columns by filling soil collected (horizon wise)from the field. The columns were pre-conditioned with water. Oxyfluorfen (100 g and 125 g/ha respectively) and oxadiargyl (200 g and 250 g/ha) were applied to the surface diluted with 5.0 ml of water. Quantity of herbicide added was at recommended (X-dose) and double the recommended doses (2X dose) equated to surface area of the column. Water was added to the surface of the column equal to the rainfall of the period.Blank columns were maintained for comparison.After 7 days, columns were opened, sampling was done from each 5 cm depth up to 30 cm depth and thereafter from each 10 cm depth up to 60 cm.

Residues of oxadiargyl and oxyfluorfen in soil were analyzed according to the procedure outlined by Shi *et al.* (2010) and Sankaran *et al.* (1993), respectively.

RESULTS

Oxyfluorfen

Retention time of oxyfluorfen was 9.17 min. Recovery varied from 90.2-94.8%. LOD was 0.005 mg/kg and LOQ was 0.025 mg/kg. In red soils, oxyfluorfen applied to surface leached up to 5-10 cm and 10-15 cm in X and 2X doses, respectively. In X dose, depth wise distribution showed that 60.6% of the total herbicide was detected in the top 0-5 cm layer of soil and remaining 39.4% in 5-10 cm layer. At 2X dose, 50.44% of the herbicide was detected in the top 0-5 cm layer. In the 5-10 and 10-15 cm soil layers 30.97-18.59% residues could be detected. At both the doses, of herbicide application, the residues could not be detected beyond 15 cm depth. In Black soils, oxyfluorfen soil leached up to 10 cm depth in X and 2X treatments. Layer wise distribution at X-dose showed that 71.83% of the total herbicide was detected in the top 0-5 cm layer of soil and remaining 28.17% in the 5-10 cm layer. At 2X dose, also similar distribution was noticed. In both soils at two levels of application, the residues could not be detected beyond 15 cm depth.

Table 1. Oxyfluorfen and oxadiargyl residue leaching to different depths in red and black soils

Depth	Oxyfluorfen (mg/kg)				Oxadiargyl (mg/kg)			
	Red soils		Black soils		Red soils		Black soils	
	X dose	2 X dose	X dose	2 X dose	X dose	2 X dose	X dose	2 X dose
0-5	0.040	0.057	0.051	0.069	0.037	0.051	0.046	0.071
5-10	0.026	0.035	0.020	0.027	0.022	0.031	0.018	0.024
10-15	BDL	0.021	BDL	BDL	BDL	0.019	BDL	BDL
15-20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20-25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25-30	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
30-40	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
40-50	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
50-60	BDL	BDL	BDL	BDL	BDL	BD L	BDL	BDL

BDL: Below detection limit (0.025 mg/kgfor oxyfluorfen and 0.015 mg/kgin oxadiargyl)

Oxadiargyl

Retention time of oxadiargyl was 6.95 min. Recovery of in the soil varied from 86.8-90.2%. LOD was 0.005 mg/kg and LOQ was 0.015 mg/kg. In red soils, oxadiargyl leached up to 5-10 cm and 10-15 cm in X and 2X doses, respectively. In X dose, 62.71% of the total herbicide detected in the top 0-5 cm layer and 37.29% in 5-10 cm layer. At 2X level 50.49% of the herbicide was detected in the top 0-5 cm layer. In the 5-10 and 10-15 cm soil layers, 30.69% and 18.81% residues could be detected, respectively. At both the levels of herbicide application, the residues could not be detected beyond 15 cm depth. Oxadiargyl applied to surface of the black soil leached up to 10 cm depth in both X and 2X dose treatments. In the top 0-5 cm and 5-10 cm layer 71.87-28.13% residues could be detected. At both the doses of herbicide application, the residues could not be detected beyond 10 cm depth in black soils.

CONCLUSION

Higher concentration of the oxyfluorfen and oxadiargyl in the top 5 cm layer of the soil indicated strong affinity of the herbicide molecules with the clay/organic matter in the soil surface horizon. The herbicide retained in the top layer was higher in the black soil compared to the red soil which could be due to higher active clays in the black soils (smectitic) and higher clay content in the surface soils compared to the red soils.

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Dissipation and persistence of quizalofop-p ethyl in soil, plant and grain in sesamum and its effect on soil properties

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Quizalofop-P-ethyl, Ethyl (2*R*)-2-[4-(6-chloroquinoxalin-2-yloxy) phenoxy] propionate, is a (*R*(+) enantiomer of quizalofop-ethyl (racemic mixture of *R* (+) and *S* (-) enantiomers) and this molecule is used as a selective, post-emergence phenoxy herbicide. In Andhra Pradesh, quizalofop-P-ethyl is extensively used in several crops like sesamum, soybean, vegetable etc, and also as tank-mix combination with pyrithiobac sodium for control of grassy weeds in cotton. Consumption of quizalofop has increased to 80000 l/ annum (2013) from the 17000 l/annum during 2008 (APPMA, 2013). Research work on persistence of quizalofop is scanty. Hence, the experiment was planned to study the persistence and field dissipation patterns of this herbicide applied at different rates to sesamum.

METHODOLOGY

A field experiment was conducted in an Alfisol during *Kharif*-2011 and 2012 at the College Farm, ANGRAU, Hyderabad. Experiment laid out in randomized block design with seven treatments comprising different doses of the quizalofop-P ethyl 5% EC (25 g/ha, 37.5 g/ha,50 g/ha, 75 g/ha, 100 g/ha) applied as post-emergence spray at 20 DAS compared with unweeded control and hand weeding treatment (20 and 40 DAS) and replicated thrice.

Collection of soil samples

Soil samples were collected at 0, 1, 3, 8, 15, 30, 45 days after application of herbicide (DAA) and at harvest time. Sesamum seed and plant samples were also collected at harvest.Soil samples collected before sowing and at harvest were analyzed for their physical, chemical and physico-chemical properties and organic carbon to assess changes in soil properties by employing the standard procedures.Quizalofop-p ethyl residues in the soil and sesamum samples were analyzed employing the procedures outlined by Jiye Hu *et al.* 2010.

RESULTS

Recovery of the herbicide in soil was 92.6-98.5%. In the seed and plant, the recovery was 87.5-94.6% and 90.8-94.4%, respectively. Limit of Quantification (LOQ) was 0.01 mg/kg.

There were no significant changes in soil physical (texture, bulk density, particle density, pore space, MWHC), physico-chemical (pH, EC, CEC, OC) and available N, P and K due to application of quizalofop-p-ethyl.

Persistence of quizalofop-p ethylin the soil samples could be detected up to 45 DAAin recommended dose (50 g/ha) treatment. The residues reached the BDL (0.01 mg/kg) after 45 DAA. When sub-optimal doses (25.0 g/haand 37.5 g/ha) were used, persistence in the soil was shorter (15 and 30 DAA, respectively). Persistence upto 45 and 60 DAA respectively at 75 g/ha and 100 g/ha.

By plotting Concentration against time it was found that, quizalofop-p ethyl dissipation in soil followed a first-order (pseudo first-order) decay process ($C=C_o exp^{-kd.t}$). Dissipation trends at different doses of application were following.

37.5 g/ha $y = 0.028e^{-0.03x}$ $R^2 = 0.927$ —— (1)

50 g/ha $y = 0.036e^{-0.03x}$ $R^2 = 0.925$ —— (2)

75 g/ha $y = 0.050e^{-0.03x}$ $R^2 = 0.989$ —— (3)

100 g/ha $y = 0.055e^{-0.02x}$ $R^2 = 0.981$ —— (4)

Using the above exponential equations (1, 2, 3 and 4) the half- life was calculated. Half-life (DT_{50}) at 100 g/ha was 27.48 days. DT_{50} was 21.16 days at 75 g/ha dose. At 37.5 g/ha dose and recommended rate of application (50 g/ha) half-lifewas 17.62 days and 19.96 days respectively. Dissipation trends indicated that with increasing doses of quizalofop p ethyl the increased half-life. Residues of quizalofop p ethyl in the sesamumplant and seed at the time of harvest were below the detection limit of 0.01 mg/kg.

Table 1. Residues of quizalofop-p ethyl (mg/kg) in soil samples (mean of two years) collected at different intervals after application of the herbicide

Treatment	Residues of quizalofop-p ethyl at different days after application								
	0	1	3	8	15	30	45	60	Harvest
Q-P-E at 25.0 g/ha	0.026	0.023	0.02	0.017	0.012	BDL	BDL	BDL	BDL
Q-P-E at 37.5 g/ha	0.033	0.028	0.025	0.018	0.014	0.01	BDL	BDL	BDL
Q-P-E at 50.0 g/ha	0.042	0.04	0.031	0.026	0.018	0.016	0.01	BDL	BDL
Q-P-E at 75.0 g/ha	0.053	0.051	0.046	0.036	0.027	0.019	0.01	BDL	BDL
Q-P-E at 100.0 g/ha	0.061	0.059	0.051	0.042	0.031	0.023	0.016	0.011	BDL
Control	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hand weeding	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Residues in grain, straw (harvest): BDL (Below Detectable Limit) Detectable Limit: 0.01 mg/kg

CONCLUSION

Persistence of quizalofop-p ethyl residues in the soil samples could be detected up to 45 DAA in recommended dose (50 g/ha) with a half-life of 17.6 days.Residues of quizalofop- p ethyl in the sesamum plant and seed at crop harvest were below the detection limit of 0.01 mg/kg.

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Leaching and persistence of metribuzin in tomato growing Soils

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Application of herbicides for control of weeds has become an integral and indispensable part of modern day agriculture. The fate of soil applied herbicide is dependent on adsorption, desorption and persistence. Metribuzin is selectively used predominantly as a post emergence herbicide in tomato. So, there could be a possibility of residues of herbicide entering into tomato fruits. As the available information regarding persistence of metribuzin in soils and tomato is scanty and meager, the present study was taken up.

METHODOLOGY

Soil samples were collected from three tomato growing farmer's fields sprayed with metribuzin at 525 g/ha as post emergence at 15-20 DAT from different depths (0-10 cm, 10-20 cm and 20-30 cm) and three fruit samples were also collected from the same farmer's fields, samples were stored in -20^{0}C freezer for analysis.

Meteribuzin residues in the soil samples were extracted using the procedure outlined by Bedmer *et al.* 2004. In fruit samples residues were assessed using the procedure as described by "Manual of Pesticide Residue Analysis, Eds Hans-peter Their and Jochen Kirchhoff of Pesticide Commission."

RESULTS

The recovery of the metribuzin in the soil samples varied between 87.5-89.6%, whereas in the tomato fruit sample the recovery percentage of 93.3-97.6% was recorded. Retention time of metribuzin was 6.95 min. LOD was 0.02 mg/kg and LOQ was 0.05 mg/kg.

Initial concentration of metribuzin in the surface samples (0-10 cm on 0 days) in the soils varied between 0.343-0.386 mg/kg. No residues of metribuzin could be detected in the 10-20 and 20-30 cm layer soil samples. At 15 DAA, highest metribuzin concentration in the 0-10 cm layer was reported in clay soil (Farmer-2) and lowest was recorded in sandy loam soil (Farmer-3). However, significant leaching of the applied herbicide into the deeper layers was recorded in the lighter soils of farmer-3 (0.126 mg /kg) and the corresponding residue concentration in case of farmer-1 and farmer-2 were 0.079 and 0.056 mg/kg, respectively. Distributions of metribuzin in different soil layers indicated the potential mobility of the applied metribuzin to the soils. Higher concentration of the metribuzin in deeper layers in case of the lighter soils (farmer-3) indicated the lesser adsorption due to lower clay and organic carbon content compared to the other soils.

At 30 DAA, metribuzin detected in the surface layer varied from 0.065 mg/kg (farmer-3) to 0.124 mg/kg(farmer-2). Metribuzin could not be detected in the 20-30cm layer in the samples drawn from farmer 1 and 2. This could be stronger sorption of the herbicide with the higher amount of the clay present in the soil of farmer-2. No leaching of residue could be observed into deeper layers at 45 DAA. Surface soil concentration of metribuzin varied from 0.056 to 0.082 mg/kg.No metribuzin could be detected in soils of Farmer-3 at 60 DAA. Whereas the residues of the metribuzin could be detected in the other two soils at 60 DAA, beyond which they reached BDL.

Table 1. Persistence of metribuzin in farmer's fields

Days after application	Metribuzin residues (mg/kg)								
	Farmer-1			Farmer-2			Farmer-3		
	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm
0	0.386	BDL	BDL	0.343	BDL	BDL	0.375	BDL	BDL
15	0.146	0.079	0.052	0.156	0.056	0.052	0.074	0.126	0.075
30	0.102	0.055	BDL	0.124	BDL	BDL	0.065	0.053	BDL
45	0.072	BDL	BDL	0.082	BDL	BDL	0.056	BDL	BDL
60	0.056	BDL	BDL	0.066	BDL	BDL	BDL	BDL	BDL
Harvest(85 d)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Farmer-1 (pH =7.12, EC=0.056 dS/m, OC= 0.53%, Clay=21.12, texture; sandy clay loam)

Farmer-2 (pH =8.06, EC=0.124 dS/m, OC= 0.49%, clay=33.46, texture: Clay loam)

Farmer-3 (pH =6.74, EC=0.065 dS/m, OC= 0.32%, clay=16.46, sandy loam)

Metribuzin residues in tomato samples collected at the time of harvest was below the detection limit of 0.05 mg/kg. The MRL for metribuzin in tomato is 0.05 mg/kg (GAIN, 2010).

CONCLUSION

Metribuzin persisted in the soils upto 60 DAA in 1 and 2 samples and 45 DAA in 3rd sample. Metribuzin residues in tomato samples collected at the time of harvest were below the detection limit of 0.05 mg/kg.

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Effect of pre-emergence herbicides on soil bacterial propulation in inceptisols

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Microorganisms occupy a unique position in biological cycles in terrestrial habitats, as they are essential for maintaining of soil fertility and plant growth. In agriculture, weeds often pose a major threat to crop yield. The use of pre-emergence herbicides makes the herbicidal weed management more acceptable to farmers. The presence of herbicide residues in soil could have direct impacts on soil microorganisms which is a matter of great concern. It has been reported that some microorganisms were able to degrade the herbicide, while some others were adversely affected depending on the application rates and the type of herbicide used (Sebiomo *et al*., 2011). Therefore, effects of herbicides on microbial growth, either stimulating or depressive, depend on the chemicals (type and concentration), microbial species and environmental conditions (Zain *et al*. 2013). The precise assessment of the potential non-target effects of herbicides on soil microorganisms is of growing interest. The study was framed to assess the effects of commonly used herbicides on soil microorganisms in Inceptisols.

METHODOLOGY

The incubation study was carried out in the laboratory under ambient conditions at field capacity moisture. The moisture content of soil at field capacity was 42%. The graded levels of pre-emrgence herbicides, *viz*. oxyfluorfen, alachlor, fluchloralinand and pendimethalin were applied as half of the recommended dose, recommended dose and double of recommended dose at field capacity. Periodical soil bacterial population was recorded at 10, 20, 30 and 60 days after herbicide application.

RESULTS

The soil bacterial population was more in all the treatments at 10 days of incubation. It gradually decreased at 20, 30 and 60 days of incubation. The periodical soil bacterial populations were numerically higher in pre- emergence application of alachlor. It was followed by fluchloralin and pendimethalin. The pre emergence oxyfluorfen herbicide recorded the least soil bacterial population. Similar observations were also recorded by Ponnuswamy *et al*. (1997).

The use of alachlor at 1.0, 2.0 and 4.0 kg/ha recorded higher soil bacterial population at 10 days of incubation (61.58, 61.32 and 62.49 x 10^4cfu/g soil respectively) followed by fluchloralin at 0.75, 1.5 and 3.0 kg/ha (58.86, 58.69 and 57.73 x 10^4cfu/g soil respectively). However, control treatment recorded the highest microbial population (60.58 x 10^4 cfu/g soil) at 10^{th} days of incubation. The soil bacterial population decreased with an advanced incubation period. The trend of soil bacterial population was similar at 20, 30 and 60^{th} days of incubation to that at 10^{th} days of incubation by the use of pre-emergence herbicides.

Table 1. Effect of pre emergence herbicideson perodical soil microbial population in inceptisol soil under laboratory condition

Treatment	Soilmicrobial population (x10^4 CFU/g soil)			
	10 days	20 days	30 days	60 days
Oxyfluorfen at 0.5 kg/ha	54.14	44.56	30.44	25.30
Oxyfluorfen at 1.0 kg/ha	54.46	43.31	30.89	23.83
Oxyfluorfen at 2.0 kg/ha	55.85	45.11	31.44	20.75
Alachlor at 1.0 kg/ha	61.58	49.93	36.37	37.93
Alachlor at 2.0 kg/ha	61.32	48.21	35.17	34.83
Alachlor at 4.0 kg/ha	62.49	49.55	34.59	33.58
Fluchloralin at 0.75 kg/ha	58.86	45.69	34.14	32.27
Fluchloralin at 1.50 kg/ha	58.69	47.45	33.17	30.04
Fluchloralin at 3.0 kg/ha	57.73	49.71	34.86	31.18
Pendimethalin at 0.75 kg/ha	56.93	43.89	33.39	28.29
Pendimethalin at 1.50 kg/ha	58.59	45.58	31.83	26.13
Pendimethalin at 3.0 kg/ha	58.59	44.73	32.41	25.19
Control	60.86	59.41	36.95	39.41
Intial	22.69			

CONCLUSION

The soil bacterial population was influenced by level and type of pre-emergence herbicide and it decreased with advanced days of incubations by the pre-emergence herbicides.

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Adsorption, desorption and quantity-intensity relationship of pre-emergence herbicides in inceptisols

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In recent years there has been an increased use of herbicides for effective weed management in crops. The adsorption, desorption and interactions of herbicide are the most significant processes influencing persistence, movement and efficacy of herbicides in soils. It is, therefore, essential to generate information on behaviour of herbicides in soils.

METHODOLOGY

The laboratory study was carried out on adsorption, desorption and quantity-intensity relationship of pre-emergence herbicide on Inceptisol. The concentration of pre-emergence herbicides *viz.* pendimethalin, alachlor, fluchloralin and oxyfluorfen used was 1, 5, 10 and 25 mg/ kg of soil. Ten gram of soil was shaken with 20 ml of working solution separately prepared in acetone solution *viz.* 1, 5, 10 and 25 g/g of soil. After 4 hr equilibration, treated soils were centrifuged for 5 min at 1000 rpm. Ten ml of aliquot were taken for herbicide content by gas chromatography method. The pre-emergence herbicides adsorbed were calculated by difference in concentration of the herbicide originally present in equilibrating solution from that after equilibration. The pre-emergence herbicide desorption characteristics of soil were determined by method adopted by Wahid and Sethunathan (1978). Soil samples equilibrated with 20 ml of 5 g/g pre-emergence herbicide were centrifuged and 10 ml of aliquot was taken out separately for analysis. The samples were resuspended with the help of shaker and equilibrated for 2 hours. Distilled water washings was analysed separately for pre-emergence herbicide.The adsorption isotherm was obtained by plotting data of adsorbed herbicide against equilibrating concentrations. The isotherm data were interpreted in terms of Freundlich equation.

RESULTS

The adsorption of pre-emergence herbicide varied by the equilibrium concentration in solution and not by the types of herbicides (Table 1). The adsorption of pre-emergence herbicide increased with increased concentration in equilibrating solution irrespective of pre-emergence herbicide (0.78, 4.57, 9.67 and 23.27 ìg/ml in 1, 5, 10 and 25 ìg/ml concentration of pre-emergence herbicide, respectively). Adsorption of herbicide irrespective of concentration was numerically more in pendimethalin (9.67 ìg/ml) followed by fluchloralin (9.65 g/ml) and alachlor (9.52 ìg/ml). The adsorption of herbicide associated with polarity power of exchangeable cations and hydrogen bonding between C=O, functional group, carboxyl oxygen and amide nitrogen was assumed to contribute to bond formation between clay and herbicide (Weiping *et al*. 2000).

The initial values of adsorbed herbicide were numerically higher in pendimethalin(48.95 g /10g of soil) followed by fluchloralin, alachlor and oxyfluorfen (42.25, 44.90 and 42.75 g/10g of soil, respectively). The total desorption of herbicide was the least in oxyfluorfen (5.646 g/10g of soil) followed by pendimethalin (6.658 g/10g of soil) and the highest in fluchloralin (7.740 g/10 g of soil) followed by alachlor (6.470 g/10g of soil).

The quantity (K) and intensity factor (1/n) of Freundlich adsorption constant were calculated by regression equation of Freundlich isotherm (Table 3). The K values which are the measure of the capacity factor were almost in order of combined adsorption capacities of pre-emergence herbicides viz., fluchloralin, alachlor and oxyfluorfen. The intensity factor measured by 1/n does not vary greatly in pre-emergence herbicides oxyfluorfen (0.83) and alachlor (0.84), and similarly, in fluchloralin (0.90) and pendimethalin (0.90). The difference in quantity and intensity might be due to soil system composition of silicate and organic matter which was highly heterogenous and hence, constant losing their inherent meaning.

Table 1. Adsorptionof differentpre-emergence herbicidein Inceptisol Soil

Pre–emergence herbicide	Herbicide adsorbed (µg/g)				
	Herbicide Concentration in equilibrating solution (µg/ml)				
	1	5	10	25	Mean
Oxyfluorfen	0.745	4.400	9.505	23.110	9.440
Alachlor	0.754	4.490	9.645	23.185	9.519
Fluchloralin	0.785	4.525	9.710	23.220	9.560
Pendimethalin	0.838	4.895	9.830	23.574	9.652
Mean	0.780	4.572	9.672	23.272	

Table 2. Desorption of different pre-emergence herbicide in Inceptisol Soil

Pre-emergence weedicide	Herbicide adsorbed (µg/10g soil)	Herbicide desorbed (µg/10g)				Per cent desorption
		Washing I	Washing II	Washing III	Total	
Oxyfluorfen	42.75	3.521	1.287	0.838	5.646	13.21
Alachlor	44.90	3.982	1.595	0.893	6.470	14.41
Fluchloralin	45.25	4.22	2.602	0.925	7.740	17.11
Pendimethalin	48.95	3.641	1.435	0.982	6.058	12.37

Table 3. Freundlich equations and adsorbtion constant of different pre-emergence herbicides in inceptisol soil

Pre-emergence weedicide	Freundlich Equation	Freundlich adsorption constant	
		K	1/n
Oxyfluorfen	$X/m=0.62\ C^{0.83}$	0.62	0.83
Alachlor	$X/m=0.60\ C^{0.84}$	0.60	0.84
Fluchloralin	$X/m=0.67\ C^{0.90}$	0.67	0.90
Pendimethalin	$X/m=0.68\ C^{0.90}$	0.68	0.90

CONCLUSION

The adsorption of pre-emergence herbicide was in the ascending order of oxyfluorfen, alachlor, fluchloralin and pendimethalin. Equilibrium solution concentration was more in oxyfluorfen and alachlor. The desorption was more in fluchloralin. The quantity (K) was in order of combined adsorption capacity of pre-emergence herbicides, *viz.* fluchloralin, alachlor and oxyfluorfen.

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Efficacy of oxyfluorfen on weeds in groundnut and its residual effect on succeeding crops

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Groundnut or peanut is known as the '*king* of oilseeds'. Weed infestation is an important limiting facor in achieving potential productivity of groundnut especially of bunch type varieties which have prostrate growth and consequently poor competitive ability. Groundnut cannot compete effectively with weeds, particularly 3 to 6 weeks after sowing and therefore, early removal of weeds is important before flowering and during pegging (Solanki *et al.* 2005). Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop production. Bioassay remains a major tool for qualitative and quantitative determination of herbicide residues in soil. Detection of the oxyfluorfen herbicide in soil can be done by bioassay which measures the biological response of a living plant to that particular herbicide.

METHODOLOGY

With a view to determine the residual effect of herbicide applied to *kharif* groundnut on succeeding *rabi* sunflower and pearlmillet crops, the present study was carried out during *kharif* season of 2009-10 and 2010-11 at Agricultural Research Station, Bhavanisagar, Tamil Nadu Agricultural University. Treatments consisted of pre-emergence application of already registered Oxyfluorfen (goal) at 200 g/ha, new formulation of Oxyfluorfen (23.5% EC) at 150, 200, 250, 300 and 400 g/ha, Pendimethalin 0.75 kg/ha + Hand weeding on 45 DAS, Pendimethalin 0.75 kg/ha + Rotary weeding on 45 DAS, Hand weeding twice on 25 and 45 DAS and unweeded check. Groundnut crop was harvested on first week of October during both the years. After harvesting of the groundnut crop to know the residual effect of herbicides, without disturbing the layout of each plot was manually prepared for sowing of succeeding crops. Seven rows of each succeeding sunflower and pearlmillet were sown in each plot in *rabi* season.

RESULTS

In groundnut, among the weed control treatments, PE application of oxyfluorfen at 250 g/ha recorded higher pod yield of 2.05 and 2.04 t/ha during 2009 and 2010 respectively, due to better control of weeds at critical stages thus providing favourable environment for better growth and development leading to enhanced pod yield. According to the findings of Solanki *et al.* (2005) the pod yield of groundnut was higher with PE application of herbicides due to reduced crop weed competition in early stage than POE application of the same herbicides. Bioassay study results revealed that the plant stand of sunflower ranged from 84-89% and pearlmillet from 87-94% under all the treatments at 10 DAS. Further, plant height and dry weight of plants recorded at 30, 60 and 90 DAS were also unaffected due to residual effect of different doses of oxyfluorfen applied in groundnut. Yield of sunflower and pearlmillet showed no distinct variation due to different doses of oxyfluorfen (Table 1). This result is in line with the results of Jayakumar (2010) who reported that, PE application of oxyfluorfen in tea at higher doses of 300 and 400 g/ha did not leave any residue in the soil and there was no toxic effect beyond 60 days.

Table 1. Residual effect of herbicides on the germination (%), dry matter production (kg/ha) and yield of succeeding crops of groundnut

Treatment	Sunflower						Pearl millet					
	Rabi 2009			*Rabi* 2010			*Rabi* 2009			*Rabi* 2010		
	Germ. (%)	30 DAS	Seed yield (kg/ha)	Germ. (%)	30 DAS	Seed yield (kg/ha)	Germ. (%)	30 DAS	Grain yield (kg/ha)	Germ. (%)	30 DAS	Grain yield (kg/ha)
T_1 - PE oxyfluorfen (Goal) at 200 g/ha	66.58(84.2)	212	938	64.79(81.9)	225	924	72.04(90.5)	260	715	71.31(89.7)	252	722
T_2 - PE oxyfluorfen at 150 g/ha	69.29(87.5)	209	871	68.16(86.2)	218	857	74.21(92.7)	244	654	69.59(87.8)	226	661
T_3 - PE oxyfluorfen at 200 g/ha	69.82(88.2)	220	958	67.02(84.8)	202	944	75.46(93.7)	261	688	74.59(92.9)	253	695
T_4 - PE oxyfluorfen at 250 g/ha	66.78(85.8)	233	984	68.33(86.4)	225	970	72.34(90.9)	274	728	70.66(89.0)	246	735
T_5 - PE oxyfluorfen at 300 g/ha	71.19(89.6)	238	968	68.26(86.3)	245	954	76.06(94.2)	287	736	75.15(93.4)	279	743
T_6 - PE oxyfluorfen at 400 g/ha	69.47(87.7)	226	892	66.71(84.4)	218	878	73.67(92.2)	265	685	70.03(88.3)	277	692
T_7 - Pendi. at 0.75 kg /ha + HW on 45 DAS	70.18(88.5)	215	932	67.35(85.2)	227	918	73.58(92.3)	258	712	73.09(91.5)	250	719
T_8 - Pendi. at 0.75 kg/ha + RW on 45 DAS	66.66(84.3)	198	894	65.62(83.0)	208	880	75.46(93.7)	245	687	71.50(89.9)	257	694
T_9 - HW twice on 25 and 45 DAS	70.35(88.7)	230	889	67.5(85.4)	232	875	76.81(94.9)	272	717	74.70(93.0)	264	724
T_{10} - Unweeded control	68.95(87.2)	217	917	66.24(83.8)	229	903	73.78(92.2)	268	698	72.98(91.4)	278	705
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figures in parentheses are arc sin transformed values; PE – Pre-emergence; HW - Hand weeding

CONCLUSION

New formulation of oxyfluorfen with different doses could be very effective against most of the broad leaved and grassy weeds in groundnut. But residual toxicity of oxyfluorfen cannot be ruled out on sensitive crops such as sunflower and pearl millet in rotation.

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Effect of atrazine and pendimethalin on soil microorganisms in maize-pea cropping system in mid-hill conditions of Himachal pradesh

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In India, over the past five decades pesticides have been increasingly added in the environment under intensively managed cultivation practices leading to contamination of natural bodies. Side-effects of herbicides on soil microbial populations can be studied on both short and long-term basis. In the present study, the herbicide application resulted suppression in population of Azotobacter, Phosphate solublising microorganisms and Azospirillum population. The population of all microorganisms was found to be regain their number at harvesting of the crops.

METHODOLOGY

A field experiment of maize-pea cropping was conducted to assess the effects of atrazine and pendimethalin herbicides on beneficial microbial population dynamics of Azotobacter, Phosphate Solubilising microorganisms (PSM) and Azospirillum regularly analysed microbiologically for three years *i.e.* 2010 to 2012 under AICRP on Weed Control in Agronomy department, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalay, Palampur. The soils are clay loam to silty clay loam in texture and classified as Alfisols. The surface soil (0-15cm) has a pH range from 5.2-6.0 (1: 2.5; soil: water ratio). The status of organic carbon in the soils is medium to high. The soils are medium in available N and P and high in available potassium.

The treatments consisted of five weed control methods, *viz*. weedy check, mechanical weeding (2), atrazine 1.0 kg/ha pre-emergence *fb* HW, atrazine 1.5 kg/ha pre-emergence and atrazine 1.0 kg/ha pre-emergence *fb* 2, 4-D 0.5 kg/ha in main plots wherein maize was grown and weedy check, mechanical weeding (2), pendimethalin 1.2 kg/ha pre-emergence and pendimethalin 0.75 kg/ha pre-emergence *fb* mechanical weeding in sub plots in which green peas were grown(Table 1).

Soil samples were collected from maize plots during harvest of maize crop from 0.0-15m depth from each plot and were processed for microbiological analysis. Microbial population of Azotobacter and Phosphate solubilising microorganisms was determined by plate count technique of Wollum (1982) through serial dilution using respective media for each group. Jensen agar medium was used for the determination of Azotobacter organisms and pikovskyas medium for the isolation of phosphate solubilising microorganisms.The estimation of Azospirillum from soil was analysed by most probable number (MPN) technique.

RESULTS

In maize-pea cropping system, the effect of atrazine and pendimethalin herbicides on beneficial microbial population dynamics of Azotobacter, Phosphate Solubilising microorganisms (PSM) and Azospirillum in soil was analysed during the year of 2010 to 2012.The population of Azotobacter and phosphate solublising microorganisms was highly influenced by the application of atrazine 1.0 kg/ha pre-emergence fb. HW, atrazine 1.5 kg/ha pre-emergence when compared to atrazine 1.0 kg/ha pre-emergence fb. 2, 4-D 0.5 kg/ha. The population of Azotobacter was recorded highest 9.05×10^4/g dry soil, 23.2×10^4/g dry soil and 8.86×10^4/g dry soil in combination of herbicide treatment of 1.0 kg/ha pre-emergence fb. 2, 4-D 0.5 kg/hawhen compared with other individual herbicide treatments and weedy check in three years *i.e.* 2010, 2011 and 2012 respectively in the main plots. (Table 1). The treatment of pendimethalein 1.2kg/ha pre-emergence recorded lower population count in sub-plots which shows that the herbicide dose influenced the count of Azotobacter at harvesting stage and it persisted when population is compared to weedy check.

Table 1. Effect of Herbicides on beneficial soil microbes in Maize-Pea cropping system

Treatment	Azotobacter ($\times10^4$/g dry soil)			Phosphate Solublising microorganisms ($\times10^5$/g dry soil)			Azospirillum ($\times10^5$/g dry soil)		
	(2010)	(2011)	(2012)	(2010)	(2011)	(2012)	(2010)	(2011)	(2012)
Weedy check	8.11	26.5	8.74	85.75	37.5	83.9	3.22	5.29	3.25
Mechanical weeding	7.61	27.8	7.97	71.99	42.2	80.3	3.16	3.62	3.41
Atrazine 1.0 kg/ha PE *fb* HW	6.06	21.2	6.29	86.84	28.9	93.3	2.52	6.28	3.48
Atrazine 1.5 kg/ha PE	6.89	30.3	7.61	94.95	48.4	89.2	2.42	4.75	3.11
Atrazine 1.0 kg/ha PE *fb* 2,4-D 0.5 kg/ha	9.05	23.2	8.86	96.55	33.9	100.3	2.31	4.37	2.85
LSD (P=0.05)	1.29	NS	1.41	NS	4.11	10.6	NS	NS	NS
Weedy check	7.91	23.8	7.88	86.56	32.6	85.9	3.01	4.93	3.73
Mechanical weeding	6.67	36.2	7.30	78.31	37.4	80.6	3.35	5.79	3.29
Pen 1.2 kg/ha PE	7.53	21.2	7.87	90.71	41.9	95.4	2.37	4.80	4.28
Pen 0.75 kg/ha PE *fb* Mechanical weeding	8.07	22.0	8.53	93.29	40.8	95.7	2.17	4.63	3.35
LSD (P=0.05)	1.04	8.46	NS	NS	2.97	8.8	NS	NS	NS

The population of phosphate solublising microorganisms recorded highest population count in 2011 and 2012 while in 2010, the population of PSM was non-significantly high in the herbicide applied main plots and same trend of population count was observed sub-plots applied the herbicide of pendimethalein in three years of analysis.

The population of Azospirillum was analysed for three years and observed the continuous application of atrazine and pendimethalein influenced the population numerically when compared with weedy check in main and sub-plots.The population of Azospirillum was always lower in herbicides treated main plots. This shows that these bacteria, Azotobacter, Phosphate solubilising microorganisms and Azospirillum might have become tolerant to herbicides due to its continuous application and might have utilized the herbicide as a nutrient source hence their count might increase in main and sub-plots in maize cropping system at the end of harvest of crop.This difference in sensitiveness to the herbicide may be due to difference in morphological make up and growing habits of the microorganisms (Selvamani and Sankaran 1993).

CONCLUSION

With the present study it may be concluded that the application of atrazine and pendimethalin in maize-pea cropping system did not have strong effect on soil microflora.

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Sensitised photo-transformation of bispyribac-sodium in soil-water biphasic system

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Bispyribac-sodium, sodium 2,6-bis [(4,6-dimethoxy-2-pyrimidinyl) oxy] benzoate, a member of the pyrimidinyloxybenzoic acid group was introduced by Japan Kumiai Chemical herbicide to manage weeds like *Echinocloa crusgalli*, *Cyperus rotundus*, *Cyperus iria*, *Fimbristylis miliacea* in transplanted as well as direct seeded rice. Bispyribac-sodium is highly soluble in water. The herbicide and its primary degradation product desmethyl bispyribac are medium to highly mobile in soil (Anonymous 2010). It may pose the risk of non-point source of contamination through surface water runoff and leaching towards ground water. Therefore, a study of degradation of this herbicide in water is needed. In the present experiment the photochemical behaviour of bispyribac-sodium was investigated in a biphasic soil-water system simulating soil-water environment of rice field.

METHODOLOGY

The experiment consisted of eight treatments each replicated thrice. In each soil-water system 4.5 cm of water was maintained on the soil layer of 4 cm depth. In case of the treatment containing water only a depth of 4.5 cm was always maintained. Bispyribac-sodium was applied on to the soil-water or water at the rate of 0.2 mg kg^{-1} of soil. All the treatments with open surface of water were exposed to sunlight in outdoor situation. A set of all the treatments was also maintained in the dark condition. Another set of experiment on the photolysis of bispyribac-sodium was also carried out in closed system, i.e. in quartz flask containing distilled water and irrigation water spiked with the herbicide resulting in a solution of 10 ppm. During the exposure under sunlight sampling was done in regular interval. Soil and water samples were extracted and cleaned up by standardized method. Samples were analysed on high performance liquid chromatograph equipped with a C-18 reverse phase chromatographic column and a UV-Vis detector. The HPLC determination of analytes was performed using a mobile phase consisting of acetonitrile/water (65:35 v/v) with a ûow rate of 0.8 mL/min and monitored at 248 nm. Total analysis time was 20 min.

RESULTS

Bispyribac-sodium did not undergo direct photolysis readily. The photolytic half-life ($T_{1/2}$) of it in distilled water under closed system of quartz tube was found as 232 days. Whereas, the $T_{1/2}$ of it in distilled water under open surface condition was only 32 days. Probably, dissolved CO_2, which becomes available in open surface condition, could enhance the rate of photolysis of bispyribac. Even during the irradiation of bispyribac dissolved in irrigation water, the $T_{1/2}$ was found to be 28 days in closed quartz flask. The enhanced rate of the photolysis of the herbicide in irrigation water, when compared to that in distilled water, is due to the sensitization action offered by the dissolved organic matter and inorganic substances. This photochemical sensitization process was further revealed in the treatments containing the herbicide along with the humic substances, and sodium nitrate, separately in sterilized distilled water. The $T_{1/2}$ values for bispyribac were 8 and 10 days in presence of humic substances and sodium nitrate, respectively.

The sensitizing effect of humic substances and inorganic compounds in the photolysis of bispyribac-sodium was revealed in the experiment conducted in a biphasic system of soil-water under natural light. A scheme for the photolytic pathways of bispyribac degradation is proposed. The first step of the scheme is the hydrolysis of bispyribac-sodium salt to its acid, i.e. bispyribac (2,6-bis[(4,6-dimethoxy-2-pyrimidinyl)oxy]benzoate). Different radicals were formed from bispyribac during irradiation in biphasic system. These radicals might also be formed from the chemical interaction between bispyribac and active species like super oxide, singlet oxygen and peroxides, which were generated from the irradiation of humic and inorganic substances in soil and water. These radicals formed from the herbicide reunited randomly making bonds of different combination with the formation of various photoproducts, viz., 4,6-dimethoxypyrimidinyl phthalate, 2-(3-methoxy phenoxy)-4,6-dimethoxy pyrimidine, 2-methoxy methyl benzoate, 2,4,6-trimethoxypyrimidine, 2-(3-hydroxy phenoxy)pyrimidin-4,6-diol and pyrimidin-2,4,6-triol. Any degraded product of pyrimidintriol was not detected in this experiment.

Table 1. Photolytic half-life values of bispyribac-sodium in soil-water biphasic system and in different aqueous phases

Treatment		Half-life (day)	R^{2*}
Open surface system	Natural soil and water	5.52	0.83
	Sterilised soil and water	10.73	0.77
	Organic matter free soil and water (sterilized)	12.07	0.79
	Organic matter free soil + humic acid and water (sterilized)	7.36	0.81
	Distilled water	32.2	0.89
	Distilled water + humic acid	8.12	0.98
	Distilled water + sodium nitrate	9.61	0.76
	Distilled water + humic acid + sodium nitrate	8.46	0.89
Closed system	Distilled water (in quartz flask)	232.60	0.90
	Irrigation water (in quartz flask)	28.02	0.95

* Regression coefficient

CONCLUSION

Bispyribac-sodium is photo-chemically persistent in pure aqueous solution. As it does not absorb much of the incident sunlight it cannot undergo direct photolysis. But the active chemical species generated from the sunlight-assisted photolysis of organic matter and inorganic substances present in the water readily react with bispyribac-sodium transforming it into different degradation products.

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Leptochloa chinensis: a relatively new weed in soybean-based cropping systems during high rainfall years in Tikamgarh district of Madhya Pradesh

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The effect of climate variabilities such as long drought periods and occasional wet years, may affect weed invasion. Weeds with high reproduction and efficient seed dispersal mechanisms may be better able to take advantage of expected calamities like cyclones and floods. *Leptochloa chinenis* is a strongly tufted annual grass of aquatic and semi aquatic environment and is known to be invasive. *Leptochloa chinensis*are found in wetland or flooded environments (Manidool 1992). The invasive potential of this species has been linked to its high seed production (Chin 2001). The genus *Leptochloa* belonging to the Poaceae family includes 45 species widespread in tropical and subtropical areas. It is characterized by very small, non-dormant seeds able to germinate in completely anoxic conditions. Thus, this species is one of the very few able to germinate in complete oxygen depletion. *Leptochloa chinensis* was observed in the soybean field of Tikamgarh district recently and the area currently infested is unknown. The present study was carried out to find out the intensity and dry weight of grassy weeds and their control in soybean.

METHODOLOGY

An experiment was conducted to control grassy weeds in soybean with 7 treatments replicated thrice. The treatments comprised of post-emergence grass weed killer; sethoxydim @ 125, 156.25, 187.50 and 312.50 g/ha and quizalofop-ethyl at 100 g/ha and these treatments were compared with two hand weeding at 20 and 40 DAS and weedy check. The soybean variety JS-93-05 was sown on July 13, 2013 with seed rate of 80 kg/ha in rows, 30 cm apart with fertilizer dose of 20:60:30 kg/ha. Post-emergence herbicides were applied at 25 days after sowing. The observations on weed intensity were recorded by using quadrate of one meter square. The density, dry weight and weed control efficiency were computed.

RESULTS

The observations on weed intensity were recorded at College of Agriculture, Tikamgarh and found that the effect of the rainfall above average rainfall in the district during *kharif* season of 2013 exerted direct influence on the invasion of weed species and resulted in the change in the grassy weed species dominance and found the dominance of *Leptochloa chinensis* with 59.43% intensity, which is not the dominant species in the soybean field in the normal or below average rainfall years in this region. The amount of total rainfall received during *kharif* 2013 was 1244.20 mm in 59 rainy days which was distributed throughout the season and it was 453.5, 676.8, 9.1 and 104.8 mm during June, July, August and September. There was no shortage of moisture throughout the crop growing season. Whereas, the rainfall received 346, 480, 128 and 0.0 mm in July, August, September and October, respectively during *kharif* 2012 which exerted the weed stress mainly due to presence of common dominating grassy weeds of the area: *Cyperus rotundus* with intensity of 22.2 and *Cynodon dactylon* 14.3%.

There was prevalence of monocot weeds in experimental field as they constituted the higher relative density of monocot weeds (61.88%) as compared to dicot weeds which had only 28.32% relative density, before spray. In the monocot weeds,the intensity of *Leptochloa chinensis* was the highest (52.06%) followed by *Cyperus rotundus* (4.22%) and *Echinochloa colonum* (3.44%) whereas among the dicot weeds, *Sida cordifolia* was more aggressive as it had the maximum relative density (23.11%) than *Digera arvensis* (3.44%).

Hand weeding twice was most effective and recorded minimum weed density among all the treatments. Sethoxydim and quizalofop-ethyl was effective against grassy weeds including *Leptochloa chinensis, Echinochloa colona,Cynodon dactylon, Commelina communis*and *Cyperus rotundus*, but it was not effective against broadleaved weeds. Uncontrolled weeds caused 61.85% yield loss in soybean.

All the herbicidal treatments and hand weeding significantly reduced the density and dry weight of grassy weeds as compared to weedy check. Hand weeding superceded over all the treatments and attained minimum weed density and dry weight due to effective control of grassy as well as broadleaved weeds.

CONCLUSION

On the basis of results obtained, it can be concluded that the weed flora of the area were shifted from the common weed flora of the year due to high rainfall during the experimetal year and *Leptochloa chinensis* was recorded as major dominating species in the soybean field which can be controlled by grass weed killers: sethoxydim or quizalofop-ethyl.

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Evaluation of Pre and Post-Emergence Herbicides in Garlic

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Garlic is the second most widely used cultivated *Allium* after onion. It is grown throughout the plains of India. The potential yield losses due to weeds can be as high as about 65 per cent depending on the crop, degree of weed intensity, weed species and management practices (Yaduraju *et al*., 2006). Garlic production is severely affected due to weeds because of non-branching habit, sparse foliage, shallow root system and narrow row spacing. To evaluate new pre and post emergence herbicides and their mix/sequential application for management of weeds in garlic this experiment was undertaken.

METHODOLOGY

A field experiment was conducted during 2012-13 on medium black soil at Junagadh (Gujarat) to study the effect of pre-and post emergence herbicides as mix/sequential application for weed management in garlic in randomised block design with four replications. Garlic variety '*GG 4*' was sown with recommended package of practices. The crop was uniformly fertilized with 25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} in form of urea and di-ammonium phosphate and as muriate of potash. Data on weed growth, yield performance and economics were recorded.

RESULTS

Among different treatments Oxyfluorfen 240 g ha^{-1} PE + HW 45 DAS remained at par with weed free, which recorded the lowest total weed density over unweeded check. Significantly the lowest dry weight of weeds was observed under weed free. Among rest of the treatments, the lowest weed dry weight was observed under treatment Oxyfluorfen 240 g ha^{-1} PE + HW and Oxyfluorfen 240 g ha^{-1} PE + Propaquizafop 90 g ha^{-1} POE. Among rest of the treatments, the lowest weed index of 9.54 % was recorded under Oxyfluorfen 240 g ha^{-1} PE + HW 45 DAS. Besides weed free, highest bulb yield was recorded with Oxyfluorfen 240 g ha^{-1} PE + HW 45 DAS and increase over 550% over unwed check. Unweeded control recorded the lowest bulb yield. The 0% weed index under weed free indicates that complete absence of competition due to weed. The highest weed index of 84.63 % was recorded under unweeded check which indicates that unrestricted weed growth reduced the bulb yield of garlic. Analogous findings have been reported by Ramani and Khanpara (2010) and Kumar *et al.* (2013). The maximum net returns of ` 182555/ha and BCR of 6.36 were realized with treatment weed free followed by Oxyfluorfen 240 g/ha PE + HW 45 DAS with net returns ' 162965 ha^{-1} and BCR of 4.94.

Table 1. Weed growth, yield and economics of garlic as influenced by different treatments

Treatment	Bulb yield (q/ha)	Numbers of weed (m^2) at harvest	Dry weight (kg/ ha)	Weed index	Net return (` /ha)	BCR
Oxyfluorfen + HW	66.13	5.90 (34.81)	1475	9.54	162965	5.94
Oxyfluorfen + Propaquizafop	50.30	9.03 (80.97)	3162	30.34	117705	4.55
Oxyfluorfen + Mix Oxadiargyl & Quizalofop ethyl	48.51	10.11 (101.61)	3266	32.27	111455	4.27
Oxyfluorfen + Sequential Oxadiargyl & Quizalofop ethyl	60.06	7.04 (49.03)	1739	16.83	146105	5.29
Oxyfluorfen + Mix Oxadiargyl & Fenoxaprop ethyl	46.54	11.97 (142.66)	3445	35.55	105395	4.08
Oxyfluorfen + Sequential Oxadiargyl & Fenoxaprop ethyl	58.16	7.22 (51.56)	1900	19.46	140255	5.10
Oxyfluorfen + Mix Oxadiargyl & Propaquizafop	40.79	12.86 (164.75)	3502	43.51	88245	3.59
Oxyfluorfen + Sequential Oxadiargyl & Propaquizafop	53.89	8.71 (75.32)	1930	25.36	127545	4.74
Weed free	72.21	0.71 (0)	0.00	0.00	182555	6.36
Control (Unweeded check)	11.10	27.01 (728.91)	4685	84.63	3785	1.12
LSD (P=0.05)	6.28	5.848	460	-	-	-

Note: Oxyfluorfen 240 g ha^{-1} PE, Propaquizafop 90 g ha^{-1} POE, Oxadiargyl 45 g ha^{-1} and Quizalofop-ethyl 20 g/ha POE, Fenoxaprop ethyl 37.5 g/ha POE, Hand weeding & post emergence at 45 DAS. Figures in parenthesis are original values.

CONCLUSION

It was concluded that the highest bulb yield, weed control and profitability of garlic can be obtained by weed free and application of Oxyfluorfen 240 g/ha PE + HW 45 DAS on medium black soil of South Saurashtra Agro-climatic region.

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Effect of combined application of insecticides and herbicides on soybean (*Glycine max* L.) in semi-arid north plain zone of India

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Soybean, *Glycine max* (L.) Merrill is the leading oilseed crop of India and the world. This widely adapted crop offers multiple benefits to mankind, such as source of minerals and vitamins, immense nutritional value (protein 40%, edible oil 20%), functional health benefits and variety of end usages (food, feed and non-edible), and high productivity potential. Soybean fits well in cropping systems/rotations and improves soil fertility by fixing atmospheric nitrogen to the extent of 50-300 kg/ha depending upon agro-climatic conditions, variety, strains, etc. (Keyser and Fudi, 1992) and adding about 1.0-1.5 t/ha leaf litter per season. The infestation of weeds and a variety of insect-pests seriously damage soybean crop and causes huge yield losses. Herbicide and insecticides when applied in isolation add to cost thus their combined application is desirable. Hence the current investigation was carried out to determine the effect of different insecticides and herbicides applied in isolation and of their combined application on composition and severity of insect-pests, weeds and on growth and yield soybean.

METHODOLOGY

A two- year field experiment consisting of 12 treatments viz., rynaxypyre 20 SC at 100 ml/ha; indoxacarb 14.5 SC at 300 ml/ha; quinalphos 25 EC at 1.5 l/ha; imazathapyr 10 SL at 1.0 l/ha; quizalafop ethyl 5 EC at 1.0 l/ha; rynaxypyre 20 SC at 100 ml/ha + imazathapyr 10 SL at 1.0 l/ha; rynaxypyre 20 SC at 100 ml/ha + quizalafop ethyl 5 EC at 1.0 l/ha; indoxacarb 14.5 SC at 300 ml/ha + imazathapyr 10 SL at 1.0 l/ha; indoxacarb 14.5 SC at 300 ml/ha + quizalafop ethyl 5 EC at 1.0l/ha; quinalphos 25 EC at 1.5 l/ha + imazathapyr 10 SL at 1.0 l/ha; quinalphos 25 EC at 1.5l/ha (T3) + quizalafop ethyl 5 EC at 1.0 l/ha and untreated check, was carried out using three-time replicated RBD at ICAR-IARI, New Delhi during rainy seasons of 2013 and 2014. The crop was planted on 2nd August 2013 and 16th July, 2014 at a row spacing of 45 cm. The crop was fertilized with 30 kg N, 75 kg P_2O_5, 40 kg K_2O and 56 kg S/ha. The treatments were imposed 15 DAS. Insect-pest and weed infestations were monitored regularly.

RESULTS

During 2013 season, soybean seed yield was the highest with lone application of quizalafop ethyl 5 EC (1.0l/ha) followed by combined application of indoxacarb 14.5 SC at 300 ml/ha and quizalafop ethyl 5 EC at 1.0 l/ha which was significantly higher than untreated weedy check. The other treatments showing significantly higher seed yield were lone application of imazethapyr10 SL (1.0 l/ha), and indoxacarb14.5 SC (300 ml/ha), and combined application of quinalphos 25 EC (1.5 l/ha) with either imazethapyr10 SL (1.0 l/ha) or with quizalafop l 5 EC (1.0 l/ha). The highest number of pods/plant and seed index were recorded with lone application of quizalafof ethyl 5 EC (1.0 l/ha). The highest net returns and B: C ratio were recorded with quizalafop ethyl 5 EC (1.0 l/ha) and combined application of rynaxypyre 20 SC (100 ml/ha) + quizalafop ethyl 5 EC (1.0 l/ha). The similar results were found during the second season (2014), but the difeernces among treatments were found significant for pods/plant only; lone application of quizalafop ethyl 5 EC (1.0 l/ha) recorded the highest number of pods/plant. Although yield and growth parametrs were better with treaments involving the application of quizalafop ethyl 5 EC (1.01 l/ha) in isolation or combined with insecticides but application of imazethapyr 10 SL (1.0 l/ha) alone or in combination with insecticide was more economical as it evinced higher net returns improved. Reddy *et al.* (2013) also reported that application of e imazethapyr 10% SL at 100g/ha elicited higher economic yield of soybean and effective control of weeds compared to other herbicides.

The general growth of soybean was poor as soybean variety 'JS 335' used in this experiment was susceptible to insects and diseases. The major insects/diseases found include yellow mosaic virus (YMV) transmitted by *Bemisia tabaci* and stem tunneling due to stem fly, *Melanagromyzae sojae*. During both years treatment involving application rynaxypyre 20 SC at 100 ml/ha + imazathapyr 10 SL at 1.0 l/ha performed best in terms of lowering pest infestations. The major weeds found in the treatments plots include *Dinebra retroflexa, Cyprus rotundus, Leptocloa chinensis, Dactyloctinium aegyptium*, among monocot weeds and *Trianthema portulacastrum* and *Eclipta alba* among the dicot weeds. Weed count of both types of weeds at 15 DAS was not affected significantly by the treatments. However at 30 and 45 DAS sowing weed count was the lowest in the treatments having imazethapyr10 SL (1.0 l/ha) either alone or in combination with insecticides. Weed dry matter followed the same trend**.** Higher weed control efficiency was also recorded from the plots treated with imazethapyr 10 SL (1.0 l/ha).

CONCLUSION

Based on the two-year experiment results it could be concluded that application of imazethapyr10 SL (1.0 l/ha) either in isolation or in combination with insecticides was more rewarding in terms of higher weed control efficiency and net returns. Among insecticides, rynaxypyre 20 SC at 100 ml/ha was more effective in controlling insect-pests.

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Adsorption and desorption behaviours of the herbicide glyphosate in agricultural soils and their effect on bioavailability

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The bioavailability of herbicides in soils is affected by adsorption and desorption characteristics of the soil. The objective of this work was to investigate the behavior of glyphosate adsorption, desorption and bioavailability in agricultural soils and to evaluate effect of adsorption and desorption on bioavailability (mineralization) of the herbicide. Adsorption, desorption and bioavailability experiments were performed using 21 soil types from Germany and Slovenian in the application rate of 10 µg glyphosate/g soil. Soils differ hugely in soil texture, soil organic matter content, pH, oxalate extractable $Al^{3+}$and Fe^{3+}. The mineralization experiments were conducted under test conditions: water tension of -15 kPa as soil moisture, a soil density of 1.3 g/cm^3 and at 20°C in the dark. Batch experiment from OECD guideline 106 (OECD 2000) was used to determine adsorption/desorption behaviors of glyphosate in soils.

The desorption-biodegradation and mineralization was used to access the bioavailability of glyphosate in the test system. The laboratory results showed that glyphosate was strongly adsorbed, but weakly desorbed in soils. The adsorption and desorption of glyphosate had a big variance among soils. The adsorption and desorption of glyphosate in soils was individually regulated by exchangeable H^+ and soil pH-CaCl2. The adsorption of glyphosate in soils was collectively controlled by soil pH-$CaCl_2$, total carbon content and silt whereas the cumulative desorption of glyphosate in soils was collectively supervised by soil exchangeable H^+, pH, and Mg^{2+}. Moreover, soil textures, soil organic content, P_2O_5, Cu^{2+}, oxalate extractable Fe^{3+} and CEC were found not to have any correlation with adsorption and desorption of glyphosate in soils. The desorption of glyphosate in soils had a much stronger positive correlation with the cumulative mineralization of glyphosate than the dissolution of glyphosate.

Soil enzyme activities under higher doses of herbicide application

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Soil enzymes play key biochemical functions in the overall processes in the soil system. They are important in catalyzing several important reactions necessary for the life process of microorganisms in soils. These enzymes are constantly being synthesized, accumulated, inactivated and decomposed in the soil, hence playing a role in agriculture and particularly in nutrient cycling (Tabatabai and Bremner, 1969). Intensive use of herbicides without adequate knowledge on its effects on soil enzymes may have adverse impact on soil biochemical processes and cycling of nutrients. Hence, a study was conducted to assess the effects of oxadiargyl (prominent herbicide widely using in paddy and vegetables) on soil enzymes i.e urease, phosphatase and dehydrogenase were chosen for study because of their influence on transformation of nitrogen and phosphorus in soil and on microbial activity of soil.

METHODOLOGY

A field experiment was conducted on an Alfisolat College Farm, College of Agriculture, Rajendra nagar for *Kharif* and *Rabi* seasons during 2007-08. The treatmental details are as follows: Two sub plots i.e S1: FYM 10 t/ha and S2: without FYM and four main treatments consisted of pre emergence application of oxadiargyl at 0.75 kg/ha and 1.5 kg/ ha applied two days after sowing. Hand weeding and unweeded check were also included in the study. The experiment was laid out in a factorial randomized block design by raising spinach as test crop. The soil was sampled at 15 days interval up to harvest. Enzymatic activities of soil viz., urease activity was assayed by quantifying the rate of release of NH_4+ from the hydrolysis of urea as described by Tabatabai and Bremner (1977), dehydrogenase activity by quantifying the µg of TPF produced and expressed as gram sample per hour described by Cassida*et al.* (1964) and the acid and alkaline phosphatase activity was assayed by quantifying the amount of p-nitrophenol released and expressed as µg of p-nitrophenol released/gm sample/hr as described by Tabatabai and Bremner (1969).

RESULTS

In both the seasons significantly higher urease activity was recorded in the treatment which received oxadiargyl at 0.75 kg/ha and lower urease activity was recorded in the plots which received oxadiargyl at 1.5 kg/ha. The treatment with hand weeding recorded lower soil urease activity than oxadiargyl at 0.75 kg/ha during both the years, however it was significantly higher than oxadiargyl at 1.5 kg/ha and unweeded check.

Acid and alkaline phosphatase activity (µg of 4-nitrophenol/g soil/h) of the herbicide applied soils were significantly higher than the unweeded check. There was significant increase in activity from the 0 days after application to 30 days after application followed by decline to harvest. Acid phosphatase activity in soils was in order of oxadairgyl at 0.75 kg/ha>oxadairgyl at 1.5 kg/ ha> hand weeding >unweeded check. Alkaline phosphatase activity also followed the similar trend.

In current study there was always a stimulation of enzyme level at active growth of the crop plants. In both the sub plots and in the two seasons of study, acid and alkaline phosphatases showed maximum activity al 30 days after application. Among two sub plots organic manure added plots (S1) recorded higher enzyme activity than non- manure plots (S2) might be due to higher availability of substrate in the S1 than S2 (Perucci *et al.* 1990)

The dehydrogenase enzyme activity is commonly used as an indicator of biological activity in soils as well as a direct measure of soil microbial activity (Garcia *et al.* 1988). There was a consistent increase in dehydrogenase activity (µg TPF /g/day) from 0 days after application to 30 days after application and later decreased at harvest in both the seasons and in both the sub plots. The dehydrogenase activity was significantly higher in herbicide treated plots as compared to control. Dehydrogenase activity in soils was in order of oxadiargyl at 0.75 kg/ha> oxadiargyl at 1.5 kg/ha> hand weeding >unweeded check.

CONCLUSION

Inhibition of soil enzyme activities was observed at higher doses of herbicide application as compared to recommended dose of herbicide application. And also noticed that enzyme activity was more when plots received oxadiargyl at 0.75 kg/ha than over hand weeding and unweeded check.

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Effect of pre-emergence herbicides on soil metabolic activities and yield of groundnut on Inceptisol

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Groundnut is an important oil seed crops in India grown on 6.86 million ha land with production of 6.99 million tones. Although India ranks first in the world in terms of area and production, the productivity is lowers just around 1 t/ha. Heavy yield losses were recorded in groundnut due to weed infestation. Weeds compete with crops for moisture, nutrients, sunlight and space. The conventional method of weed control is very laborious, expensive and insufficient. Under such a situation chemical weed control is better alternative to manual weeding during the early stage of crops. But the herbicides have been found to affect the nutrient status and biochemical health of the soil. In order to know the harmful effect of herbicide on soil microbial population and nutrient status of soil, the present investigation was undertaken.

METHODOLOGY

A field experiment was carried out on groundnut in two successive years during summer 2002-2003 and 2003-2004 at Mahatma Phule Krishi Vidyapeeth, Rahuri (M. S.) on Inceptisol. The experiment was laid out with fourteen treatments replicated three times in randomized block design. Groundnut variety *JL 24* was sown in the experimental plot. Recommended dose of 100:50:50 kg/ha N: P_2O_5: K_2O respectively along with 10 t/ha FYM is applied to each plot. The graded level of pre-emergence herbicides treatments *viz.* half of the recommended dose, recommended dose and double of recommended dose of oxyfluorfen, alachlor, pendimethalin and fluchloralin weedicide were given immediately after sowing. Soil enzyme activity and microbial population were recorded for each treatment 20 days after weedicide application.

RESULTS

The pre-emergence herbicides in summer groundnut significantly affected the yield. The pod yield of summer groundnut was significantly higher in weeded control treatment. (2.33 t/ha) and it was at par with oxyfluorfen0.5 kg/ha (1.96 t/ha) and fluchloralin 1.5 kg/ha (1.95 t/ha), whereas, treatments with pendimethalin application were recorded the low pod yield.

Soil enzyme activities at 20 days after herbicide application were significantly influenced by the levels and type of per emergence weedicide application. The soil urease activity was statistically the highest in alachlor 1.0 kg/ha (21.82 mg NH_4-N 100/g of soil/hr) which was closely followed by alachlor1.0 kg/ha treatment (21.67 mg NH_4-N 100/g of soil/hr). The activity of urease enzyme in soil was higher in alachor treatments while lower in fluchloralin treatments. This might be because of alachlor contains amide group. Similar observation was also recorded by Martens and Bremner (1993). The soil acid phosphatase activity was significantly higher and similar in pendimethalin 0.75 kg and 1.5 kg/ha (8.34 mM P/g soil/hr) followed by pendimethalin 3.0 kg/ha (8.23 mM P/gsoil/hr). While the activity is lower in alachlor treatments. The soil dehydrogenase activities were significantly influenced by the pre emergence weedicide application and it was the highest in fluchloralin application at 1.50 k/ha. (8.34 m mol TPF/g/day). Increased levels of pre emergence herbicides decreased the soil dehydrogenase activity. The variation in dehydrogenase might be because of variation in microbial population and their activity due to application of different herbicide treatments and levels. These observations were in accordance with Kim and Hong (1998).

Table : Effect of pre emergence herbicide on Groundnut pod yield and soil enzyme activity at 20 days after sowing.

Treatment	Pod Yield (q/ha)	Soil Enzyme Activity at 20 DSA		
		Urease (mg NH_4-N 100/ g of soil/hr)	Acid phosphatase (μM P/g soil/hr)	DHA (μ mol TPF g/day)
Oxyfluorfen 0.5 kg/ ha	19.62	19.94	7.27	4.87
Oxyfluorfen 1.0 kg/ha	17.87	19.53	7.62	4.47
Oxyfluorfen2.0 kg/ha	17.79	19.71	7.14	4.18
Alachlor 1.0 kg/ha	18.94	21.82	6.70	5.10
Alachlor 2.0 kg/ ha	18.17	20.81	6.88	4.53
Alachlor 4.0 kg/ha	18.57	21.67	7.12	4.32
Fluchloralin 0.75 kg/ha	19.18	19.61	6.86	5.17
Fluchloralin 1.50 kg/ha	19.59	19.43	6.91	5.43
Fluchloralin 3.0 kg/ha	18.27	18.75	6.72	4.72
Pendimethalin 0.75 kg/ha	16.19	19.99	8.34	5.10
Pendimethalin 1.50 kg/ha	14.08	20.19	8.34	5.23
Pendimethalin 3.0 kg/ha	16.26	19.30	8.23	4.53
Weedy check	9.38	19.67	7.98	4.32
Hand weeding	23.37	18.76	7.38	5.62
LSD (P=0.05)	3.83	2.12	0.35	0.38

CONCLUSION

The uses of preemergence herbicides significantly influenced the groundnut yield. The higher dose of pre emergence herbicide adversely affects the soil metabolic activities.

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Theme 8

Allelopathy: the current status and role in weed management

Phytoherbicides : opportunities and research needs

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Weed management in present day agriculture mainly depends on synthetic herbicides, which may cause environmental pollution besides restricting the choice of succeeding crops through long residual activity. Hence, herbicide industry is continuously searching for most effective, economical and environmentally safer synthetic herbicides by screening of natural products for herbicidal activity. This has provided significant lead molecules for insects' control (pyrethroids), but not in herbicide discovery. Hence the allelopathic properties of plants can be exploited successfully as a tool for the management of pathogens, insects and weeds. Some of them were act as potential herbicides with considerable crop selectivity and unique mode of actions (Vyvyan 2002), which could be directly used in the form of aqueous water extracts for weed management in organic and sustainable agriculture systems. Chemistry of these products may also be used as lead molecules/templates for the development of new commercial herbicides.

METHODOLOGY

The use of aqueous water extract of different plants such as sorghum, sunflower, maize, rice, sesame, eucalyptus and some of the weeds alone or in combination with reduced doses of synthetic herbicides are very effective and environmentally safe to manage the weeds in different crops.

RESULTS

The concentrated sorghum extract (*sorgaab)* at 12 l/ha along with reduced dose of pendimethalin 0.5 kg/ha as pre-emergence resulted in lowest density of *Cyperus rotundus* L. and *Trianthema portulacastrum* L. in cotton (Cheema *et al*. 2002). Post-emergence application of *sorgaab* at 12 l/ha along with isoproturon 600 g/ha reduced the total weed dry weight by 91% in wheat and was comparable with isoproturon 1000 g/ha (Jamil *et al.* 2005). Structural modification of monoterpene, 1,8-cineole gives the synthetic herbicide cinmethylin, which is highly effective on grassy weeds and some broad leaved weeds by the inhibition of mitosis in rice at 75 g/ha (Subramanyam *et al.* 2007). The mode of action of leptospermone, a triketone in *Leptospermum scoparium* J.R. and G. Frost and *Callistemone citrinus* (Curtis) Skeels was similar to a synthetic herbicide, mesotrione to control broad leaved weeds in corn by inhibiting *p-hydroxy phenyl pyruvate dioxygenase*. Benzoquinones like sorgoleone, DIBOA and DIMBOA are well known natural allele chemicals may be considered as successful templates for designing new herbicide molecules. However, the success of natural plant based herbicides is limited due to complexity in chemical structures, limited stability in environment, low herbicidal activity and difficulties in commercialization. Hence, investigation on rapid analytical techniques for identification and characterization of plant based herbicides, selectivity mechanisms to different crops and cultivars with alleleopathic potential through biotechnological approaches.

CONCLUSION

Aqueous water extracts of different plants alone or in combination with reduced dose of synthetic herbicides can be applied for weed control in organic and sustainable agriculture. Some secondary metabolites/allelo-chemicals may provide lead molecules and clues for the discovery of target sites and designing new herbicides. However, there is a need to investigate the research gaps to use potential phyto-chemicals as natural herbicides.

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Allelopathic potential of botanicals against *Parthenium*

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Parthenium (*Parthenium hysterophorus* L.) is the major problematic weed found in India due to the prolific seed producing nature. Management of this dreaded weed is possible by the repeated use of herbicides but chance of environmental pollution is also inevitable. Hence, the use of eco-friendly approach like allelopathy is a viable option. Application of allelochemicals, in either pure or crude form, is a potentially valuable and sustainable approach in management of parthenium. Eucalyptus (*Eucalyptus spp.*), Tamarind (*Tamarindus indica* L.) and Leucaena (*Leucaena leucocephala* (Lam.) de Wit) are important tree species, which are widespread in tropics and subtropics. Hence, a laboratory investigation was undertaken to study the allelopathic potential of different botanicals on controlling parthenium.

METHODOLOGY

A laboratory experiment was conducted to study the allelopathic potential of eucalyptus and leucaena on the germination, seedling growth and vigour index of parthenium. Aqueous leachates of eucalyptus, tamarind and leucaena (10 and 20%) were prepared by soaking air dried leaf in distilled water (1:10 w/v) for 24 hrs and filtered in Whatman No.1 filter paper. Calculated quantity of eucalyptus oil was mixed with distilled water to prepare required 0.5 and 1.0% concentration. Four replicates of each 50 seeds of parthenium were evenly placed on moist germination paper in sterilized petridish under completely randomized design with three replications. The petridishes were maintained at 25°C and 95% humidity with a slow and continuous exposure to 10 ml of aqueous leacahtes of allelopathic plant products and distilled water (for comparison as control). The data collected from the experiments were subjected to the Fisher's method of Analysis of Variance (ANOVA).

RESULTS

The results revealed that minimum reduction in germination percentage was observed with the 10% tamarind leaf leachate (50.5%) and maximum with eucalyptus leaf leachate (100%), in comparison to control (Table 1). Reduced germination using leaf extract of eucalyptus might be attributed to the release of phenolic acids and volatile oils, which functioned as allelopathic agents (Sasikumar *et al.* 2002). Seedling growth and vigour index was significantly higher with control (1.5 cm and 48.4 respectively). However, vigour index of parthenum seedling was significantly lesser with the leucaena and eucalyptus oil at both concentrations (Table 1). Pires *et al.* (2001) observed that mimosine is the possible allelochemical responsible for the inhibition of germination and development in *Bidens pilosa* and *Amaranthus hybridus*.

Table 1. Alleopathic effect of botanicals on controlling the parthenium under lab study

Treatment	*Reduction in germination (%)	Seedling length (cm)	Vigour index
Leucaena leaf leachate 10%	88.8	1.5	49.0
Leucaena leaf leachate 20%	95.8	0.5	1.7
Tamarind leaf leachate 10%	50.5	0.3	0.6
Tamarind leaf leachate 20%	85.2	0.7	12.0
Eucalyptus leaf leachate 10%	100.0	0.4	2.0
Eucalyptus leaf leachate20%	100.0	0.0	0.0
Eucalyptus oil 0.5%	81.5	0.0	0.0
Eucalyptus oil 1.0%	95.9	0.6	3.1

*Data statistically not analysed

CONCLUSION

It was concluded that eucalyptus and leucaena was found to be promising in inhibiting the germination and growth of parthenium under controlled condition.

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Allelopathy - an environmental friendly method for weed control

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Allelopathy is defined as the direct or indirect harmful or beneficial effects of one plant on another through the release of certain chemical compounds into the environment (Ashrafi *et al.* 2008). Chemicals that impose allelopathic influences are called allelochemicals or allelochemics. Many weeds are now achieving importance as an agent of weed control for having special types of allelochemicals.

METHODOLOGY

These allelochemicals are capable of suppressing germination and growth of several other weeds, some of which are herbicide resistant. Different crops have allelochemicals were extracted and used for inhibiting weeds.

RESULTS

Application of sorghum and sunflower water extracts reduced weed biomass by 33-53% and increased wheat yield (7-14%), according to Cheema et al. (1997). Aqueous leaves extract of different concentration weeds (*Tridaxprocumbens* L.) have alleopathic effect on seed germination, root and shoot length and dry weight of some leguminous plants viz. green gram, horse gram and cow pea (Femina *et al. 2012*). Allelopathic crop water extracts (Sorghum, Sunflower and Brassica) can reduce the glyphosate dose up to 75% in controlling purple nut sedge.

CONCLUSION

For successful utilization of allelopathic properties the identification of allelochemicals is necessary. Before application of allelochemicals, field experiments should be exclusively needed to study its interaction with various physical, chemical, biological and physic-chemical properties of soil. The movement of allelochemicals, mode of action, selectivity etc. should be broadly studied and the impact of use of allelochemicals from agronomic and environmental point of view needs special attention. Before use of any chemicals the security from environment point of view is to be taken into consideration.

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A new phenol glycoside with strong allelopathic activities from root exudates of *Peperomia pellucida*, L. HBK

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Peperomia pellucida (L.) HBK is also known as shiny bush or silver bush belonging to family Piperaceae and is an herbaceous plant found in many South American and Asian countries. The species develops during rainy periods (often in the spring) and thrives in loose, humid soils under the shade of trees (Majumder *et al.* 2011). It grows in moist habitat and is found throughout the major parts of India. Despite its wide range of folk medicinal uses in India subcontinent, there is very little scientific documentation available on its biological activities as well as its chemical constituents. Hence in the present study, the phenolic glycosides from this plant were tested for its alleopathic activity.

METHODOLOGY

A new phenol glycoside isolated from the root exudates of *Peperomia pellucida,* L. using chromatographic techniques and the structure was confirmed on the basis of spectral data (MS, IR, ^{1}HNMR and ^{13}C NMR). *In vitro* allelopathic activities of the compound were studied by rice wheat and mustard seed bioassay techniques.

RESULTS

This compound showed maximum inhibitory activity in rice, than in wheat and mustard. In case of mustard seeds, concentration-dependent inhibitory and stimulatory activity on both shoot and root length was exhibited by this bioactive compound whereas in rice and wheat, this compound revealed almost inhibitory activity at all concentrations on both shoot and root length. At a concentration of 62.5, 31.25 and 7.81 ppm, it revealed stimulatory activity on both shoot and root length of mustard seeds. This phenol glycoside secreted from roots of *P. peromia* plays an important role for invasive allelopathic nature of the plant.

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Efficacy of shoot leachates of potential allelopathic plants on famine weed (*Parthenium hysterophorus*)

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Famine weed (*Parthenium hysterophorus* L.) is an annual herbaceous plant thought to be originated in North East Mexico and has spreaded to Ethiopia, Pakistan and Nepal during the last ten years. Presence of certain strong allelochemicals in allelopathic plants likes *Cassia occidentalis*, *Calotropis procera* and *Croton bonplandianum*, may have subsequent influence and appears to affect *parthenium* to some extent. Hence the shoot leachates of allelopathic plants in solvents like methanol and ethanol have been tried here to control the parthenium.

METHODOLOGY

Fresh leaves of *C.occidentalis*. *C. procera* and *C. bonplandianum* were collected from six different sites of Agra and washed with tap water and then distilled water to remove dirt and dust and dried naturally. The fresh leaves (20g) were soaked in 100 ml of both methanol and ethanol solvents each under aseptic conditions for 15 days and placed in conical flask under refrigeration at 8 ± 10^{0}C. After the stipulated period, the solvent leachates were filtered through three layers of muslin cloth / cheese cloth to remove debris. Two different concentrations (50 and 100%) of leachates were prepared and used for bioassay. Pure methanol and ethanol blanks were used as control. Seeds of *Parthenium* were collected from different sites of Agra, thoroughly washed with tap water, sterilized with 0.1% $HgCl_2$ for 10 minutes and again washed with distilled water for 4-6 times. Viable *Parthenium* seeds were divided into 6 replicates of 15 seeds each and were placed on filter paper in sterilized petridishes, moistened with distilled water and 5 ml of methanol and ethanol shoot leachates of different concentrations were used for further moistening and treatment. All the seed lots were allowed to germinate in 12 cm petridishes. Petridishes were covered and placed in sealed polythene bags to prevent further loss of volatile compound (allelochemicals) and kept undisturbed for 15 days at 25 ± 2ºC. The number of germinated seeds, growth of plumule and radical was also recorded after 15 days.

Table 1. Effect of methanol and ethanol shoot leachates of competitive plant shoots on seed germination and seedling growth of *parthenium*

Competitive plants	Concentration (%)	Germination (%)		Methanol shoot leachates		Ethanol shoot leachates	
		Methanol	Ethanol	Plumule length (cm)	Radicle length (cm)	Plumule length (cm)	Radicle length (cm)
C. occidentalis	50	6.5±(2.3)	5.24±(1.8)	6.15±(3)	5.15±(1.5)	4.75±(1.5)	4±(0.5)
	100	5.12±(0.5)	4.75±(1.5)	5.75±(1.5)	4.95±(2.3)	4.5±(2)	3.9±(1.5)
C. procera	50	8.24±(0.5)	6.1±(2.3)	8±(2)	7.9±(2)	5.98±(0.5)	5±(1.2)
	100	6±(1.5)	5.5±(2)	7.55±(0.5)	7±(0.5)	5.75±(2)	5±(1.5)
C. bonplandianum	50	10.25±(1.5)	9.15±(1.8)	10.15±(1.2)	9.98±(1.3)	9±(0.2)	8.9±(1.5)
	100	8.75±(2.3)	7.25±(0.5)	9.25±(2)	9.15±(1.3)	8.95±(0.2)	8.25±(0.5)
Control	-	93.33±(0.0)	90±(0.0)	13.14±(1.3)	9±(0.2)	12.35±(2)	10.75±(1.5)

Values in parenthesis are ± SD of mean.

RESULTS

The significant reduction in seed germination of *Parthenium* was obtained in 100% ethanol shoot extract of *C. occidentalis* followed by *C. procera and C. bonplandianum.* The significant inhibition in plumule length was observed in *C. occidentalis* at 100% concentration of leachate in ethanol whereas minimum was observed in *C.bonplandianum* at 50% concentration of methanol shoot extract. The significant inhibition in radicle length was observed in *C. occidentalis* at 100% concentration of leachate in ethanol whereas minimum was observed in *C. bonplandianum* at 50% concentration of methanol shoot extract (Table 1).

CONCLUSION

It was concluded that allelopathic plants does have some potential in curbing the population of this obnoxious weed.

Bioefficacy of some plant extracts against weeds of groundnut

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Allelopathic properties of plants can be used successfully as a means for the management of pathogens, insects and weeds (Farooq *et al*. 2011). Large number of secondary metabolites produced by the plants may provide eco-friendly, diverse and challenging chemicals, which could be directly used in the form of aqueous water extracts for weed management in organic and sustainable agriculture systems. With this view, the present study was undertaken to study the bioefficacy of some common plant extracts on the controlling the weeds of groundnut.

METHODOLOGY

Field experiment was conducted with 9 treatments replicated thrice following Randomised Block Design during pre-*kharif* 2012. 5% aqueous extracts of six botanicals, T_1 (*Echinochloa colonum* plant), T_2 (*Cyperus difformis* plant), T_3 (*Ageratum conyzoides* plant),T_4 (*Blumealacera* plant), T_5 (*Cucumis sativus* leaf and stem), T_6 (*Bambusa vulgaris* root and leaf) were used along with alachlor 50 EC at 1.5 kg/ha and HW at 15 DAS was also included in the experiment besides the weedy check.

RESULTS

The results revealed that all the botanicals influenced the weed density and biomass considerably and recorded weed density and biomass in the order $T_3<T_6<T_5<T_1<T_2<T_4$. Hand weeding at 15 DAS gave maximum pod yield of groundnut crop followed by alachlor and all the botanical treatments excepting T_2 and T_4, were at par with the chemical treatment. Similar results were observed in case of kernel yields. Regarding the pod and kernel yield obtained from the botanicals treated plots, it was in the increasing order $T_3>T_6>T_5>T_1>T_2>T_4$ and the average more pod yield in botanical treatments T_3, T_6 and T_5 was 37% and that of T_1, T_2 and T_4 was 28% compared to weedy check. The botanical treatments as well as the chemical alachlor 50 EC exhibited no phytotoxic symptoms such as epinasty/hyponasty, leaf yellowing, necrosis, stunting growth, wilting *etc*. on groundnut plants.

CONCLUSION

It is concluded that the extract of *Ageratum conyzoide, Blumealacera plants and Bambusa vulgaris* root and leaf can be used to control weeds in groundnut cultivation.

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Characterization of physiological effects of phytotoxic volatile compound octyl acetate

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Plant allelochemicals are defined as natural compounds which affect the growth of neighboring plants after released from plants into environment. They are also useful sources of lead compounds for environmentally safer novel herbicide development. This study was aimed to find new natural phytotoxic volatile compounds, and investigate physiological responses of susceptible species in order to understand the mode of action.

METHODOLOGY

The allelopathic activities of 25 plant species were examined by dish pack method which was developed by Fujii (2005) for screening of plant species containing volatile allelopathic compounds. The volatile compounds from resin of *Boswellia* sp., leaves of *Numbo nucifera Gaertn*, leaves of *Platycladus orientalis* and shoot of *Cyperus microiria* were analyzed by GC/MS.

To study the plant growth inhibitory activity of volatile compounds from resin of *Boswellia* sp., five pre-germinated seeds were placed into glass vial with distilled water. The compounds found from resin of *Boswellia* sp. were volatilized into the sealed vial. After incubating for 3days in darkness at 25°C, the dose required to cause 50 % reduction in shoot or root growth (GR_{50}) were calculated.Cell viability, O_2^{-} production, lipid peroxidation, and PCD in lettuce roots were estimated by staining with fluorescein diacetate (FDA) and propidium iodide (PI), dihydroethidium (DHE), Schiff's reagent, and terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL), respectively.

RESULTS

Seven plant species including *Boswellia* spp. showed strong inhibitory effect on seedling growth of lettuce. Four volatile compounds, á-pinene, limonene, octyl formate, and octyl acetate were detected from *Boswellia* spp. by GC/MS analysis. The GR_{50} values 3 days after octyl acetate treatment for root and shoot growth of lettuce were 100 and 60 ìmol/l, respectively. Cell death, O_2^{-}production, lipid peroxidation, and PCD were induced by octyl acetate treatment in lettuce roots.

CONCLUSION

Octyl acetate showed strong inhibitory effect on seedlings growth of lettuce. ROS overproduction and subsequent oxidative damage may be related to the phytotoxic action of octyl acetate in lettuce seedlings.

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Allelopathic activity of *Piper retrofractum*

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Cogongrass (*Imperata cylindrica* (L.) Raeusch.) is a perennial rhizomatous weed and is distributed in tropical and subtropical regions with strongly invading habitats of other plant species. Allelopathic property of cogongrass may contribute to its invasion potential (Donald *et al.* 2013). Allelochemicals inhibit / stimulate the growth of neighboring plant species through releasing allelochemicals. There are several ways to release allelochemicals such as volatilization from leaves, leaching by rain and also exudation from roots. However, available information about the allelopathic potential of cogongrass rhizomes is limited. Thus, this study aimed to evaluate the allelopathic potential of aqueous methanol extracts of cogongrass rhizomes.

METHODOLOGY

The cogongrass rhizomes (100 g dry weight) were cut into small pieces and extracted with 600 ml of 70% aqueous methanol for 48 hours and filtered. The residues were extracted again with 600 ml of cold methanol for 48 hours and filtered. Filtrates were combined and evaporated using rotary evaporator at 40ºC. Aliquots of the extracts were dissolved in methanol and added to filter paper in petridish and then, methanol was evaporated in a fume hood. The filter papers were moistened with 0.05% aqueous solution of Tween 20. The final assay concentrations of the extracts were 1, 3, 10, 30, 100, 300, 1000 and 3000 mg dry weight equivalent extract/ml. The germinated seedlings of monocotyledons, Italian ryegrass (*Lolium multiflorum* Lam.), timothy (*Phleum pratense* L.) and barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.), and the seeds of dicotyledons, cress (*Lepidium sativum* L.), lettuce (*Lactuca sativa* L.) and alfalfa (*Medicago sativa* L.) were separately arranged on the petridishes and different assay concentrations were added. Then, they were incubated in the dark at 25ºC for 48 hours. Control seedlings and seeds were incubated under the same condition described above without the extracts. After incubation, coleoptile/hypocotyl and root length of the tested plant species were measured and compared to control. Then, concentrations required for 50% growth inhibition of the extracts were determined by a logistic regression analysis.

RESULTS

At the concentration of 300 mg dry weight equivalent extract/mL, the aqueous methanol extract of cogongrass rhizomes inhibited the coleoptiles and root growth of Italian ryegrass, timothy and barnyard grass less than 60 and 15% than control, respectively. At the same concentration, the hypocotyl and root growth of cress, lettuce and alfalfa were inhibited less than 15% than control. Inhibitory activity of the aqueous methanol extracts of cogongrass rhizomes was found to be concentration dependent. Comparing the concentrations required for 50% growth inhibition, the extracts showed the strongest inhibition on the growth of lettuce, and followed by cress, alfalfa, Italian ryegrass, barnyard grass and timothy with 54.4, 92.8, 120.5, 128.2, 186.2 and 491.3 mg dry weight equivalent extract/mL, respectively. The inhibitory activity on the coleoptile growth of Italian ryegrass was 3.8 times stronger than that of timothy and the hypocotyl growth of lettuce was 2.2 times stronger than that of alfalfa. Comparing the concentrations required for 50% growth inhibition on the roots of tested plants, the extracts showed the strongest inhibition on the growth of timothy, and followed by barnyard grass, lettuce, Italian ryegrass, cress and alfalfa with 33.0, 54.0, 65.1, 73.3, 87.1 and 104.2 mg dry weight equivalent extract/mL, respectively. The inhibitory activity on the root growth of timothy was 3.2 times stronger than alfalfa. These results suggest that the aqueous methanol extracts of cogongrass rhizomes may possess allelopathic activity.

CONCLUSION

This study suggests that the aqueous methanol extracts of cogongrass rhizomes possess allelopathic activity.

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Incorporation of green leaf manures and its allelopathic effect on weeds and maize productivity

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The reduction of chemical inputs into agricultural systems has renewed interest in the use of incorporation of green leaf manures, cover crop and mulches to suppress weeds. Using green leaf manures for weed control can significantly reduce the density and biomass of several weed species in maize. Green plants produce numerous secondary metabolites, many of which are capable of initiating chemical warfare among the neighboring plants growing in a community. Both, crop and weedy plants may possess such allelopathic compounds, but, unfortunately, the weed species often possess much higher levels of these than our present day crop varieties. Hence the field experiment was conducted to evaluate the weed control abilities of different green leaf manures incorporation in combination with the application of foliar spray.

METHODOLOGY

The field experiment was conducted to study the influence of different green leaf manures using the maize as a test crop. The tree leaf extract were used as as plant growth promoting substances by foliar spray. For comparison of treatments, two separate plots of 5 × 4 m were maintained outside the experimental plot with maize as test crop. In one plot maize was grown with the crop production guide recommendation for cultivation and in another plot it was grown with zero input management.

RESULTS

The highest BLW population was recorded in *Gliricidia sepium* + *Morinda tinctoria* while the highest sedge population was with *Gliricidia sepium* + *Morinda tinctoria* and *Peltophorum ferrugineum* + *Alangium salvifolium*. Lowest population of both BLW and sedge was recorded by *Albizia lebbek* + *Annona squamosa*. The interaction of *Albizia lebbek* + *Annona squamosa* recorded the lowest grasses population. The greater inhibitory effect on weed emergence than on weed growth of the survived plants could be attributed to the greater amounts of allelo-chemicals in the soil immediately after incorporation of GLM and were reduced drastically afterwards during decomposition, consequently did not have any effect on weed germination and further growth of the survived plants (Dhima *et al.* 2009). The combination of *Albizia lebbek* + *Annona squamosa* recorded highest grain yield and was on par with *Albizia lebbek* + *Morinda tinctoria* (Table 1). The lowest grain yield was in *Leucaena leucocephala* + *Aegle marmellos* at harvest of the crop. Positive influence of soil microbial population due to the application *Albizia lebbek*, higher concentration of micronutrients in *Annona squamosa* as foliar spray in addition to low incidence of weed infestation have been attributed for the better performance of *Albizia lebbek* + *Annona squamosa* combination in terms of yield parameters and yield (Vijayalakshmi *et al.* 2002).

Table 1. Influence of treatments on grain yield (kg/ha) of maize

Treatment	S_1 Alangium	S_2 Aegle	S_3 Morinda	S_4 Annona	MEAN
M_1-Albizia	1602	1790	1795	1820	1751
M_2-Gliricidia	1295	1691	1652	1372	1502
M_3-Leucaena	1310	1252	1295	1572	1357
M_4-Delonix	1770	1375	1437	1770	1588
M_5-Peltophorum	1690	1472	1636	1630	1607
MEAN	1533	1516	1563	1633	
	M	S	M at S	S at M	
LSD (P=0.05)	323	165	454	369	

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Sustainable management of *Parthenium hysterophorus* through highly competitive flora

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Parthenium hysterophorus L., commonly known as carrot weed or congress grass in India, is a herbaceous erect and annual plant belonging to the family "Asteracae". At present, it is widely distributed throughout India due to high invasive weedy characteristics and has replaced local flora in most of the Indian states. *Parthenium hysterophorus* has become a serious threat to the native floral diversity and none of the single methods alone has proved effective in its management. Integrated weed management is one such approach which has shown remarkable results in containing *parthenium* but suffers, due to some limitations in their applications and lack of quality research exposure. Allelopathy is one of the integrated approaches, came in existence few decades back and may play an important and eco-friendly role in management of this weed. Therefore, the present study aims at (i) plant community analysis at *P. hysterophorus* infestations and its interaction scenario with surrounding flora (ii) to identify and screen some promising plants through *in vitro* and *in vivo* studies that may be used as bio-controlling agents against *P. hysterophorus* with special reference to their phytotoxic/allelopathic potential.

METHODOLOGY

Phyto-sociological surveys were conducted during 2013-2014 in Agra at heavily infested sites with *P. hysterophorus* in different seasons. Ecological indices (Importance value index percentage) of this weed estimated, using quadrat and data analysed according to Hanson and Churchill (1961). To confirm field observation further *in vitro* (bioassay studies) and *in vivo* studies (Foliar spray; seedling bioassay, number of flower heads, seed output and biomass) were carried out by selecting some prominent weed species and to evaluate the allelopathic potential of competing cohabiting flora against *P.hysterophorus*.

RESULTS

Vegetation analysis at *P. hysterophorus* infested fields clearly indicates the higher population rate of it throughout the year, while other weed species were found in close vicinity of this weed. Few weed species like *Cassia occidentalis*, *Croton bonplandianum*, *Tephrosia purpurea*, *Calotropis procera* and *Withania somnifera* showed their competitive potential in all the seasons, though in winter season *C. Occidentalis* completely dominated *P. hysterophorus*, either through competition or phytotoxic potential. Competitive displacement of *P. hysterophorus* with other plant species has also been reported in several parts of the world (Shabbir and Adkins 2013). Seed germination of *P. hysterophorus* was influenced at higher concentration of leachates (100%) of *C. occidentalis* and *C. bonplandianum*, by significantly suppressing the germination (*in vitro* studies), and confirms their phytotoxic potential (Fig. 1). Similarly, foliar spray of leaf leachates extracted in hot water showed remarkable reduction in seedlings survival, number of flower heads, seed output and biomass of *P. hysterophorus* (*in vivo* studies) respectively. Dominance over *P. Hysterophorus* population with *C. occidentalis* at field level and inhibition on its overall growth with *C. occidentalis* and *C. bonplandianum* appears to be due to the strong allelopathic influence exerted by them.

CONCLUSION

Identification of *C. occidentalis* and *C. bonplandianum* plants as strong phytotoxic bio-agents from vegetation analysis and *in vitro* studies as well, propose an eco-friendly and cost effective alternative against other chemical approaches used in management of *P. hysterophorus* population in the field of integrated weed management strategies.

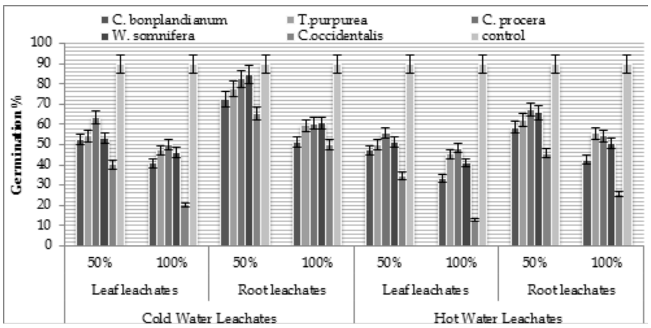

Fig. 1. Phytotoxic efficacy of leaf and root leachates of selected weeds on seed germination of *P. hysterophorus.*

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Bioherbicidal potential of lemon-scented *Eucalyptus* oil in rice

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The use of botanicals and allelopathic chemicals could possibly replace environmentally harmful synthetic herbicides and is becoming an important mean of controlling noxious weeds. Eucalyptus essential oils and their constituents have attracted much attention because of their phytotoxicity and relatively quicker degradation in the environment. This will not only help in reducing harmful use of excess chemicals but also helps in minimizing damage due to insect pest and diseases. Phenolic acids and volatile oils released from the leaves, bark and roots of certain *Eucalyptus* spp. have deleterious effects another plant species**.** There are also indications of a possible role played by allelopathy in weed suppression by eucalyptus; most of these studies have focused on the physical suppression of weeds. So, there is need to critically analyze the differential response (if any) of allelo-chemicals secreted by eucalyptus on weed species. Eucalyptus oil extracted from *Eucalyptus citriodora* has been tested its potential as a natural herbicide. This phytotoxic oil consists primarily of citronellal (77%) and other small terpenes.

METHODOLOGY

Seeds of all these test plants were germinated in petridishes (15 cm diameter) on a filter paper (Whatman No. 1) wetted with 10 ml of distilled water. To test the inhibitory effect of oil, different amounts of oil were loaded on the inner side of cover of petridish after spacing the seeds on the base and then sealed immediately with paraffin tape. Control was kept without oil. For each concentration, three replicates were maintained. All the petridishes were kept in an incubator maintained at the temperature of 20°C. After 14 days, the number of seeds that germinated was counted and on this basis LC_{50} (least concentration for 50% inhibition) was calculated. Another investigation was carried out to assess the inhibitory effect of leaf oil of *E. citriodora* against dominant weed species of rice, *viz. Cyperus iria, Echinochloa colona and Celosia argentea*. Seeds were collected from N.E.Borloug Crop Research Centre, Pantnagar and plants were raised in 20 cm diameter pots. For the study, 5 kg of garden soil was taken in each pot and fifty seeds were sown in each pot. A week after emergence, pots were thinned to ten plant per pot. When the plants were 4-week-old, they were spray treated with different concentration of *Eucalyptus citriodora* oil (or distilled water to serve as control) in such a manner that each plant received 2ml of treatment solution. Essential volatile oil from fresh, mature and healthy leaves of *Eucalyptus* was extracted by steam distillation, using Clevenger's apparatus. The experiment was performed in a completely randomized block design with three replications. Another greenhouse experiment was conducted to establish the herbicidal activity of *E. citriodora* against 4 week old rice crop and weed species (*C. iria, E. colona* and *C. argentea*) and to explore their possible mechanism of action.

RESULTS

In a laboratory bioassay, seed germination of test plants were significantly reduced in response to the concentrations of leaf oil. Maximum inhibition was observed with *C. argentea* followed by *C. iria* and *E. colona,* whereas, least effect was seen on *Oryza sativa*. Dose response curve was generated and least concentration for 50% reduction (LC_{50}) was maximum for *E. colona*, whereas, minimum for *C. argentea.* Further, seedling growth of test plants in the treated seedling was significantly reduced at concentrations from control to 5.0 ppm volatile oil.

Another greenhouse experiment was conducted to establish the herbicidal activity of *E. citriodora* against 4 week old rice crop and weed species (*C. iria*, *E. colona* and *C. argentea*) and to explore their possible mechanism of action. Spray treatment of volatile oil on the 4 week old mature plants of weedy species adversely affected the growth in term of plant height, chlorophyll content and fluorescence, thereby indicating the adverse effect of eucalyptus oil on photosynthetic machinery. The increase in proline and H_2O_2 content in oil treated plants indicating oxidative stress caused cellular damage and electrolytic leakage.

CONCLUSION

It is concluded that volatile oil of *Eucalyptus citriodora* show strong phytotoxicity and possess weed-suppressing ability hence, it could be used as a potential bio herbicide for future weed management programmes.

Barnyard grass-induced rice allelopathy

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Allelopathy of plants is strongly coupled with external stress factors. Stress factors such as, heavy metal, weak solar radiation, higher temperature, and nutrient starvation increased allelopathic activity due to increased production of allelochemicals (Belz 2007). Allelopathy of rice has been shown to be induced by jasmonic and salicylic acids which are important signaling molecules regulating inducible defense genes against the pathogen infection (Kato-Noguchi 2009). It was recently reported that allelopathic activity and three allelochemicals including momilactone B in rice were increased by the presence of barnyard grass (Zhao *et al.* 2005; Kong *et al.* 2006). However, it was not determined whether the increase in allelopathic activity and alleochemicals were caused by chemical-mediated interactions or by nutrient competitive conditions with barnyard grass. The objective of this study was to investigate the possible involvement of chemical-mediated rice/barnyard grass interaction in rice allelopathy.

METHODOLOGY

Seeds of rice (Oryza sativa L. cv. Koshihikari) and barnyard grass (*Echinochloa crus-galli* (L.) Beauv) were grown with Hoagland solution at 25°C with a 12-h photoperiod for 10 days. Then, effectiveness of barnyard grass, nutrient condition in the medium, root exudates of barnyard grass on allelopathic activity and momilactone B concentration in rice was determined in a series of experiments.

RESULTS

Allelopathic activity of rice seedlings exhibited 5.3-6.3 fold increases when rice and barnyard grass seedlings were grown together, where there may be the competitive interference between rice and barnyard grass for nutrients. Barnyard grass is one of the most noxious weeds in rice cultivation. Momilactone B concentration in rice seedlings incubated with barnyard grass seedlings was 6.9 fold greater than that in rice seedlings incubated independently. Low-nutrient-growth conditions also increased allelopathic activity and momilactone B concentrations in rice seedlings. However, the increases in low-nutrient-induced allelopathic activity and momilactone B concentration were much lower than those in barnyard grass-induced allelopathic activity and momilactone B concentration. Root exudates of barnyard grass seedlings increased allelopathic activity and momilactone B concentration in rice seedlings at concentrations greater than 30 mg/l of the root exudates, and increasing the exudate concentration increased the activity and momilactone B concentration. Therefore, barnyard grass-induced allelopathic activity of rice seedlings may be caused not only by nutrient competition between two species but also components in barnyard grass root exudates. As momilactone B possesses strong allelopathic activities, barnyard grass-induced allelopathic activity of rice may be due to the increased concentration of momilactone B in rice seedlings.

CONCLUSION

The present research suggests that rice may respond to the presence of neighboring barnyard grass by sensing the components in barnyard grass root exudates and increase allelopathic activity by production of elevated concentration of momilactone B. This elevated production and secretion of momilactone B of rice may provide a competitive advantage for root establishment through local suppression of pathogens and inhibition of the growth of competing plant species including barnyard grass.

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Inhibition of photosynthesis in water hyacinth by parthenium leaf allelochemical crude

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Water hyacinth (*Eichhornia crassipes* Mart. Solmns) is a ubiquitous aquatic plant of warm waters and a noxious weed of aquatic ecosystems including agro-ecosystems and water bodies world over with serious economic consequences. Parthenium (*Parthenium hysterophorus* L.) is a terrestrial plant spread from its place of origin Mexico to most of the tropical and sub-tropical world assuming the status of one of the worst weeds of the world and national weed of our country with tremendous implications on human and animal health, agriculture, forestry, environment and natural biodiversity. Parthenium plant parts especially leaf residue in water has been reported inhibitory to water hyacinth. The allelochemicals released into the aquatic environment from the leaf residue inhibited the aquatic weed and desiccated and killed the treated plants. Effect of the parthenium leaf allelochemicals on photosynthesis of water hyacinth plants has not been investigated. The study would have relevance for understanding mechanism of action of the herbicidal activity of the allelochemicals and may have implications on exploring use of parthenium leaf allelochemicals for development of a natural herbicide. Prompted by these considerations, present investigation was undertaken on inhibition of photosynthesis in water hyacinth by parthenium leaf allelochemical crude outdoors.

METHODOLOGY

Parthenium leaf allelochemicals crude (PLAC) was procured by the method developed in the laboratory. The allelochemical crude was applied in water at 0.25%, w/v with a quarter strength nutrient medium in 10 litre water in replications outdoors. Ten water hyacinth plants were loaded in each of the plastic buckets. The plastic buckets were placed in earthenware pots of larger size filled with water to act as a cooling jacket for ensuring dissipating of heat (absorbed by the plastic). Evapotranspiratory loss of water from the buckets and evaporative loss of water from the earthenware pots housing the buckets were replenished thrice daily. The water hyacinth plants placed similarly in water containing the nutrient medium comprised controls. Photosynthetic pigments (chlorophyll a, b, and total chlorophyll and carotenoids) and photosynthetic measurements were taken at intervals until death of the treated plants.

RESULTS

The PLAC toxicity appeared hours after initiation of the treatment. The water hyacinth plants showed dull appearance and wilting from margins which intensified and progressed further with treatment duration until the plants desiccated and died in 6-10 days. There was rapid increase in dry to fresh weight ratio in the treated plants with time, showing progressive loss of water from the treated plants. This showed inability of plant to draw water in spite of floating in it, evidencing root dysfunction due to action of the PLAC. Photosynthesis experienced an initial spurt in treated plants by 2 days followed by rapid decrease with treatment duration and ceased completely by 5 days. Transpiration and stomatal conductance followed similar course. There was concomitant decline in chlorophyll a, b, total chlorophyll and carotenoids with treatment duration.

CONCLUSION

The results showed that the PLAC action involved root dysfunction derived water stress – inability of the plants to replenish evapotranspiratory loss of water - and associated loss of photosynthetic pigments and consequent loss of photosynthesis probably through mediation of macromolecules.

Allelopathic potential of *Callistemon* oil against some weeds of paddy fields

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Allelopathy refers to any direct or indirect, harmful or beneficial effects of one plant on another mediated by chemical compounds released into the environment and the responsible chemicals are called allelochemicals. Among this, volatile essential oils and their constituent monoterpenes, are receiving much attention of plant researchers as potential bioherbicides for managing weeds nowadays. Further, these plant essential oils are biodegradable thus environmentally safer and possess low mammalian toxicity than the synthetic herbicides, however, little is known about its bioherbicidal potential. Therefore, the present study was undertaken to investigate the allelopathic potential of volatile oil of *C. Viminalis* against some harmful weeds of paddy with a view to exploring its bioherbicidal potential.

METHODOLOGY

Mature leaves of *C. viminalis* collected from Punjab University campus, Chandigarh were used to extract oil by hydro-distillation using Clevenger's apparatus. The chemical characterization of oil was done using GC and GC-MS. For phytotoxic studies, seeds of paddy field weeds were collected locally from agricultural fields around Chandigarh. *Callistemon* oil (0.1-1.0 mg/ml) solutions were prepared by dissolving the requisite amount of oil in Tween-80 (0.05%, *v/v*). Pre-imbibed seeds of weeds were placed equidistantly in 15 cm dia petridishes on thin layer of cotton wad and Whatman No. 1 filter paper moistened with 10 ml of *Callistemon* oil or distilled water (control) and then dishes were sealed with tape. Five replicates were maintained in a completely randomized manner in a growth chamber set at 25 ± 2°C, 16/ 8 h dark/light photoperiod of ~150 µmol photons/m^2/s and a relative humidity of around 75%. After 7 days, % germination, root and shoot length was measured.

Table 1: Percent inhibition in root length of test weed species on exposure to Callistemon oil

Concentration (mg/ml)	*E. crus-galli*	*L. chinensis*	*C. rotundus*	*C. benghalensis*
0.1	16.02	11.97	12.80	10.11
0.25	35.55	37.64	24.32	32.11
0.50	50.00	47.89	34.07	52.83
0.75	58.59	65.81	47.37	100
1.0	77.73	84.32	65.51	100

RESULTS

The essential oil of *C. viminalis*, comprised of 22 compounds, constituted ~ 98.73% of oil with 1, 8- cineole (63.82%) as major component followed by á - pinene (16.85%) and á - terpineol (9.88%). Upon exposure to 1mg/ml oil, *Callistemon* oil inhibited % germination up to ~ 82%, ~ 94% and ~ 74% in *E. crus-galli*, *L. chinensis* and *C. rotundus*, respectively. A complete inhibition in seed germination was observed at 0.75 mg/ml oil in *C. benghalensis*. Further, root and shoot length was reduced by the different concentration of oil. The effect was more severe on roots of *C. benghalensis*, followed by *L. chinenesis*, *E. crus-galli* and *C. rotundus* (Table 1). Similar results were observed for shoot length in response to *Callistemon* oil. At 1mg/ml oil, there was a reduction of ~100, 75, 83, and 60% in *C. benghalensis*, *E. crus-galli*, *L. chinenesis*, *C. rotundus*, respectively. Not only the root and shoot length, total chlorophyll content also decreased significantly in a dose- dependent manner. Upon exposure to 0.50 mg/ml oil, ~71% inhibition was observed in total chlorophyll content of *C. benghalensis*, however, it reduced to ~61, 45, and 80% at 1mg/ml in *E.crus-galli*, *L. chinensis* and *C. rotundus*, respectively. A reduction in chlorophyll content in response to *C. viminalis* essential oil suggests its negative impact on photosynthesis.

CONCLU SION

From the above study, it is clear that *Callistemon* oil exerts strong allelopathic effects against paddy weeds. The allelopathic effect may be attributed to the presence of constituent monoterpenes (Singh *et al*. 2003). Furthermore, studies are required to investigate its possible mode of action under green house or natural conditions to explore its bioherbicidal potential.

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Allelopathic effect of invasive alien weed *Hyptis suaveolens* on germination of *Oryza sativa*

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Hyptis suaveolens (L.) Poit. is an invasive alien weed commonly known as *Bana tulsi* in Odisha belonging to the family Lamiaceae and widely distributed in India. Leaves of this plant have been used as stimulant, carminative, sudorific and as a cure for parasitic cutaneous diseases whereas the crude leaf extract is used as a relief to colic and stomachache. The leaves of *H. Suaveolens* L contain alkaloids, terpenes and volatile oils whichhave allelopathic potential and suppress the seedling growth of barnyard grass *Echinochloa crusgalli*. In view of the little work on the allelopathic effect of *Hyptis suaveolens*, the present work was aimed to investigate the allelopathic effect on germination of rice (*Oryza sativa* L.)

METHODOLOGY

The leaves of *Hyptis suaveolens* (L.) Poit. were collected from Kapilash forest region of Dhenkanal district, Odisha. The leaves were shade dried and leachate was prepared by soaking 50 g of dried powdered leaves of *Hyptis suaveolens* (L.) Poit in 1000 ml of distilled sterile water for 48 hrs at 26 ± 10 %C and normal pressure. The solutions were filtered through whatmann No.1 filter paper and the leachate of 50 g in 1000 ml, was diluted to 40, 30, 20 and 10 g/L. The different dilution of leachate were tested against the control (Distilled water) on the growth of the test crops *Oryza sativa* L obtained from CRRI, Cuttack. Seeds of *Oryza sativa* L. were surface sterilized with 0.1% of mercuric chloride and washed thoroughly with distilled water. Fifty uniform sized seeds were placed in petridishes with different concentrations of leachate and one with control at a constant temperature at 26 %C. Seeds were irrigated with 30 ml of test solutions and distilled water twice a day. Each treatment was replicated five times. The number of seeds germinated in each treatment was counted on fourth day after sowing and the total germination percentage were calculated. Vigour index (Abdul Baki and Anderson 1973), Tolerance index of seedlings (Turner and Marshal 1972) and percentage of phytotoxicity were calculated.

Table 1. Effect of aquous extract of *Hyptis suaveolens* on seed germination, radicle length, seedling vigour index and percentage of phytotoxicity in *Oryza sativa* L. after 4 days of treatment

Treatment	Germination Percentage	Radicle length (in cm)	Seedling Vigour Index	Percentage of Phytotoxicity
Control	96.4±0.670	5.6±0.136	539.84	0
10 g/l	62±0.567	3.1±0.084	192.2	44.642
20 g/l	43.6±0.671	2.6±0.068	113.36	53.571
30 g/l	30.4±0.671	1.5±0.079	45.6	73.214
40 g/l	23.2±0.439	0.8±0.067	18.56	85.714
50 g/l	19.2±0.439	0.2±0.047	3.84	96.428

Values of 5 replicates ± SEM

RESULTS

Germination percentage was significantly decreased from 96.5% to 19.2% with the increase in leachate concentration of 0.0 to 50 g/l respectively. Similarly the radicle length of the seedling also decreased from 5.6 cm to 0.2 cm with increase in the concentration of the leachate i.e 0.0 to 50 g/l respectively. Seedling vigour index was found to be decreased with the increase in the concentration of the leachate under use. Similarly the percentage of phytotoxicity was increased with increasing concentration of the leachate. The data of the present investigation are presented in Table 1.

CONCLUSION

The present investigation indicated that *Hyptis suaveolens* had a strong allelopathic effect upon germination of rice. Further studies confirm the efficacy of the alien weed as a suitable option for a potential bio-herbicide.

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Theme 9

Aquatic weeds-biology, management and utilization

Management of water hyacinth in Khyber Pakhtunkhwa-Pakistan

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Water scarcity and water pollution are the most important issues of the 21st century, and hence conservation of quality water for future generations is essential. Aquatic weeds are the major culprits responsible for destroying the aquatic bodies' balance, deteriorating water quality and causing water pollution. Water hyacinth (*Eichhornia crassipes*) is a problematic aquatic weed because of its rapid production, dense population and impenetrable mat formation across water surface that destroys fish and wildlife habitats (Stroud 1991). It reduces biodiversity, eliminates local submerged plants by blocking sunlight, causes shifts in emerging plant communities by competing for space, and also affects native animal communities by destroying their nesting and mating environment in the native water bodies (Gowanloch 1944). Though being a problem in Pakistan, no study had been conducted on water hyacinth management. Hence, this study was initiated to study the affect of different chemicals, natural products and mulching on water hyacinth management.

METHODOLOGY

The experiment was conducted at District Swabi, KP, Pakistan, during spring 2014. The experiment was laid out in complete Randomized Block Design, replicated 3 times with 8 treatments which were T_1-2,4-D ester at 1.5 kg/ha, T2-Paraquat at 1.0 kg/ha, T_3-Glyphosate at 2.0 kg/ ha, T_4-*Parthenium hysterophrous* water extract (WE) at 1:10 (w/v), T_5-*Sorghum bicolor* (WE) at 1:10 (w/v), T_6-Dark plastic (mulching), T_7-Hand weeding (physical control) and T_8-Control (Weedy check). The size of each experimental unit was 2 x 2 m^2. All herbicides were applied as foliar spray on water hyacinth infestations on 25 March, 2014. Control treatments were kept unsprayed for the whole season. Re-growth from mother plants was observed for 30 days, after the treatment application. Mulching was done by covering the water hyacinth infestation with dark plastic to alter the micro-environment.

RESULTS

Data were recorded on plant height (cm), weed density/m^2, species abundance/m^2, fresh weight (kg/m^2), re-sprouts/ ramets /m^2 and mortality (%) of water hyacinth. All the parameters, except species abundance, were significantly affected by the various methods of weed control. Minimum plant height (0.00 cm) was recorded in the treatment of hand removal (because of zero re-growth) and 2, 4-D plots (because of 100% control) followed by dark plastic (5.50) while maximum plant height (43.94 cm) was observed in the control treatment. The lowest weed density/m^2 (0.00 plants/m^2) was recorded in hand weeding, which was at par with dark plastic plots (1.33 plants/m^2) while the highest density (28.33 plants/ m^2) was recorded in the control plots. Similarly, minimum fresh weight (0.00 kg/m^2) was recorded in hand weeding, yet it was statistically similar to that of dark plastic (1.29 kg/m^2), while maximum (7.22) fresh weight was recorded in the control plots. There were zero re-sprouts in the hand removed plots and dark plastic followed by 2, 4-D (1.33 sprouts/ramets/m^2) as compared to control (13 sprouts/ramets/m^2). Water hyacinth mortality was 100 % in hand weeding, followed by dark plastic, 2, 4-D and glyphosate (90 % each) while the lowest mortality (5 %) of water hyacinth was obtained in *Sorghum bicolor* water extract followed by *Parthenium hysterophrous* (16 %) as compared to control (0.00 %) (Table.1)

Table 1. Plant height, weed density, species abundance, fresh weight, ramets and mortality of water hyacinth as affected by different treatments

Treatment	Plant height (cm)	Weed density (plants / m^2)	Species abundance	Fresh weight (kg/ m^2)	Ramets / m^2	Mortality (%)
2, 4-D ester	0.00^{d}	2.333^{e}	1.00^{ab}	1.55^{e}	1.33^{d}	4.67^{ab}
Paraquat	12.70^{c}	8.000^{c}	3.67^{ab}	3.01^{d}	7.00^{c}	3.67^{c}
Glyphosate	7.87^{c}	5.33^{d}	2.67^{ab}	2.53^{d}	4.67^{c}	4.33^{b}
Parthenium hysterophrous (WE)	28.19^{b}	19.67^{b}	0.67^{b}	4.27^{c}	10.00^{b}	1.67^{d}
Sorghum bicolor (WE)	33.44^{b}	21.33^{b}	2.67^{ab}	6.49^{b}	12.67^{a}	0.67^{e}
Dark plastic (mulching)	5.50^{cd}	1.33^{ef}	0.00^{b}	1.29^{e}	0.00^{d}	4.67^{ab}
Hand weeding	0.00^{d}	0.00^{f}	0.00^{b}	0.00^{f}	0.00^{d}	5.00^{a}
Control (Weedy check)	43.94^{a}	28.33^{a}	7.00^{a}	7.22^{a}	13.00^{a}	0.00^{f}

CONCLUSIONS

Hand weeding is the most effective and environment friendly method for complete eradication of small scale infestations of water hyacinth. Herbicides can be economical for large scale infestations but can endanger the lives of non-target species and deteriorate the environment if not used sagaciously.

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Efficiency of inoculants for composting of water hyacinth and water cabbage and the effect of composts on soil enzyme profile

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Weeds like water cabbage (*Limnocharis flava* L. Buchenau) and water hyacinth {*Eichhornia crassipes* (C. Martius) Solms-Laub} have now emerged as devastating plants in the wet land ecosystem, especially in Kerala. They are easily decomposed by microorganisms to produce compost whose quality varies with the source material and the organism used for composting.

METHODOLOGY

The study was carried out during 2013-14 to evaluate the efficiency of different inoculants, *viz. T. reesei, P. sajor-caju*, composting inoculum and commercial enzyme cocktail for composting the aquatic weeds water hyacinth (*Eichornia crassipes*) and, water cabbage (*Limnocharis flava*). The prepared composts were then evaluated for enzyme activities as a measure of compost stability and maturity, through a pot culture experiment using *Amaranthus* as the test crop. Enzymes such as urease, phosphatase, dehydrogenase, aryl sulphatase and cellulase were measured indirectly by determining their activity in the laboratory, which reflect potential activity and do not represent true *in-situ* activity levels and can be viewed as index of soil fertility. The activity of various soil enzymes after incorporating the composts was also studied.

RESULTS

Compost prepared from water hyacinth using composting inoculum recorded the highest value for urease proving the superiority of composting medium. This may be attributed to high availability of easily degradable substrate and varying nutrient contents which ultimately resulted in the spurt of ureolytic bacteria and ultimately increased the urease activity. Phosphatases or phosphomonoesterase, enzymes that hydrolyse compounds rich in organic P and transform them into inorganic P, catalyse the hydrolysis of esters of phosphoric acid to release PO_4 and are of paramount importance as a soil quality indicator. In the present study, the application of compost (coir pith + composting inoculum) was observed to have increased phosphatase activity as compared to control. Dehydrogenase exists as an integral part of intact cell involved in oxidative phosphorylation and reflects the total oxidative potential of soil microbial community by transferring hydrogen and electrons from substrates to acceptors. It was evident that the application of water hyacinth and composting inoculum had increased the dehydrogenase activity in soil. Activity of arylsulphatase (an enzyme catalyzing the hydrolysis of organic sulphate esters) increased in the post harvest soil sample that had been applied with compost prepared from water hyacinth and composting inoculum. The â-glucosidase activity was found to be sensitive to soil management and hence proposed as a soil quality indicator because it is an early indicator of change in organic matter status. Highest activity was noted with the application of compost from water hyacinth.

Respiratory activity of soil is an important index of microbial growth and activity in soil (Castaldi *et al.* 2008). From this study, no significant variations were observed with the application of various substrates. A higher soil respiration supports the notion that the rapid decomposition of plant residues (coir pith) will increase the nutrients available for stimulation of heterotrophic microorganisms. Soil microbial communities are the driving force in regulating soil processes such as organic matter decomposition and nutrient cycling. The composts from water cabbage and composting inoculum have proved their efficiency individually in increasing bacterial count. Addition of composted water cabbage increased the bacterial activity representing a shift in microbial response resulting in changes in substrate availability.

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Water hyacinth rafts for open water vegetable cultivation

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Land is a limiting resource in Kerela, and to meet with the food requirement of growing population, agricultural technologies need to adapt to special situations to sustain agricultural production. Water bodies are abundant in Kerkela that may be used for growing certain vegetables, but aquatic weeds restrict their use. Water hyacinth (*Eichhornia crassipes*), an aquatic weed and potential threat to water bodies, grows rapidly and can cover an area of one hectare within 9 months. Due to its ability to multiply fast, complete elimination of the weed is impossible. But the adverse impacts can be eliminated by reducing the weed density. Also, the inflated bladder like petioles of the weed has abundant aerenchymas which make them buoyant. The ability of water hyacinth to remain afloat has been exploited, and a study was undertaken on open water cultivation of Red *Amaranthus* var. Arun by utilizing weed beds of water hyacinth as floating rafts and a medium for farming. Red *Amaranthus* require bright sunlight for color development which is available abundantly over water bodies.

METHODOLOGY

The experiment was carried out in the ponds of RARS Kumarakom. The pond was of the size 32.5 x 11 m and it was infested with water hyacinth. Bamboo poles, immersed vertically into mud at the bottom of the water body along the borders of the weed bed, were used to fix it in position to avoid damage due to wave action or drifting and to define the area of required bed. The average dimensions of freshly prepared platforms were 5.7 m (L) x 1.8 m (B) x 0.7 m (H). Here, water hyacinth was allowed to stand on and more water hyacinth was piled up to make it compact. Red *Amaranthus* var. Arun was transplanted on a thin layer of coir pith compost over the bed. The seedlings were spaced closely at a distance of 5 cm since open water culture permits to trap maximum solar radiation. Foliar application of 19:19:19 at 1% and supernatant filtered cow dung slurry at alternate weekly intervals were given to the plants to meet their nutrient requirement. The crop was harvested in 60 days and the nutrient content in fresh as well as decayed water hyacinth, coir pith compost and *Amaranthus* at harvest was recorded to evaluate the dynamics of nutrient absorption.

RESULTS

The indigenous method tried with bamboo poles in live water hyacinth platforms was more viable and profitable. Weeds were collected seven times from the area of the bed so that a platform with a height of 0.70 m above the water surface could be achieved. Duration or stability of the floating bed depends on density of the first layer, which remains at the bottom. The thickness depends on the duration of crop as it needs to be afloat for the whole cultivation period. The beds can be recycled as organic fertilizer in the next floating bed which is economical as well as environment friendly. An yield of 17.35 t/ha was recorded which was comparable to the potential yield of 20t/ha (Gopalakrishnan and Indira 2001) for *Amaranthus* var Arun. No incidence of pest or disease was recorded.

Table.1. Nutrient content of bedding material and amaranthus harvested from the beds.

Treatment	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Fresh water hyacinth	0.271	6.29	1.4	1.2	1775	630.2	33.0
Coir pith compost (CPC)	0.163	1.72	1.6	1.8	370	16.4	88.6
Amaranthus at harvest	0.873	7.17	2.0	0.24	390	235.2	89.2
Decayed water hyacinth + CPC	0.543	4.66	2.4	1.1	10060	277.6	94.4

Data analysis revealed that *Amaranthus* cultivated in water hyacinth beds contained nutrients well below the safe limit, as prescribed by Indian/WHO standards though the weed absorbed very high levels of dissolved plant nutrients (Table.1) *E. crassipes* composts were effective as organic manure source for production of green-leaved vegetables devoid of heavy metal contamination (Sasidharan *et.al*. 2013).

CONCLUSION

Floating cultivation can help reduce the pressure on arable lands by turning waterlogged areas into productive ones. This technique provides a means of using the invasive weeds in a beneficial way. The novel concept of utilizing water hyacinth for open water vegetable farming in waterways by managing natural resources can provide ecological balance and nutritional security. This technique can improve the livelihoods of those landless farmers living adjacent to water bodies by attaining self sustainability in food production, thus promoting the concept of family farming.

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Evaluation of compost from water cabbage and water hyacinth for their maurial value and impact on soil health

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The most widely available but the most wasted energy source is a wide variety of agricultural wastes. Most of the farm wastes including weeds are of biological origin and thus are easily decomposable by microorganisms and can be exploited for the production of biofuels and manures. Wetland plants like water cabbage (*Limnocharis flava* L. Buchenau) and water hyacinth {*Eichhornia crassipes* (C. Martius) Solms-Laub} are obnoxious weeds of the wet land ecosystem, especially in Kerala. These weeds are not easy to manage and are also a threat to biodiversity, economic development and human wellbeing (UNEP 2012). But these troublesome weeds can be effectively utilized for production of quality manure.

The present study was carried out in the Department of Soil Science and Agricultural Chemistry at College of Agriculture, Vellayani, during August, 2013 to February, 2014 to prepare compost from water hyacinth and water cabbage and evaluate its quality with other manures.

METHODOLOGY

Representative samples of water cabbage, coir pith, water hyacinth, and farm wastes (dried leaves and pseudostem of banana) were collected and analysed for bio-chemical composition. The method followed for composting was aerobic heap method where 100 kg of biomass was mixed with 10 kg of cowdung. After completion of the thermophilic stage, 1 kg of the following inoculants were added to the substrates. The inoculants used in the study were I_1- *Trichoderma reesei,* I_2- *Pleurotus sajor-caju,* I_3- composting inoculum developed by the Dept. of Agricultural Microbiology, College of Agriculture, Vellayani, I_4- Commercial enzyme cocktail (Cellulase / pectinase and laccase). The resultant compost was evaluated in a pot culture experiment using Amaranthus as test crop.

RESULTS

The composition of major nutrients (Table 1) revealed that different composts affected soil available N, P and K. Compost S_1I_3 (water cabbage and composting inoculum) was found to be efficient in mineralizing the N from organic sources whose effects are similar to composts from water cabbage + commercial enzyme cocktail, water hyacinth + composting inoculum and farm waste + composting iInoculum. It was evident that composting inoculum has a strong effect in influencing soil available N and recorded the highest value. Similarly, the substrate water cabbage also significantly influenced the available N status. This might be due to the conversion of organic nitrogen by the process of mineralization by nitrifying bacteria present in compost and soil as reported by Monedero *et al.* (2001). The available P content decreased generally with the application of various composts. Application of composts *viz.* water cabbage + composting inoculum, water cabbage + *P. sajor-caju*, farmwaste + *T.reesei*, farm waste + composting inoculum revealed to have significant influence on the available P status of the soil. The dramatic increase in available P status of the soil might be due to the solubilisation of P from the unavailable fixed forms by the action of various organisms in the inoculum used. This might be also due to increased microbial activity causing greater mineralization of added compost and production of organic acids which solubilise fixed P in soil.

The highest value for available K in the soil was recorded by the application of compost prepared out of water hyacinth and compostingi. Like the major nutrients, organic carbon status of the soil was also affected by the application of various composts. The compost prepared out of water hyacinth and *Trichoderma* was found to increase the organic carbon content of soil. The effect of inoculants used in the study was not found to be significant.

Table 1.Effect of different composts on the soil chemical characters

Treatment	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Organic Carbon (%)
$T_{1\text{-Package of practice}}$	167.25	71.89	290.08	1.16
$T_{2\text{-FYM alone}}$	209.07	63.79	255.26	1.65
T_3 (S_1I_1)	209.07	73.17	290.48	1.37
T_4 (S_1I_2)	209.07	79.97	290.85	1.97
T_5 (S_1I_3)	275.97	73.10	282.38	1.51
T_6 (S_1I_4)	250.88	60.24	256.79	1.76
T_7 (S_2I_1)	192.34	65.39	299.93	2.31
T_8 (S_2I_2)	188.16	55.84	221.56	2.30
T_9 (S_2I_3)	188.16	48.01	236.80	2.41
T_{10} (S_2I_4)	183.98	54.83	189.65	2.33
T_{11} (S_3I_1)	192.34	63.79	223.87	2.60
T_{12} (S_3I_2)	225.79	90.10	211.47	2.13
T_{13} (S_3I_3)	246.70	97.70	396.28	2.23
T_{14} (S_3I_4)	234.15	77.21	201.90	2.46
T_{15} (S_4I_1)	221.61	82.94	259.63	2.34
T_{16} (S_4I_2)	209.07	76.10	256.07	2.00
T_{17} (S_4I_3)	246.70	81.24	211.88	2.12
T_{18} (S_4I_4)	225.79	79.04	269.36	2.22
$T_{19\text{control}}$	136.25	44.63	171.06	1.23
LSD(P=0.05)	36.956	16.07	40.845	0.664

CONCLUSION

Teh study reveals water cabbage to be the best substrate in terms of its chemical composition followed by water hyacinth. S_1I_3 (water cabbage + composting inoculum) and S_3I_3 (water hyacinth + composting inoculum) yielded the best composts. T_{13}{100% N as compost (water hyacinth + composting inoculum)}and T_5{100% N as compost (water cabbage + composting inoculum)} were performed better in pot culture. With regards to inoculants used on different substrates, composting inoculum was found to be the most effective for composting the agrowastes.

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Biocontrol of water hyacinth by *Neochetina bruchi* and *Alternaria alternata*

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Water hyacinth (*Eichhornia crassipes*) is the most problematic weed of water bodies. It is a monocotyledonous, perennial, fresh water aquatic weed with a very high rate of multiplication (can double its number within a month). Intensive infestation of water bodies by this weed destroys native habitats of fish, reduces human access to drinking and irrigation water, deteriorates water quality and also provides breeding space to mosquitoes. Although glyphosate is quite effective herbicide for controlling water hyacinth in water bodies (Chinuswamy *et al.* 2012), but concerns regarding its toxicity to aquatic life has made its use controversial. Hence, there is need to formulate non-chemical strategies that are cost effective and eco-friendly. Jayanth (1988) reported that 95 % infestation of water hyacinth was cleared in 32 months by *Neochetina eichhorniae*. *Alternaria alternata* is a pathogenic fungus with good biocontrol potential against water hyacinth and is non-pathogenic on plants of economic and ecological importance of India (Babu *et al.* 2002). The present investigation was initiated to study the efficacy of the two different bioagents- beetle *Neochetina bruchi* and fungus *Alternaria alternata* isolate *DWSR* for controlling water hyacinth under simulated pond conditions in pre-fabricated cemented pits.

METHODOLOGY

Water hyacinth plants were collected from a perennial pond in village Jainpur, district Ludhiana of Punjab. Twenty plants were inoculated in pre-fabricated cemented pits (dimensions-9 x 3 x 3 ft) and watering was done periodically. Plants were allowed to grow for establishment. After one month, 500 adult beetles of *Neochetina bruchi* received from Directorate of Weed Science Research (DWSR), Jabalpur were released in these pits during September, 2014. In another cemented pit, talc formulation of fungus *Alternaria alternata* isolate *DWSR*, received from DWSR, Jabalpur was sprayed during October, 2014. This formulation was sprayed at 1 kg/ 100 m^2 area after adding cold rice solution (starch) at 250 ml/kg of talc formulated product. Rice solution was prepared by boiling 100g rice in 1 l water followed by filtration. Visual scoring for qualitative assessment of water hyacinth control/ mortality was done at weekly intervals for eight months.

Fig. 1. Biocontrol of water hyacinth (A) water hyacinth transplanted in cemented tanks at PAU, Ludhiana (B) three months after infestation of *Neochetina bruchi* beetles (C) 45 days after infestation of *Alternaria alternata* fungus.

RESULTS

Die back symptoms appeared on leaves after one week of beetle release. After three months, die back symptoms were observed to the extent of 25-50 %, however, clear water appearance was not observed. There was extensive multiplication of water hyacinth plants by ramet production and beetles failed to inhibit multiplication of water hyacinth (Fig.1). Water hyacinth plants died during winter season (last fortnight of January), but there was again regeneration of plants on arrival of summer season (last fortnight of March).

Initial symptoms of disease due to attack of fungus *Alternaria alternata* appeared within two weeks after spray of fungus. It took about a month for the disease to spread in the total plant population. The growth of water hyacinth plants was severely hampered and clear water appearance was observed 45 days after spray of fungus (Fig.1). No new plantlet regeneration was observed even after six months of spray.

CONCLUSION

Alternaria alternata isolate *DWSR* is a rapid and highly effective biocontrol agent for controlling water hyacinth infestations in water bodies.

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Interactive effect of native fungal pathogens and *Neochetina bruchi* against water hyacinth

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The presence of invasive aquatic plants, both floating as well as submerged, has threatened aquatic ecosystem throughout the world. Some of the aquatic species, *viz*. water hyacinth (*Eichhornia crassipes*), Alligator weed (*Alternanthera philoxeroides*), Giant Salvinia, (*Salvinia molesta*) and water lettuce (*Pistia stratiotes*) have been emerged as major invaders of the aquatic habitat. Among these obnoxious water weeds, water hyacinth [*Eichhornia crassipes* (Mart.) Solms] is a threatening aquatic weed in India. Aquatic weeds can be controlled by several methods including mechanical, chemical and also biological methods. Among all, biological method of aquatic weed control is considered as the safest approach keeping in view the environmental consequences. Microbial weed control represents an innovative means to manage troublesome aquatic weeds by pathogens like fungi, bacteria and viruses.

METHODOLOGY

During the present investigation, five lakes were surveyed in and around Dharwad-Hubli city (Unkal lake, Kelgerilake, Nuggikeri lake, Mugad lake and Kittur lake) and the aquatic weeds exhibiting symptoms like spots, lesions, rots and browning were collected and carried in a separate clean polythene bag and stored at 5^0C. The diseased plant parts were dissected and transferred on to the plate containing Potato Dextrose Agar (PDA) medium. The plates were incubated at 25°C for 5-7 days. After a period of four days pure culture of the fungal bio agents was obtained using hyphal tip or single spore isolation techniques. The cultures were identified based on the sporulation as described in Barnett and Hunter (1990). The tentative identification of the fungal isolates was carried out based on the colony morphology as well as through microscopic observations.

The native fungal isolates were screened for their disease causing ability on water hyacinth by spraying the spore suspensions from each fungal isolate at of 2.5% (w/v) in 0.2% Tween-20 in distilled water, while the control plants were sprayed with sterilized water under the same conditions. The treated plants were observed daily for the appearance of typical disease symptoms. Based on the disease severity index three promising isolates were selected for further studies of integrating with weevil. In the *in vivo* experiment, the weevils were introduced to the plants a week before the spray of the fungal pathogens in order to get enough weevil feeding scars to serve as entry point for fungal spores. After a week, the plants were sprayed with a spore suspension of each fungus diluted to 2.5% (w/v) in 0.2% Tween-20 in distilled water using low-pressure atomizers.

RESULTS

The fungal pathogens identified during the investigations (Table -1) include three isolates that belonged to the genus *Colletotrichum* and *Alternaria* while two were the representatives of *Cercospora*. Regarding symptoms, initially roundish oil-soaked spots appeared mainly on the leaves which turned brown later. Eventually, these spots enlarged with the rounded side facing the petiole and tapering to a narrow point in the direction of the laminar tip. Additionally, on the upper surface of the leaves, distinct concentric zonations were observed. Further, the fruiting bodies of the fungi were also noticed on the upper surface along these concentric rings. The combination of *Colletotrichum* spp + *Neochetina bruchi*, recorded the highest percentage of damage (75-100 %) and chlorophyll content of water hyacinth (6.3). followed by the treatment of *Colletotrichum* spp. The lowest per cent damage was observed in control (<5%).

Treatment	Percentage foliar damage (%)	Chlorophyll content
Colletotrichum spp.	50-75	6.5
Colletotrichum spp. + Neochetina bruchi	75-100	6.3
Alternaria spp.	50-75	11.5
Alternaria spp. + *Neochetina bruchi*	50-75	9.7
Cercospora spp.	25-50	12.5
Cercospora spp. + Neochetina bruchi	50-75	7.2
Neochetina bruchi	5-25	31.1
Control	<5	44.5

*Samples were collected from Kelgeri (GPS Location: N15°27' 18.6 E 074° 58' 50.7 altitude of 699 m)

CONCLUSION

The *in vitro* studies revealed that the fungal phathogens viz., *Colletotrichum* spp., *Alternaria* spp. and *Cercospora* spp. along with interaction of the beetle *Neochetina bruchi*, were responsible for decaying of water hyacinth. Hence, the possibility of exploiting these native fungal pathogens along with the beetle is an eco-friendly way. However, before taking this technology to the natural water bodies, the host range of these pathogens have to be investigated in a systematic way.

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Alligator weed menace in Telangana, India

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The introduction and spread of invasive alien species (IAS) has become a concern globally, in context of environment ecology and conservation. These species are continuously altering the terrestrial and aquatic ecosystems leading to loss of native biodiversity and extinction of native species. The natural environment and productivity of aquatic ecosystems in India are disturbed by weeds that grow abundantly in water and complete at least a part of their life-cycle in it, pollute the environment when they die and decay. They also offer suitable breeding grounds for mosquitoes, snails and other animals which spread disease. Aquatic weeds in canal systems reduce the designed flow by 40-50%. On the other, the obstructed flow of water in canals results in forced seepage, water logging and soil salinity (Varshney *et al*. 2008). Many of the aquatic ecosystems in Telangana are choked by floating and emergent weeds of which the most troublesome exotic weeds include *Eichhornia crassipes*, *Alternanthera philoxeroides*, *Pistia stratiotes*, *Ipomoea carnea* ssp. *fistulosa*, species of *Typha*, *Salvinia* and *Azolla*. Of these, *Alternanthera philoxeroides* (Mart.) Griseb. (Amaranthaceae), popularly known as alligator or pig weed, is one of the noxious weeds in aquatic, marshy areas and agro ecosystems. It is a native of South America, the Parana River region of Brazil, Paraguay and Argentina. It was first reported from India by J.K. Maheshwari from West Bengal and Bihar in 1965.

METHODOLOGY

Field trips were conducted to survey and monitor the status of alligator weed in Telangana, especially in polluted and contaminated sites of urban areas.

RESULTS

Alternanthera philoxeroides is a fast-spreading perennial, with decumbent stems which are long, hollow and rooted at nodes. It was first reported from Warangal district by V.S. Raju in 1987 as a rare, problematic weed in marshy areas and aquatic systems. In three decades of time, it has become one of the worst aquatic weeds in Telangana because of its tremendous potential to spread by vegetative means, more so in polluted habitats, posing economic and environment impacts. It is abundant in contaminated water bodies in the urban and peri-urban areas in polluted swamps, margins of lakes, urban waterways, sewage sludge and drainage. t is an excellent leafy vegetable and tastes delicious and therefore sold in the markets in urban areas, especially in greater Hyderabad, Warangal, Karimnagar, Khammam, Nizamabad, Nalgonda and Mahabubnagar even though it is hardly cultivated as a vegetable crop. But, it is sold even in tiny markets on a large scale. It is sold on the name of *ponnaganti kura*, the native species *Alternanthera sessilis*. For its rich and rapid growth and its ready availability in the sewage sludge of lotic and lentic ecosystems, the local people harvest the shoots of this taxon and sell in the local markets of Telangana region, more so in greater Hyderabad. The vendors, without investing/cultivating, are picking the green leafy-shoots from contaminated areas and selling it as vegetable at the cost of human health.

Other native aquatic macrophytes, including grasses and sedges, are significantly replaced by alligator weed infestation. The alligator weed has a negatively impact onthe macrophyte diversity and richness in the littoral zones of aquatic ecosystems. It has reduced the availability of many useful plants for native biota and altered the habitat conditions to facilitate other invaders. The weed sucks-up heavy metals from polluted waters. When consumed, it can cause serious health hazards to human beings or other animals. On the positive side, the alligator weed cleans up the sewage water by accumulating pollutants like lead, mercury, cadmium, chromium, copper, *etc*. as an excellent hyperaccumulator of heavy metals. Therefore, the alligator weed has a great potential for phytoremediation of contaminated sewage sludge, soil and sediment with lead and mercury (Prasad 2003).

It is extremely difficult to control once established in ponds/lakes/streams/sites. Its eradication is very expensive to newly constituted States like Telangana. Although there are three types of controlling methods available, viz. biological, chemical and mechanical/manual that are known and tried, relief from this weed is very little. Three insect

(a) (b) (c)

Fig. a) High infestation of alligator weed in Hussain Sagar; b) Vendor selling it in the local market.

species have been introduced as agents to control alligator weed biologically viz. *Agasicles hygrophila* (flea beetle), *Amynothrips andersoni* (thrips) and *Vogtia malloi* (stem borer) (Raju 1987). However, only the manual method has been effective in eradicating the weed from affected sites. Sometimes herbicides must also be used to eradicate the weed.

CONCLUSION

Surveillance of alligator weed suggests that the species should be banned in the vegetable markets, like cat fish sale. Public awareness campaigns should be taken up by the Government, more specifically for its control in natural and aquatic habitats. Some TV channels have focused on this issue sometime back, which is an appreciable move, and the other channels must follow suit. There is an immediate need to go for more surveillance of alligator weed to arrest its further spread.

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Alligator weed menace in Telangana, India

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The introduction and spread of invasive alien species (IAS) has become a concern globally, in context of environment ecology and conservation. These species are continuously altering the terrestrial and aquatic ecosystems leading to loss of native biodiversity and extinction of native species. The natural environment and productivity of aquatic ecosystems in India are disturbed by weeds that grow abundantly in water and complete at least a part of their life-cycle in it, pollute the environment when they die and decay. They also offer suitable breeding grounds for mosquitoes, snails and other animals which spread disease. Aquatic weeds in canal systems reduce the designed flow by 40-50%. On the other, the obstructed flow of water in canals results in forced seepage, water logging and soil salinity (Varshney *et al*. 2008). Many of the aquatic ecosystems in Telangana are choked by floating and emergent weeds of which the most troublesome exotic weeds include *Eichhornia crassipes, Alternanthera philoxeroides*, *Pistia stratiotes*, *Ipomoea carnea* ssp. *fistulosa*, species of *Typha*, *Salvinia* and *Azolla*. of these, *Alternanthera philoxeroides* (Mart.) Griseb. (Amaranthaceae), popularly known as alligator or pig weed, is one of the noxious weeds in aquatic, marshy areas and agro ecosystems. It is a native of South America, the Parana River region of Brazil, Paraguay and Argentina. It was first reported from India by J.K. Maheshwari from West Bengal and Bihar in 1965.

METHODOLOGY

Field trips were conducted to survey and monitor the status of alligator weed in Telangana, especially in polluted and contaminated sites of urban areas.

RESULTS

Alternanthera philoxeroides is a fast-spreading perennial, with decumbent stems which are long, hollow and rooted at nodes. It was first reported from Warangal district by V.S. Raju in 1987 as a rare, problematic weed in marshy areas and aquatic systems. In three decades of time, it has become one of the worst aquatic weeds in Telangana because of its tremendous potential to spread by vegetative means, more so in polluted habitats, posing economic and environment impacts. It is abundant in contaminated water bodies in the urban and peri-urban areas in polluted swamps, margins of lakes, urban waterways, sewage sludge and drainage. t is an excellent leafy vegetable and tastes delicious and therefore sold in the markets in urban areas, especially in greater Hyderabad, Warangal, Karimnagar, Khammam, Nizamabad, Nalgonda and Mahabubnagar even though it is hardly cultivated as a vegetable crop. But, it is sold even in tiny markets on a large scale. It is sold on the name of *ponnaganti kura*, the native species *Alternanthera sessilis*. For its rich and rapid growth and its ready availability in the sewage sludge of lotic and lentic ecosystems, the local people harvest the shoots of this taxon and sell in the local markets of Telangana region, more so in greater Hyderabad. The vendors, without investing/cultivating, are picking the green leafy-shoots from contaminated areas and selling it as vegetable at the cost of human health.

Other native aquatic macrophytes, including grasses and sedges, are significantly replaced by alligator weed infestation. The alligator weed has a negatively impact onthe macrophyte diversity and richness in the littoral zones of aquatic ecosystems. It has reduced the availability of many useful plants for native biota and altered the habitat conditions to facilitate other invaders. The weed sucks-up heavy metals from polluted waters. When consumed, it can cause serious health hazards to human beings or other animals. On the positive side, the alligator weed cleans up the sewage water by accumulating pollutants like lead, mercury, cadmium, chromium, copper, etc. as an excellent hyperaccumulator of heavy metals. Therefore, the alligator weed has a great potential for phytoremediation of contaminated sewage sludge, soil and sediment with lead and mercury (Prasad, 2003).

It is extremely difficult to control once established in ponds/lakes/streams/sites. Its eradication is very expensive to newly constituted States like Telangana. Although there are three types of controlling methods available, viz. biological, chemical and mechanical/manual that are known and tried, relief from this weed is very little. Three insect species have been introduced as agents to control alligator weed biologically viz. *Agasicles hygrophila* (flea beetle), *Amynothrips andersoni* (thrips) and *Vogtia malloi* (stem borer) (Raju, 1987). However, only the manual method has been effective in eradicating the weed from affected sites. Sometimes herbicides must also be used to eradicate the weed.

CONCLUSION

Surveillance of alligator weed suggests that the species should be banned in the vegetable markets, like cat fish sale. Public awareness campaigns should be taken up by the Government, more specifically for its control in natural and aquatic habitats. Some TV channels have focused on this issue sometime back, which is an appreciable move, and the other channels must follow suit. There is an immediate need to go for more surveillance of alligator weed to arrest its further spread.

(a) (b) (b)

Fig. a High infestation of alligator weed in Hussain Sagar; b) Vendor selling it in the local market.

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Regeneration of reed under different water levels by soil digging and banking in an experimental site on Lake Biwa, Japan

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Reed (*Phragmites australis)* is a worldwide invasive species usually forming a dense stand in riparian sites along rivers, ponds or lakes. In contrast to its harmful effect in agricultural fields such as rice paddies, reed provides us useful fiber or stems as well as a habitat to aquatic fish and animals. In Lake Biwa, a large stand of reed was artificially maintained for papers and blinds, roof thatching, and fuel for supporting the dwellers' life. But, with a decline in such human activities, this reed is now looked up to as a weed, and thus its sustainable management is desired. And for successful management, the biology of growth of reed needs to be understood, In this context, a study was done to analyzes the regeneration pattern of reeds under different water levels.

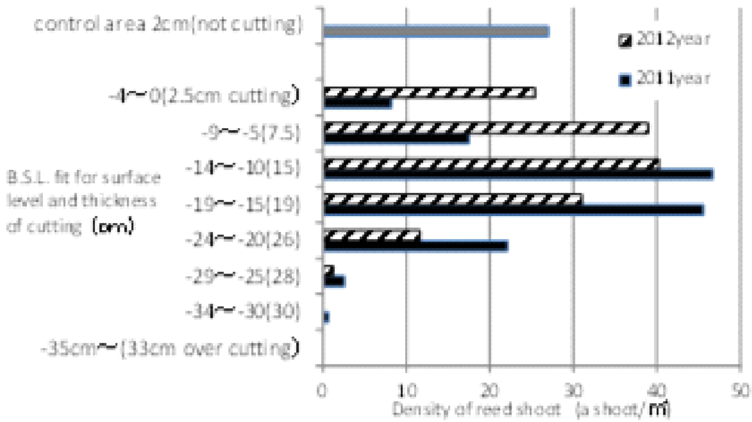

Fig.1 Shoot density of regenerate reed in relation to water level after soil digging.

METHODOLOGY

In order to measure reed grass growth- recovery under different water levels a grand surface of reed grass habitat was reformed into two design regimes, a sloped soil surface regime and a cut down and banking soil regime, during March, 2011. The shoot diameter, shoot growth height, shoots density, and standing dry weight of reed grass was measured for two years. In the first regime, a grand surface was cut-down as sloping from 60 cm soil depth which is equivalent to -80cm of Biwako Surface Level (B.S.L.) at the water front line of a reed grass patch with a control regime, non-cut soil, equivalent to 0 cm of Biwako Surface Level (B.S.L.) at 22.5 m inner part from the water front line.

In the second regime, soil cutting and banking of reed grass-land were performed in a patch of 7 x 14 m. Half of the patch was cut and another half was banked. Soil surface was cut down to a depth of 75 cm at an edge, and was not cut at a place 3.5 m from the edge so as to form a slope. The cut soil was banked to height of 70 cm on a place 7.0 m from the edge and was not banked at the place 3.5 m from the edge so as to form the slope. In both regimes, biomass parameters for regenerated reed were quantified.

RESULTS

Reed grass had rarely regenerated in an area lower than B.S.L.-25 cm in 2011 and lower than -20 cm in 2012 (Fig. 1). The water level always submerged the reed grass throughout the growing season from March to July.

Standing crop weight of reed grass was the lowest in the area where ground surface was dug lower than B.S.L.-20 cm. On the other hand, reed grass could regenerate well on the area of soil banking more than a thickness of B.S.L.70cm, despite the delayed growth.

CONCLUSION

Reed grass land is very hard to restore by ground surface digging in a height lower than the usual water level in the growing season despite that active buds of rhizomes were present. Water level control is a useful tool to manage reed grass growth in the pond as well as weedy conditions in agricultural fields. If there is need to rehabilitate the grass-land, the reed should be allowed to stand exposed to the ground for flash time. When aiming to suppress reed grass, it should be allowed to remain submerged in water. Our results suggest that when conserving indigenous fish and plants, they require not only habitat rehabilitation but also a control in water level control as per need of their life cycle.

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Pretilachlor tolerance and nitrogen uptake by *Vetiveria zizinoides* in contaminated soil

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The enhancing use of synthetic chemicals for pest control and plant growth is now a common practice to increase crop production. This heavy reliance on chemical fertilizers and soil applied herbicides affect the eutrophication of natural wetlands and non-target organisms in surface water bodies. A certain proportion of the soil applied herbicides reaches natural systems via surface runoff during strong rainfall events (Schulz 2004). It is recognized that weedy plants can remediate organic herbicides by direct root uptake and subsequent accumulation as phyto-toxic metabolites in plant tissue. However, current reports emphasize that plants should possess desirable attributes such as tolerance to high pollutant concentration, faster growth and high biomass production, limited root to shoot translocation, and plant ability to phyto-transform toxicants. Among macrophytes, terrestrial weedy plants are more suited to tolerate and phyto-transform herbicide residue across a broad range of nutrient levels at contaminated sites. This study was therefore undertaken to assess the tolerance potential of weed species to pretilachlor and nitrogen uptake.

METHODOLOGY

A pot experiment was conducted to assess the tolerance of three weedy plants, *Typha latifolia*, *Acorus calamus* and *Vetiveria zizinoides* at Directorate of Weed Research, Jabalpur. These plants were exposed to three levels of pretilachlor (0, 750, 1500 g/ha) and two levels of fertilizers (control and 120:60:60 kg NPK/ ha) in a pot filled with 1.7 kg soil. The plant height and number of tillers were taken at fortnightly whereas leaf area, root length, root biomass, dry weight and pretilachlor residues were taken at harvest of the plants.

RESULTS

At higher level of pretilachlor (1500 g/ha), both root length and dry weight of *Acoru scalamus*, root of *Typha latifolia* were reduced whereas no adverse effect was observed on *Vetiveria zizinoides* (Table 1*)*. Except *Vetiveria* , a change in chlorophyll b and leaf area was recorded in *Acorus* and *Typha* at higher levels. Soil analysis in context of persistence of pretilachlor in soil revealed it to be 0.695, 0.760 and 0.809 mg/kg in rhizospheric soil of *Typha latifolia, Vetiveria zizinoides and Acorus calamus* respectively. Significantly higher uptake of pretilachlor i.e 1.261 mg/kg was observed in *Acorus calamus* followed by *Typha latifolia* (1.153 mg/kg) and *Vetiveria zizinoides* (0.584 mg/kg).

Table 1. Effect of pretilachlor on growth of plant species

Treatment	Dry weight ((g/pot)			Root length (cm)			Chlorophyll b (mg/gfw)		
	Acorus	*Typha*	*Veti-veria*	*Acorus*	*Typha*	*Veti-veria*	*Acorus*	*Typha*	*Veti-veria*
Pretilachlor (g/ha)									
0	2.31	1.62	4.10	20.05	20.88	33.70	0.687	0.642	0.290
750	2.30	1.70	4.51	19.10	16.06	40.18	0.509	0.566	0.283
1500	1.87	1.79	4.78	16.57	15.26	48.68	0.498	0.318	0.271
SEm±	0.23	0.05	0.24	0.74	1.90	2.11	0.030	0.061	0.022
LSD (P=0.05)	0.50	0.12	NS	2.24	5.7	4.71	0.06	0.13	NS
Nutrients (Kg/ka)									
$N_0P_0K_0$	2.25	1.61	4.16	18.93	18.02	38.28	0.509	0.294	0.273
$N_{120}P_{60}K_{60}$	2.34	1.79	4.76	18.21	16.78	43.42	0.621	0.724	0.290
SEm±	0.19	0.04	0.19	0.61	1.55	1.73	0.024	0.050	0.018
LSD (P=0.05)	NS	0.10	0.43	NS	NS	3.85	0.054	0.11	0.04

Among plant species, higher N uptake was observed in *Vetiveria zizinoides* than in *Acorus calamus* and *Typha latifolia* which may be due to production of higher biomass.

CONCLUSION

Among weedy plants, *Vetiveria zizinoides* tolerated higher levels of pretilachlor (1500 g/ha) and showed no adverse effect on its growth in terms of dry weight, root length, root biomass, leaf area and chlorophyll. *Vetiveria* can be used for development of vegetative barriers for preventing the transport of pretilachlor and nitrogen through runoff water into the nearby surface water bodies.

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Folklore claims of some less known aquatic and marshy weeds in the rice fields at Jagatsinghpur district of Odisha, India

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Aquatic and marshy habitats represent an excellent ecological model for study of plant diversity as well as their medico-botany with variation in geography. Plants grown in these habitats normally affect the population dynamics of native plants of the area. In turn, they also contribute substantially to the local populace by utilizing the bio resources for food, fodder, vegetable and also for medicinal purposes.

METHODOLOGY

An extensive floristic inventory was undertaken in 4 C.D. blocks in Jagatasinghpur, district of Odisha namely, Jagatsinghpur, Balikuda, Tirtol and Kujang during 2013-14. The floristic survey was undertaken in different aquatic bodies and marshy habitats including water logged and marshy crop fields. The collected plant materials were critically studied, identified (Saxena and Brahmam, 1994-96) and deposited in the Herbarium of P.G. Department of Botany, Utkal University, Vani Vihar, Bhubaneswar, Odisha (India). During the inventory and investigation of this work, local populace, farmers, agricultural laborers were approached to have the first hand information related to potential uses of these marshy and aquatic weeds. Local traditional healers were interviewed to collect the information on the uses of some less known weeds used to cure human and animal diseases.

RESULTS

Findings of the present investigation revealed that environmental reclamation activities resulted in the appearance of several weeds which grow along with the principal crop in the field, thereby influencing its productivity. Of the total 70 plant specimens collected from the study area present in 4 C.D. Blocks of the district, 60 species were found to be utilized for local healthcare needs. This shows that healthcare requirements are met from more than 80% of the total number of species found in the crop fields of the district. Some of the plants having both ethnomedicinal and ethnopharmcological relevance include *Aeschynomene americana* L. used against fever and impotency; *Alternanthera philloxeroides* (whole plant) against fever and dysentery; *Aponogeton natans* (L.) Engl. & Krause, (tubers) against gastritis; *Corchorus aestuans* L. (Leaf paste) against Leucorrhoea; *Crinum defixum* Ker-Gawl, (bulb paste) against piles; *Cyperus triceps* Endl. (root decoction) against dermatitis; *Eriocaulon quinquangulare* L. (whole plant paste with goat milk) applied on the body to cure body ache caused due to fever; *Hydrolea zeylanica* (L.) Vahl (leaves) against intestinal diseases; *Limnophila heterophylla* (Roxb.) Benth. (leaves) for quick healing of wounds; *Ludwigia perennis* L. (decoction fruits) applied to cure leucorrhoea; *Neptunia oleracea* Lour. (stem) against earache and *Otelia alismoides* (L.) Pers. (leaves) against arm and leg poultice due to fever.

CONCLUSION

To avoid the increasing use of antibiotic and other synthetic medicines, these folk medicines already in use need to be scientifically utilized by identifying the active alkaloids and other chemicals responsible for curing diseases or disorders. It was, however, reported by agricultural laborers, tribes and other people that they use these weeds for curing wounds, abscesses or temporary disorders particularly for primary healthcare needs.

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Exploitation of some selected aquatic weeds in the treatment of lead and their utilization in vermicomposting

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In India, where most of the developmental activities are dependent on water bodies, heavy metal pollution is posing a serious environmental threat and also causing health problems (Siwela *et al.* 2009). Lead (Pb) is one of the highly toxic heavy metals that not only accumulates in individuals, but also has the ability to affect the entire food chain and disrupt the health system of human beings, animals and phytoplanktons (Kaur *et al.* 2010). The main objective of the present investigation was to develop an economically viable technology for the treatment of Pb contaminated water through phytoremediation using the aquatic weeds *Azolla microphylla* Kauf., *Pistia stratiotes* L., *Salvinia molesta* D.Mitch and *Salvinia cucullata* Seg. These treated weeds could be utilized for vermicomposting (using the earthworm *Perionyx excavatus*), which could yield a rich source of nutrients like organic carbon and nitrogen for plant growth.

METHODOLOGY

The four different aquatic weeds (*Azolla microphylla*, *Pistia stratiotes*, *Salvinia cucullata* and *Salvinia molesta*) of uniform size and equal weight (10 g) were treated with a similar concentration (50 ppm) of $Pb(NO_3)_2$ solutions, along with 100 % Hoagland medium. The setup was left undisturbed in a green house for 15 days with three sets of replicates. After 15 days, the plants were removed and analyzed for Pb by AAS (atomic absorption spectrophotometer). Physico-chemical parameters of composting and vermicomposting units were analyzed by the APHA (1995) method.

RESULTS

Analysis of treated plants revealed high accumulation of Pb in *A. microphylla* (9321 ± 2.30 mg/kg) followed by *S. cucullata* (9031 ± 7.79 mg/kg), *P. stratiotes* (6534 ± 6.55 mg/kg) and *S. molesta* (5869 ± 8.18 mg/kg) (Fig-1). The percentage of organic carbon was found to be highest in AV (1.42 ± 0.08 %) followed by PV (1.70 ± 0.08 %), S.m V (1.65±0.05 %) and S.cuV (1.07 ± 0.06 %) while in composting units the organic carbon percentage was found to be highest in PC (1.51 ± 0.08 %) followed by AC (1.26 ± 0.03 %), S.m C (1.18 ± 0.05) and S.cuC (1.03 ± 0.01 %) (Table-1). When concentrations of the major macronutrients *i.e.* NPK values were estimated, they were found high in vermicompost as compared to normal compost. This finding indicates that earthworms could increase the amount of extractable nitrogen by feeding on aquatic weed biomass. The present study also reveals that all the Pb remediated aquatic weeds vermicomposting units were within the permissible limit except TAV (108.2 ± 0.38 mg/kg) and in composting units AC (199.23 ± 0.13 mg/kg), S.cuC (128.48 ± 0.039 mg/kg) and PC (110.63 ± 0.11 mg/kg).

Table 1: Physical and chemical properties of different composting and vermicomposting units

Parameters	T	AC	AV	PC	PV	S.cu C	S.cu V	S.m C	S.m V
pH	8.33±0.02	8.2 ±0.01	8.13 ±0.01	8.0 ±0.01	8.01 ±0.08	8.41 ±0.01	8.32 ±0.01	8.22 ±0.07	8.13 ±0.01
Electrical conductivity (ds/m)	2.03 ±0.02	2.31 ±0.01	2.14 ±0.02	1.75 ±0.02	1.73 ±0.02	1.96 ±0.01	1.84 ±0.05	1.71 ±0.01	1.66 ±0.03
Organic carbon (%)	0.91 ±0.06	1.26 ±0.03	1.82 ±0.08	1.51 ±0.05	1.70 ±0.08	1.03 ±0.01	1.07 ±0.06	1.18 ±0.05	1.65 ±0.05
Nitrogen (kg/ha)	211 ±2.30	410.1 ±0.54	452.2 ±0.41	498.4 ±1.10	518.5 ±2.12	447.3 ±0.03	489.6 ±0.26	518.2 ±1.35	575.8 ±2.7
Phosphorous (kg/ha)	25.4 ±1.46	175.8 ±0.14	206.9 ±2.07	171 ±0.06	173.1 ±1.16	183.2 ±0.42	190.5 ±0.32	155.4 ±0.48	193.3 ±0.88
Potassium (kg/ha)	201.7±0.8	285.1 ±0.2	298.9 ±0.22	305.1 ±0.63	355.0 ±1.08	310 ±0.45	328.1 ±1.01	275.5 ±0.51	305.2 ±0.95
Lead (mg/kg)	13.26±0.1	199.23 ±0.1	108.2 ±0.33	110.63 ±0.11	73.97 ±0.71	128.48 ±0.03	48.87 ±0.59	97.13 ±0.07	89.43 ±0.29

Data represents mean value of three determinantions ± SEM. (Where, T-control, AC- *Azolla* compost, AV- *Azolla* vermicompost, PC- *Pistia* compost, PV- *Pistia* vermicompost, S.cu C- *Salvinia cucullata* compost, S.cu V- *Salvinia cucullata* vermicompost, S.m C- *Salvinia molesta* compost, S.m V- *Salvinia molesta* vermicompost)

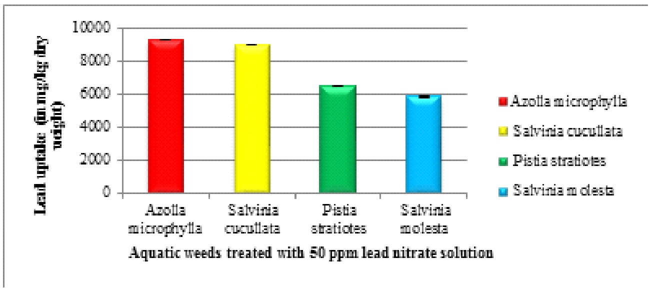

Fig. 1. **Accumulation of Pb by different aquatic weeds treated with 50 ppm lead nitrate solution on 15th day of inoculation**

CONCLUSION

Water contaminated with Pb could be detoxified through phytoremediation technology by using aquatic weeds including *Azolla microphylla*., *Pistia stratiotes*., *Salvinia molesta* and *Salvinia cucullata*. The study also indicated that *Perionyx excavatus* was efficient in converting the lead contaminated aquatic weeds into vermicompost. Further, vermicomposting of phytoremediated aquatic weeds can be suitably utilized for maximum waste utilization and reduction of pollutants from the aquatic environment contaminated by heavy metals.

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Theme 10

Parasitic weeds and their management

Effect of trap crop rotation cycles on broomrape infestation in FCV Tobacco

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Tobacco is one of the common crops that are most seriously affected by broomrapes. Two species that commonly parasitize tobacco are *Orobanche cernua* and *Orobanche ramosa*, of which former being most common in India. The germination of broomrape seeds is triggered by the interplay of three factors viz. root exudates of host/ trap crop, low soil temperature and high soil moisture. A review of literature on control measures indicates that there is no single consistent, effective and economical method for complete eradication of broomrape infestation in tobacco. Trap crops like blackgram, greengram, sesamum, sunnhemp when grown in broomrape infested field cause germination of the parasite but not allow the seedlings to establish and reduce the incidence of the parasite in succeeding tobacco. In view of the beneficial effect of trap crop rotations in reducing the broomrape infestation in succeeding tobacco a field study was conducted in FCV tobacco with different trap crops and their rotation cycles under vertisols of Andhra Pradesh.

METHODOLOGY

A field experiment was conducted in the broomrape infested field at the Central Tobacco Research Institute Research Farm, Katheru, Andhra Pradesh, India with three trap crops and tobacco cv. VT 1158 during four *Rabi* seasons (2008-09 to 2011-12). Ten treatments comprised of three crops viz. greengram, sesamum, sorghum cultivated for one, two and three years as trap crops preceding the tobacco during *Rabi* season were replicated thrice in a randomized block design to see their rotational effect on *Orobanche* infestation in four years experimentation. The usual practice of hand removal of the broomrape was followed in all the treatments. Infestation (%) and fresh weight of broomrape at 75 and 100 days after planting (DAP) and cured leaf yield of tobacco from 70 DAP onwards was recorded in the fourth year of the experimentation.

RESULTS

In fourth year of experimentation, field crop broomrape infestation (%) and fresh weight of broomrape (kg/ha) at 75 and 100 DAP in different treatments has been presented in Table 1. Infestation (%) and fresh weight (kg/ha) of broomrape was higher where trap crops were grown for one year and tobacco grown for three years in four year crop rotation cycle. Considerable reduction in infestation (%) and fresh weight was recorded where trap crops were grown for two years and three years and tobacco grown for two years and one year, respectively in four year crop rotation cycles. Sesamum has been proved to be a potential trap crop for control of broomrape in vegetables (Abebe *et al.* 2005). Lower fresh weight of broomrape was observed in Sorghum-Sorghum-Sorghum-Tobacco at 75 days and in Grengram-Greengram-Greengram-Tobacco at 100 days after planting tobacco. Krishnamurthy *et al.* (1977) also reported that in sorghum-tobacco rotation there was reduced infestation of *O. cernua* when compared to fallow-tobacco. Continuous hand pulling for three years reduced the fresh weight of broomrape from 4628 to 782 kg/ha in sole tobacco. In Greece, Oriental tobacco farmers' hand-pulled broomrape plants every week where tobacco is hand harvested. Sorghum-Sorghum-Sorghum–Tobacco crop rotation, being on a par with sesamum trap crop for two years and three year cycles recorded significantly higher cured leaf yield as compared to four years monocultured FCV tobacco. Monocrop tobacco always recorded lower cured leaf and bright leaf yield.

Table 1. Broomrape infestation, fresh weight and Tobacco cured leaf yield in 2012 in four year crop rotation cycles

Crop rotation (four year)	Infestation of Broomrape (%)		Fresh weight. of broomrape (kg/ha)		Cured leaf Yield
	75 DAP	100 DAP	75 DAP	100 DAP	(t/ha)
Greengram-Tobacco-Tobacco-Tobacco	25.7	30.0	366	689	2.00
Greengram-Greengram-Tobacco-Tobacco	16.3	22.0	275	547	2.10
Grengram-Greengram-Greengram-Tobacco	9.7	13.3	107	366	2.15
Sesamum-Tobacco-Tobacco-Tobacco	16.3	28.7	197	563	2.10
Sesamum-Sesamum-Tobacco	12.7	28.0	191	547	2.21
Sesamum-Sesamum-Sesamum-Tobacco	6.0	19.3	156	395	2.24
Sorghum-Tobacco-Tobacco-Tobacco	24.0	21.3	238	508	2.14
Sorghum-Sorghum-Tobacco	11.7	14.3	111	415	2.10
Sorghum -Sorghum-Sorghum-Tobacco	5.7	14.0	8	402	2.33
Tobacco-Tobacco-Tobacco-Tobacco	16.3	23.7	224	558	1.99
S. Em±	1.76	0.92	8.4	22.6	0.06
LSD (P=0.05)	5.24	2.72	24.9	67.1	0.18
Monocrop Tobacco Initial season (2008-09)	73	93	2571	2057	

CONCLUSION

Infestation (%) and fresh weight (kg/ha) of broomrape in tobacco crop was reduced and higher tobacco yields were recorded when tobacco was grown with succeeding trap crop for two and three years in crop rotation cycles. Hand pulling for three years also reduced the infestation in mono-cropped tobacco.

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On-farm assessment of *Orobanche* management strategies in Indian mustard

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Oilseed brassica (OSB) is an important *Rabi* oilseed crop of semi-arid region contributing almost one third of vegetable oil produced in the country. Although the crop is being exposed to many abiotic and biotic stresses but of late *Orobanche aegyptica* has become endemic in many semi-arid tracts causing devastation to the OSB crop. *Orobanche* is an obligate root parasite that causes severe damage in many important crops throughout the world (Musselman, 1896). Unavailability of suitable management strategy against this parasite is favouring its spread to new areas. Herbicides used in OSB do not kill this weed effectively. While mechanical control after emergence is impractical and by this time significant loss to the crop has already been made. Recently, use of sub-lethal doses of glyphosate, neem cake + pendimethalin and soybean oil has been advocated for *Orobanche* management (Rathore *et al*. 2014). Thus, efficacy of various recommendations was evaluated in *Orobanche* infected plots of the farmers.

METHODOLOGY

The experiment was conducted at 8 *Orobanche* infested fields of farmers. At each location replicated trial was conducted with 5 treatments: Glyphosate at 25 g/ha (25DAS) *fb*50 g/ha (55-60 DAS), Glyphosate at 25 g/ha with 1% AS solution (25DAS) *fb*50 g/ha with 1% AS solution (55-60 DAS), Neem cake at 200 kg/ha at sowing *fb* pendimethalin 0.5 kg /ha as pre emergence *fb* by hand weeding (60 DAS), 2 drops of soybean oil/young shoot of *Orobanche* and control. The crop was irrigated within 24 hours of glyphosate application. The data for 8 locations over 2 years has been pooled and discussed.

RESULTS

On an average 135 orobanche colons/m^2 emerged under conventional (control) condition. The rate of emergence of colons was 43.0% by 90 DAS and 83.0% by 120 DAS. Application of sub lethal doses of glyphosate with or without 1% ammonium sulphate solution decreased the *Orobanche* colon counts by atleast 38% over control. Glyphosate application reduced the emergence to almost 27% by 90 DAS and 75% by 120 DAS. Reduction in colons was just 18.5% due to neem cake + pendimethalin treatment and 6.7% due to application of soybean oil drops over control. The reduction in *Orobanche* population due to various treatments was proportionally limited in the mustard seed yield. Use of neem cake + pendimethalin or soybean drops increased the seed yield of Indian mustard by at least 7.3% over control (1.43 t/ha). Application of sub-lethal doses of glyphosate significantly increased the seed yield by 20.6% over control. Addition of 1% ammonium sulphate solution did not improve the seed yield further.

Table 1. Effect of different treatments on orobanche emergence and seed yield of mustard

Treatment	*Orobanche* colons/m^2			Seed yield (t/ha)
	90 DAS	120 DAS	Harvest	
Glyphosate 25 g/ha (25DAS) *fb*50 g/ha (55-60 DAS)	22	61	83	1.72
Glyphosate 25 g/ha with 1% AS solution (25DAS) *fb*50 g/ha with 1% AS solution (55-60 DAS)	18	52	78	1.75
Neem cake 200 kg/ha at sowing *fb* pendimethalin 0.5 kg/ha as pre emergence *fb* by hand weeding (60 DAS)	35	89	110	1.57
2 drops of soybean oil/young shoot of *Orobanche*	40	104	126	1.63
Control	58	112	135	1.43

CONCLUSION

It is therefore concluded that the obligate root parasite *Orobanche* of Indian mustard could effectively be controlled by the use of sub lethal dose 25 and 50g/ha glyphosate at 25 and 55-60 DAS, respectively.

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Management of *Orobanche* in mustard

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Orobanche has been a serious problem in mustard in Rajasthan Madhya Pradesh and Haryana in recent years (Singh *et al.* 2013). Orobanche is a root parasitic weed having 50-60 cm height affecting mustard, tomato, brinjal, cotton, potato, tobacco, cabbage and other solanaceous crops. Optimum temperature for germination of orobanche seed is 20 to 25°C. Higher temperature favours germination. It causes 30-35 percent reduction in yield.

METHODOLOGY

A field experiment was carried out during *Rabi* 2011-12 and 2012-13 at ARSS, Diggi (Rajasthan) to evaluate the suitable control measures for orobanche in mustard. Ten treatments (Table 1) consisting of different chemicals at varying doses were replicated three times in the randomised block design on black cotton soil. Mustard variety 'Pusa Jai Kisan (BIO 902)' was used in experimental field with recommended package of practices. The RDF (60 kg N, 40 kg P_2O_5, 40 kg S/ha) was uniformly applied through urea, single super phosphate and gypsum. The herbicides spray was done as per treatment. Data on weed control efficiency, yield and economics were recorded.

RESULTS

The two years experimentation revealed that when pyrazosulfuron ethyl applied as pre-plant at 200g/ha proved superior in controlling the weeds and recorded highest WCE, seed yield, net return and B:C ratio followed by imazapic at 2.5 g/ha as post emergence. Similar results were reported by Punia (2014) and Anonymous (2011).

Table 1. Weed control efficiency, yield and economics of mustard as influenced by different weed control treatment

Treatment	WCE (%)		Seed yield (t/ha)		Mean Net returns (Rs/ha)	B:C ratio
	2011-12	2012-13	2011-12	2012-13		
Weedy check	0	0	1.19	1.12	23856	2.16
Pyrazosulfuron ethyl 200 g/ha as PPI	82.8	81.0	1.70	1.79	43339	2.82
Sulphosulfuron 0.25 kg/ha as POE	48.3	48.3	1.35	1.41	32296	2.04
Acetachlorphen 16.5% + clodinafop 250 g/ha as PE	79.3	58.6	1.79	1.42	38996	2.01
Oxyflorofen 0.25 kg/ha as PE	38.0	38.0	1.31	1.24	27124	2.24
Neem Cake 200 kg/ha at sowing	54.5	69.0	1.54	1.57	28909	2.55
Copper Sulphate 2.0 kg/ha at sowing	68.3	55.2	1.41	1.46	31876	2.47
Imazapic 2.5 g/ha as POE	75.9	58.6	1.66	1.36	36274	2.65
Imazathypr 25 g/ha as POE	38.0	31.1	1.26	1.26	27286	2.29
Propanil 60% DF 5.0 litre/ha as POE	41.4	17.3	1.25	1.15	18706	1.68
SEM±	-	-	0.07	0.06	-	-
LSD (P=0.05)	-	-	0.20	0.18	-	-

CONCLUSION

It was concluded that pre plant incorporation of pyrazosulfuron ethyl at 200 g/ha was effective for controlling Orobanche in mustard.

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Isolation, screening and selection of efficient native arbuscular mycorrhizal fungi for suppression of *Striga*

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The control of *Striga* is difficult to achieve because of its high fecundity and asynchronous seed germination. Management of *Striga* needs an integrated approach including host plant resistance, cultural, chemical and biological practices. Among all the components, biological control of *Striga* gives a demonstrable crop yield benefit within one growing season. Recent studies have shown that AM fungal colonization is likely to induce resistance to plant parasitism by converting strigolactones into mycorradicin, which is accumulated in mycorrhized roots and thereby reduces availability of strigolactones for *Striga* to germinate.

METHODOLOGY

An investigation was carried out to isolate native AM fungal (AMF) isolates from the *Striga* suppressive soils of sugarcane growing areas of northern Karnataka. Further, sixteen native AMF isolates were screened for their ability to suppress *Striga* as well as plant growth promotional abilities in sugarcane under pot culture studies. The pots were filled with *Striga* infested soil prior to the planting of sugarcane sets of equal bud size. AMF inoculum at 150 g per pot was mixed thoroughly with the top 10 to 15 cm of the soil and pots were treated with Hoagland's nutrient solution once a week. The data on the emergence of *Striga*, Striga biomass, plant height, and soil microbiological activities were recorded.

RESULTS

The *striga* emergence was significantly inhibited in the treatment received standard AMF consortium, Native consortium, UASDAMF -2, UASDAMF-5, UASDAMF-9 and UASDAMF-12 (0.00). While, the Uninoculated resulted in highest emergence of *striga* (70). Furthermore, the plant height (131.8 and 151.4 cm at 90 and 120 DAP respectively), and spore load/50g of soil (379 and 668 at 90 and 120 DAP, respectively) were highest with native AMF consortium. Whereas, in Uninoculated treatment plant growth, physiological and soil biological activity were recorded lowest.

Table 1. Effects of native AM fungal isolates on *Striga* emergence, *Striga* biomass, plant heightand soil microbiological activities in sugarcane

Treatment	Total Number of Striga emergence/ pot	*Striga* Biomass (gm)	Plant height (cm)		Dehydrogenase (µg TPF/g soil/d)		Phosphatase activity (µg p-nitrophenol/g soil/h)		AMF spore count/50 g soil	
			90 DAP	120 DAP	90 DAP	120 DAP	90 DAP	120 DAP	90 DAP	120 DAP
UASD AMF1	42	13.93	109.2	117.0	7.61	7.77	26.33	32.58	281.5	687.5
UASD AMF2	00	0.00	120.2	153.0	10.94	12.44	35.71	41.92	310.5	615.0
UASD AMF3	34	15.17	97.6	118.4	7.13	8.26	26.33	32.58	273.5	564.5
UASD AMF4	35	16.83	96.4	114.2	6.12	7.84	25.10	30.35	288.5	540.0
UASD AMF5	00	0.00	123.6	158.4	12.13	11.15	38.16	42.41	366.5	625.5
UASD AMF6	45	14.74	108.6	139.4	8.84	9.27	29.29	35.92	283.5	572.0
UASD AMF7	44	13.96	110.4	120.8	7.56	8.69	26.33	32.58	271.5	584.5
UASD AMF8	32	15.04	96.8	136.0	8.31	9.10	26.33	32.58	268	497.5
UASD AMF9	00	0.00	102.6	161.6	12.16	12.44	38.83	43.75	373	641.5
UASD AMF10	42	16.19	102.8	133.0	7.64	9.22	25.55	32.30	288.5	592.5
UASD AMF11	51	17.26	124.5	144.0	5.32	5.64	24.55	30.80	267.5	528.5
UASD AMF12	00	0.00	122.6	153.0	11.17	11.87	37.50	41.96	349.5	623.5
UASD AMF13	68	17.52	96.4	126.4	6.51	7.92	27.73	33.48	254.0	594.0
UASD AMF14	68	12.91	112.6	124.2	8.97	10.51	26.33	32.58	274.5	556.0
UASD AMF15	31	14.90	110.0	129.6	7.63	8.14	25.44	31.69	285.0	551.5
UASD AMF16	38	19.11	95.2	125.6	3.81	4.80	26.33	32.58	234.0	527.0
Standard Consortium	00	0.00	144.8	204.2	14.16	14.29	40.17	46.42	384.5	454.5
Uninoculated	70	20.62	37.6	42.8	4.67	4.15	22.32	28.57	167.0	211.0
Native consortium	00	0.00	131.8	151.4	12.30	12.59	38.86	45.08	379.0	668
S.Em±	-	0.23	2.39	3	0.21	0.29	1.01	1.19	4.47	10.25
LSD (P=0.05)	-	0.65	109.2	117	0.61	0.87	2.99	3.54	13.24	30.33

***USADAMF** means *University of Agricultural Sciences, Dharwad* AMF isolates

CONCLUSION

Thus, the preliminary findings were indicative of the effectiveness of AMF in protecting sugarcane against *Striga* infestation and hence can be a promising strategy to develop a biological tool for *Striga* control.

Pattern *of Striga* emergence in sugarcane as affected by time and method of application of herbicides

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Striga asiatica is an extremely sinister parasitic weed which causes serious damage to its host crop before emerging from the soil. It survives by siphoning off water and nutrients from the host crop for its own growth and development. It is a semi root parasitic weed that seriously limit the productivity of maize, sorghum, sugarcane, millet and upland rice. In Northern Karnataka, sugarcane is severely infested with *Striga* resulting in yield loss of 20-70%. In order to reduce yield loss in cane caused by *Striga,* an experiment was carried out in the infested sugarcane field on participatory approach. The major thrust was on the emergence pattern of *Striga* as influenced by time and method of herbicide application.

METHODOLOGY

The trial was conducted in Hebballi village, Badami taluk of Bagalkot district on farmer's field. The soil was medium deep black with nitrogen (298 kg/ha), phosphorus (47 kg/ha) and potassium (234 kg/ha). Sugarcane (Co-86032) was planted on 12th January, 2013. Recommended dose of fertilizer (250, 75 and 190 kg NPK/ha) was applied as per package of practice. The efficacy of herbicide mixtures (Table 1) was evaluated under two methods of application *viz*., surface application and deep placement in the furrows. The herbicides were applied at 90 days after planting (DAP). In recommended practice, atrazine 1 kg/ha was applied immediately after planting followed by 2,4-D 2.5 kg/ha at 60 DAP. In deep placement, herbicides were sprayed at 90 DAP in the furrows opened on either side of cane rows by ploughing with balaram plough. Observations on *Striga* emergence and *Striga* density (per m^2) were recorded at 120, 135, 150, 165 and at 180 DAP.

RESULTS

Under deep placement of herbicides, *Striga* took more number of days for its emergence (135-150 DAP) compared to surface application of herbicides. Deep placement of herbicide mixtures with 2, 4-D postponed the *Striga* emergence up to 150 DAP as against 135 DAP in case of herbicides when applied alone (without 2,4- D). *Striga* emergence at (112 and 110 DAP) in weedy check and recommended practice was quite early. Deep placement of herbicides was effective in keeping down the *Striga* density. Deep application of oxyfluorfen (200 g/ha) or oxyfluorfen (100 g/ha) + 2,4-D (1 kg/ha) resulted in lower *Striga* count compared to weedy check or recommended practice at 150 DAP.

Table 1. Days taken for emergence of *Striga* after planting and number of *Striga* emerged (*Striga* density/m^2) in sugarcane as influenced by method and time of herbicide application

Treatment	Days taken for *Striga* emergence after planting				
Surface application of herbicides					
2,4-D 2kg/ha	120(12)*	135(19)	150(23)	165(44)	180(48)
Atrazine 1.25 kg/ha	120(9)	135(15)	150(27)	165(42)	180(47)
Diuron 1.5 kg/ha	120(8)	135(14)	150(24)	165(39)	180(43)
Oxyfluorfen 200 g/ha	120(7)	135(12)	150(21)	165(35)	180(42)
Metribuzin 1 kg/ha	120(10)	135(15)	150(26)	165(41)	180(46)
Atrazine 0.62 kg/ha+ 2,4-D (1kg/ha)	120(8)	135(11)	150(19)	165(31)	180(40)
Diuron 0.75 kg/ha + 2,4-D (1kg/ha)	120(6)	135(9)	150(14)	165(24)	180(36)
Oxyfluorfen (100g/ha)+ 2,4-D (1kg/ha)	120(5)	135(7)	150(10)	165(23)	180(35)
Metribuzin 0.5 kg/ha+2,4-D (1kg/ha)	120(6)	135(10)	150(15)	165(28)	180(38)
Deep placement of herbicides					
2,4-D 2kg/ha	0(0)	135(7)	150(13)	165(23)	180(33)
Atrazine 1.25 kg/ha	0(0)	135(5)	150(8)	165(12)	180(16)
Diuron 1.5 kg/ha	0(0)	135(4)	150(5)	165(9)	180(11)
Oxyfluorfen 200 g/ha	0(0)	135(3)	150(5)	165(5)	180(10)
Metribuzin 1 kg/ha	0(0)	135(4)	150(7)	165(10)	180(12)
Atrazine 0.62 kg/ha+ 2,4-D (1kg/ha)	0(0)	0(0)	150(6)	165(8)	180(9)
Diuron 0.75 kg/ha + 2,4-D (1kg/ha)	0(0)	0(0)	150(3)	165(4)	180(6)
Oxyfluorfen (100g/ha)+ 2,4-D (1kg/ha)	0(0)	0(0)	150(1)	165(1)	180(3)
Metribuzin 0.5 kg/ha+2,4-D (1kg/ha)	0(0)	0(0)	150(4)	165(5)	180(7)
Weedy check	112(31)	135(40)	150(48)	165(62)	180(68)
Recommended practice (atrazine *fb* 2,4-D)	110(27)	135(38)	150(49)	165(59)	180(66)

*The values in parentheses are number of *Striga* emerged per m^2 in infested sugarcane field

CONCLUSION

Deep placement of herbicides applied in furrows at 90 DAP was an effective alternative to surface application in curtailing the *Striga* incidence and maintaining a *Striga* free sugarcane crop for quite long period. This helped to increase the cane yields.

Incidence of root-knot nematodes on weeds in coconut cropping system

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Weeds growing along with crop plants not only compete for light, space, water, and nutrients but also they serve as reservoirs of pests, including plant-parasitic nematodes (Davis and Webster, 2005). In the absence of a suitable crop host, weeds act as alternative hosts for plant-parasitic nematodes and help to maintain nematode populations targeted for suppression by various management strategies (Thomas *et al.* 2005). Information and knowledge on the host status of weeds to common pests and diseases can be used to develop integrated weed and pest management strategies. *Meloidogyne* sp. is considered as the most economically damaging plant parasitic nematode mainly due to its wide host range that includes more than 3,000 species of wild and cultivated plants (Hussey and Jansen, 2002). Among the weed hosts *Amaranthus spinosus* and *Portulaca oleracea* (Brito *et al.* 2008). *Cyperus rotundus, Amaranthus* sp., *Chenopodium album* and *Digitaria* sp. are often cited in the literature (Myers *et al.* 2004). However, no information is available for weed hosts of root-knot nematodes in coconut cropping system, hence, the present investigation was undertaken.

METHODOLOGY

A survey was carried out in root-knot nematode (RKN) infested coconut cropping system gardens of CPCRI farm, Kasaragod, Kerala. The most commonly grown intercrops are pepper, banana, ginger, turmeric, noni, okra, egg plant, tomato, cucurbits, nutmeg and tuber crops. Four different weed species that were commonly present in coconut garden infested by root-knot nematodes were identified. The root and soil samples were collected with the help of khurpi from diseased and apparently healthy weeds at 10-15 cm depth covering 20-30 cm radius and examined the entire root system for the presence of root galls characteristic of RKN infection. The weeds found infected were identified, and the number of root galls and egg masses were recorded and rated on a root gall and egg mass index scale from 0 to 5 (0, no galls or egg masses; 1, 1 or 2 galls or egg masses; 2, 3 to 10 galls or egg masses; 3, 11 to 30 galls or egg masses; 4, 31 to 100 galls or egg masses; and 5, more than 100 galls or egg masses), as outlined by Taylor and Sasser (1978). The count was based on a minimum of 10 specimens per weed species.

RESULTS

Differences in galling and egg mass production by root knot nematodes were observed for some weeds (Fig.1). Preliminary survey showed that four weed species were infected by the *Meloidogyne* group of nematodes with different scale of galls (Table 1). Amongst the weeds, *Alternanthera sessilis* (4.5) and *Vernonia cinerea* (3.8) were highly infected by the root knot nematode as compared to *Ageratum conyzoides* (2.5) and *Leucas aspera* (0.7).

On the roots of other experimental weeds, no gall and egg masses were observed. There are several reports on weeds as hosts of different species of RKN in the world (Rich *et al.* 2009). However, very little information is available from India Mani *et al.* (1998) and Holm *et al.* (1977) reported that *Ageratum conzyoides*, *Amaranthus spinosus*, *Eleusine indica* and *Portulaca oleracea* the multiple hosts of *Meloidogyne* sp. The presence of egg masses on the weed hosts indicated their ability to sustain root-knot nematode populations.

Table 1. Different weed species infected by root-knot nematode

Weed species	Family	Common name	RGI	*Meloidogyne* sp.
Ageratum conyzoides	Asteraceae	Goat/chick weed	2.5	MI
Vernonia cinerea	Asteraceae	Puvankurutala	3.8	MI
Alternanthera sessilis	Amaranthaceae	Dwarf copper leaf	4.5	MI / MJ
Leucas aspera	Lamiaceae	Thumbai	0.7	MI

RGI - Root gall index, MI - *Meloidogyne incognita*, MJ - *Meloidogyne javanica*

CONCLUSION

It was concluded that the *Alternanthera sessilis*, *Vernonia cinerea* and *Ageratum conyzoides* are potential weed hosts for root knot nematodes in coconut cropping system help them to persist in the soil throughout the year.

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Studies on biology of *Striga* – a means for its effective management

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A thorough knowledge of weed biology is quite essential to develop effective and economic management of the weed in question. Recently, in North Karnataka, severe incidence of *Striga* in sugarcane has created panic among the farmers who have converted their traditional sorghum and maize fields to sugarcane in view of its remunerative nature. Introduction of sugarcane and its monoculture has aggravated the incidence of *Striga asiatica*. Cane being a long duration crop, it facilitates repeated flushes of *Striga* thereby enriching soil seed bank, threatening cane cultivation in future. Since, *Striga* is of new invasion in sugarcane crop in the region and of severe nature, systematic efforts are required to study its biology which can provide a useful clue for its effective management.

METHODOLOGY

Intensive field surveys were carried out in districts of North Karnataka (Belagavi, Bagalkot and Vijayapur) to know *Striga* incidence in sugarcane. The severely infested soils (red and black soil) were collected from the farmers' fields of Belagavi district pot culture studies. The black and red soils were low in nitrogen content (265 and 268 kg/ha, respectively) and the seed bank of *striga* was 2.46 and 1.1 g/kg, respectively. The experiment was carried out in cage house at *Dharwad*. Two cane sets of variety Co-86032, each containing two eye buds were planted in the pot on 15-1-2014 (during summer) and on 22-10-2014 (during winter). The symptoms of *Striga* infested cane are almost similar to water stress or drought condition. Hence, to avoid such conditions cane was optimally watered. Observations on days taken for *Striga* emergence pattern, its height, days taken for flowering and number of capsules per plant were recorded. *Striga* emergence and height were taken at 15 days interval after the first flush of *Striga* emergence. Days taken for flowering in *Striga* were counted from first flowering to cessation of flowering. The capsules per plant were counted at ten days interval.

RESULTS

The total number of *Striga* emerged per pot was higher (27) in black soil (164 DAP) than in red soil (24). Similar result was noticed for its height. *Striga* took lower number of days for flowering in black soil than red soil which resulted in early capsule formation in black soil. This was mainly due to low soil fertility status and number of *Striga* seeds/kg of soil in black soil.

Table 1. Biological parameters of *Striga* in different soils

Biometric observations on *Striga* Total number of emerged *Striga*/pot	Black soil	Red soil
119 DAP*	2	1
134 DAP	20	10
149 DAP	24	19
164 DAP	27	24
Striga height (cm)		
119 DAP	0.2	0.1
134 DAP	9.3	7.1
149 DAP	19.7	13.4
164 DAP	31.4	28.8
Days taken for flowering (DAP)	140-165	152-165
Capsules/*Striga*		
157 DAP	10-24	9-20
167 DAP	39-54	31-47
177 DAP	48-73	42-70

CONCLUSION

From this cage house study, it is clear that *Striga* emerges at 119 DAP. It clearly indicated that preventive measures have to be taken prior to its emergence *ie* at about 90 DAP, since it is more likely that haustorium formation takes place 90 DAP. The all-embracing work on its biology under cage house and in farmers fields is in progress. This would be an important critical stage during which effective *Striga* management strategies can be advocated to the farmers.

Theme 11

Weed management in organic farming systems

Crop–weed competition for nutrients in cotton

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Rice fallow cotton is a unique system of cultivation. Dibbling the cotton seeds amidst the rice stubbles without tilling the soil effectively utilize the residual soil moisture. However, in this system, cotton faces a severe competition not only from the early emerging weeds but from those that are already present in rice field at the time of harvest. The problem of weed menace in cotton would be aggravated if the previous rice was not weeded adequately. Weed management during the early stages of cotton growth is more important. The weeds deplete nutrients and reduce their availability to the crop. Hence, the present study was carried out in the coastal deltaic region of Karaikal.

METHODOLOGY

The field experiment was conducted during summer 2007 at PAJANCOA & RI, Karaikal. The soil was sandy clay and high in P (33 kg/ha) and K (373 kg/ha). Twelve treatments consisting of weed free and weedy periods up to 20, 40, 60, 80 and 100 DAS and at harvest were arranged in randomized block design with 3 replications. The cotton variety 'MCU7' was sown at 15 kg/ha with a spacing of 60 × 30 cm. The recommended dose of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha was applied. Half of nitrogen was applied at sowing and remaining half was top dressed 41 days after sowing (DAS). The weed samples were collected from individual plots at different times 20, 40, 60, 80, 100 DAS and at harvest. The crop was harvested from net plot. Nutrient uptake by crop and weeds was estimated using standard methods.

RESULTS

The major weed flora of the experimental field were *Cyperus rotundus* (sedge after 40 DAS), *Echinochloa colona* L., *Leptochloa chinensis* L. (among grasses), *Trianthema portulacastrum*, *Rotala densiflora*, *Eclipta alba* and *Phyllanthus maderaspatensis* (broad leaf weeds). The maximum NPK depletion by weeds (32.6, 3.33 and 18.46 kg/ha, respectively) was observed (Table 1) when weeds were left unchecked for entire season followed by that was kept in weedy for 100 DAS (31.0, 3.16 and 18.28 kg/ha, respectively). The nutrient depletion by weeds was substantially curtailed with increase in the duration of weed free period. By maintaining the field weed free for first 40 DAS, the nutrient depletion by weeds could be checked by more than 60%.

Table 1. Influence of weedy and weed free periods on nutrient depletion by weeds and uptake of cotton (kg/ha)

Treatment	Nutrient depletion by weeds (kg/ha)			Nutrient uptake by cotton (kg /ha)		
	N	P	K	N	P	K
Weedy for 20 DAS	2.8	0.20	1.50	4.36	0.47	2.47
Weedy for 40 DAS	17.4	1.13	12.24	2.83	0.30	1.69
Weedy for 60 DAS	17.7	1.16	12.89	1.79	0.16	1.12
Weedy for 80 DAS	30.6	2.47	18.03	1.04	0.09	0.50
Weedy for 100 DAS	31.0	3.16	18.28	0.82	0.09	0.44
Weedy up to harvest	32.6	3.33	18.46	0.29	0.03	0.11
Weed free up to 20 DAS	15.2	2.71	11.46	1.43	0.18	0.70
Weed free up to 40 DAS	11.3	1.74	9.20	4.66	0.41	2.76
Weed free up to 60 DAS	10.4	1.14	7.43	5.95	0.42	2.32
Weed free up to 80 DAS	4.4	0.64	5.02	6.20	0.49	2.94
Weed free up to 100 DAS	0.8	0.07	0.63	6.09	0.49	2.87
Weed free up to harvest	-	-	-	5.51	0.47	3.50
LSD (P=0.05)	5.3	0.6	1.6	1.33	0.13	0.67

The nutrient uptake by cotton was significantly higher when the crop was weed free for first 40 DAS or beyond. Further, the nutrient uptake by cotton increased corresponding to increase in the duration of weed free period. When left unchecked, weeds reduced the nutrient uptake by cotton to the tune of 94-96%. The maximum depletion of nutrients by weeds occurred between 20 and 60 DAS which coincided with the critical period of cotton-weed competition.

Evaluation of non-chemical weed management practices in transplanted organic fingermillet

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Weeds remain one of the most significant agronomic problems associated with organic arable crop production. Organic weed management emphasizes balancing the detrimental effects of weeds (like loss of crop quality or yield) with the beneficial aspects (like biodiversity or pest control). Weed control is a major concern for organic farmers around the world. A concern about the potential increase in weed population due to non use of herbicides is rated as serious problem in organic farming (Bond and Grundy, 2001). Hence, the present study was initiated to find out effective and economical weed management practices in organic finger millet.

METHODOLOGY

A field experiment was laid out to study the efficacy of weed management practices in organic finger millet during *Kharif* 2012 at Hebbal, Bengaluru. Treatments (Table 1) were replicated thrice in a Randomized Complete Block Design. Seedlings were raised in nursery bed prepared one month before transplanting of the crop. Stale seedbed treatment was initiated 15 days before transplanting of the crop. One irrigation was given to stale seedbed plots and weeds were allowed to germinate. The germinated weeds were removed by passing cultivator cris-cross one day before transplanting of the crop. Organic mulching was done with crop residues (paddy straw) and dried panicum grass at 10 t/ha one week after transplanting.

RESULTS

Total weed density and weed dry weight was significantly lower in hand weeding twice at 20 and 30 DAP (26.32 and 6.4 g/m^2). However, it was at par with stale seed bed technique + inter cultivation twice at 20 and 35 DAP (29.67 and 8.0 g/m^2) and passing wheel hoe at 20, 30 and 40 DAP + one hand weeding (41.26 and 10.7 g/m^2). Stale seed bed and spray of cattle urine were not effective against weeds and were at par with unweeded control.

Table 1. Weed density, weed dry weight, grain yield and weed control efficiency in organic finger millet

Treatment	Weed density (number/m^2)	Weed dry weight (g/m^2)	Grain yield (t/ha)	WCE (%)	B:C
Passing wheel hoe at 20, 30 and 40 DAP	1.72 (50.2)	1.62 (39.7)	4.09	58.2	1.99
Inter cultivation twice at 20 and 35 DAP	1.92 (80.9)	1.76 (55.8)	3.93	41.3	2.03
Stale seedbed technique	2.25 (177.5)	1.91 (80.0)	3.39	15.8	1.78
Passing wheel hoe at 20, 30 and 40 DAP + one hand weeding at 45 DAP	1.64 (41.2)	1.10 (10.7)	5.14	88.7	2.38
Inter cultivation twice at 20 and 35 DAP + one hand weeding at 45 DAP	1.69 (47.3)	1.65 (42.9)	4.22	54.9	2.00
Stale seedbed technique + Inter cultivation twice at 20 and 35 DAP	1.50 (29.6)	1.00 (8.0)	5.36	91.6	2.59
Organic mulching at 10 t/ha after transplanting	2.10 (124.0)	1.74 (52.4)	3.77	45.2	1.96
Growing cover crops (Horse gram/cowpea) and mulching at 55 DAP	1.89 (76.0)	1.74 (53.5)	3.20	43.7	1.77
Directed spray of *Eucalyptus* leaf extract on weeds at 15 and 30 DAP	2.22 (165.5)	1.92 (81.3)	2.92	14.5	1.63
Directed spray of cattle urine on weeds at 15 and 30 DAP	2.27 (185.8)	1.84 (67.7)	3.30	28.8	1.83
Hand weeding twice at 20 and 30 DAP	1.45 (26.3)	0.92 (6.4)	5.46	93.2	2.57
Unweeded check	2.45 (279.6)	1.99 (95.1)	2.73	0.0	1.53
LSD (P=0.05)	0.20	0.06	945.6	-	-

Hand weeding twice at 20 and 30 DAP produced significantly higher grain yield (5.46 t/ha). However, it was statistically at par with stale seedbed + inter cultivation twice at 20 and 35 DAP (5.36 t/ha).These treatments had higher weed control efficiency 93.2% and 91.6%, respectively. Unweeded check resulted in yield reduction of 50% due to season long competition by weeds. The stale seedbed technique with inter cultivation twice at 20 and 35 DAP and hand weeding twice at 20 and 30 DAP resulted in higher net returns and B:C ratio (Rs. 56,939 and 56,545/ha and 2.61 and 2.56, respectively).

CONCLUSION

Since, the labour availability is a problem besides high cost involved in the hand weeding, stale seedbed technique in combination with inter cultivation twice at 20 and 35 DAP or passing wheel hoe at 20, 30 and 40 DAP with one hand weeding would be a viable alternative for weed management in organic finger millet production.

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Influence of non-chemical weed management practices on performance of sunflower

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Sunflower is a valued versatile oilseed crop for its richness in poly unsaturated fatty acids (PUFA). Common weed management practices in organic system include, stale seedbed technique, crop rotation, use of the green manures and cover crops, forages, mulches, intercropping, use of highly competitive crops, crop cultivars, use of the allelopathic crops and matching crops to fertility (Bond and Grundy, 2001). Weed ecology in organic systems indicate greater species diversity (Barberi 2002). Study of non chemical weed management practices in field crops is scare. Hence an attempt was made to study the effect of non chemical weed management practices comprising of various physical and cultural means of weed control.

METHODOLOGY

The field experiment was conducted at TNAU, Coimbatore, during *Rabi*-2006 under irrigated conditions. Soil of the experimental site was calcareous black soil, slightly alkaline pH (8.68), low in organic C (0.60 %) and available N (173.6 kg/ha) and high in available P_2O_5 (40 kg/ha) and K_2O (740 kg/ha). Experimental site was under organic conversion period (since three years before initiation of experiment). Organic source of well decomposed thoroughly mixed and powdered phosphorus (rock phosphate) enriched FYM inoculated with *Pseudomonas*, *Azospirillum*, *Phosphobacteria* cultures was used as nutrient source. Sunflower variety CO-4 was used in the experiment. Twelve treatments including weed free and weedy check were laid out in randomized block design with three replications. Periodic biometric observations on the crop were recorded. Weed index and weed control efficiency were calculated as per standard procedure.

RESULTS

Hand weeding twice at 25 DAS and 45 DAS recorded significantly higher growth parameters LAI at 30 DAS, 60 DAS and at harvest, CGR (30-60 DAS and 60 DAS - harvest), total dry matter production (TDM) at 60 DAS and at harvest. Hand weeding twice at 25 DAS and 45 DAS and manually operated weeder at 25 DAS + hand weeding at 45 DAS recorded higher and on par TDM, yield attributes (head diameter, test weight and number of filled seeds) and yield (stalk, oil and seed) on account of effective management of weeds.

CONCLUSION

Among the various non chemical weed management practices, physical methods proved to be better than cultural methods resulting in higher yield and lower weed index.

Table. Effect of different non chemical weed control treatments on weed index, growth and yield attributes in sunflower

Treatment	LAI	CGR (g/g/day)	Total dry matter (kg/ha)		Yield attributes			Yield (kg/ha)			Weed Index (%)*	WCE (%)*
	60 DAS	30 to 60 DAS	60 DAS	Harvest	Head diameter (cm)	Test weight per 100 seeds(g)	Filled grains	Stalk	Oil	Seed		
Hand weeding twice at 25 DAS and 45 DAS	2.57	8.72	3090.3	4998.1	16.10	4.35	457.0	3748	488.8	1250	5.8	75.6
Manually operated weeder twice at 25 DAS and 45 DAS	2.21	7.85	2803.7	4572.2	15.40	4.28	407.0	3432	443.5	1140	14.1	66.6
Manually operated weeder at 25 DAS + hand weeding at 45 DAS	2.36	8.36	2981.2	4814.0	15.80	4.09	454.0	3583	482.2	1230	7.3	37.1
In situ green manuring-cowpea incorporation at 45 DAS	2.07	7.22	2579.7	4230.8	15.20	4.31	416.8	3148	419.1	1083	18.4	66.4
In situ green manuring-sun hemp incorporation at 45 DAS	2.01	6.89	2465.4	4007.1	15.70	4.25	415.8	2983	393.2	1024	22.8	68.3
Intercropping with coriander	1.88	6.62	2365.4	3689.5	14.90	4.10	342.0	2700	377.2	990	25.4	50.2
Mulching with maize stalks at 5 t/ha	2.05	7.40	2642.9	4341.7	16.10	4.51	417.6	3257	422.1	1085	18.2	51.2
Mulching with weeds (composite, broad leaved weeds) at 5 t/ha	1.95	6.87	2455.5	3993.2	15.57	4.05	408.1	2957	395.8	1036	21.9	46.1
Stale seed bed technique	1.93	6.73	2399.3	3917.5	15.22	4.07	396.6	2911	383.3	1006	24.2	35.1
Spray of eucalyptus oil at 0.4% at 3 DAS	1.90	6.64	2372.1	3838.8	15.10	3.95	364.8	2859	376.3	995	25.0	17.9
Weed free	2.73	9.29	3312.1	5438.3	17.75	4.76	492.1	4111	524.2	1327	-	100.0
Weedy check	1.79	5.90	2103.9	3244.2	13.70	3.77	325.5	2399	320.3	845	36.3	-
LSD (P=0.05)	0.180	1.462	257.60	420.26	1.443	0.315	31.04	271.9	34.07	67.8	-	-

*Not statistically analyzed

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Alternate benefit of poultry manure on weed management in maize-maize cropping system

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Maize (*Zea mays* L.) is a miracle crop grown all over the globe as poor man's food and also as cattle and poultry feed. The initial slow growth, wider spacing and heavy fertilization, invites multiple weed species infestation. The possibilities and prospects of exclusive organic farming *vis-à-vis* exclusive chemical farming and integrated nutrient management on weed density and weed dry weights in continuous maize has not been studied thoroughly. Hence, the present study was taken up.

METHODOLOGY

Field investigation was carried out during *Kharif* and *Rabi* seasons of 2008 and 2009 on sandy clay loam soil at Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in randomized block design, replicated thrice and the same layout was maintained during both the years of study. The experiment consisted of ten treatments comprising four organic manures and their combinations, *viz*. 100%. RDF through farmyard manure, vermicompost and poultry manure and all the combination at 1/3, 1/3, 1/3 proportion. The four treatments were integrated *i.e.* 50% RDF through organic manures and 50 per cent RDF through inorganic fertilizers. The remaining two treatments were 100 per cent RDF through inorganic fertilizers and control (without organic and inorganic).

RESULTS

The application of organic manures and fertilizers in the *Kharif* and *Rabi* seasons of 2008 and 2009, significantly influenced the weed dry weights. Lowest dry weights of weeds and weed density was recorded with 100% RDF through poultry manure and it was comparable with 50 per cent RDF + 50 per cent RDF through poultry manure during both the years of study (Table-1). This is due to when poultry manure is added, aerobic fermentation occurs with the production of heat and loss of CO_2 and ammonia (Simpson 1986). The heat produced and the immediate higher availability of N have caused the caustic effect on the germinating weeds and reduced the weed biomass. Another reason is that poultrymanure is totally free of weed seeds because of the use of broken grains in poultry rations (Amanullah *et al.* 2006).

Table 1. Effect of integrated nutrient management practices on weed dry weights (g/m²)

Treatment	*Kharif* 2008		*Rabi* 2008		*Kharif* 2009		*Rabi* 2009	
	20DAS	40DAS	20DAS	40DAS	20DAS	40DAS	20DAS	40DAS
T_1 – Control (No manure)	*5.17 (24.8)	7.34 (52)	4.47 (18)	6.32 (38)	5.0 (23)	7.48 (54)	3.64 (11)	4.24 (16)
T_2 – 100% RDF	4.51 (18.4)	4.89 (22)	4.12 (15)	5.74 (31)	6.92 (46)	5.47 (28)	2.82 (6)	4.12 (15)
T_3 –100% RDF through FYM	4.79 (21.0)	4.69 (20)	4.24 (16)	4.69 (20)	5.65 (30)	6.16 (36)	3.46 (10)	4.58 (19)
T_4 – 100% RDF through Vermicompost (VC)	5.23 (25.4)	8.12 (64)	3.46 (10)	5.83 (32)	6.48 (40)	6.92 (46)	3.16 (8)	4.24 (16)
T_5 – 100% RDF through Poultry manure (PM)	3.74 (12)	4.44 (18)	2.23 (3)	4.24 (16)	4.35 (17)	5.47 (28)	2.44 (4)	3.60 (11)
T_6 – 100% RDF through 1/3 FYM+1/3VC+ 1/3 PM	5.53 (28.6)	7.07 (48)	2.82 (6)	5.09 (24)	6.16 (36)	7.34 (52)	3.31 (9)	4.35 (17)
T_7 – 50% RDF + 50% through FYM	5.51 (28.4)	8.60 (72)	5.65 (30)	7.0 (47)	6.48 (40)	7.0 (47)	3.46 (10)	4.69 (20)
T_8 – 50% RDF + 50% through VC	5.04 (23.4)	5.74 (31)	5 (23)	6.40 (39)	5.29 (26)	7.41 (53)	2.82 (6)	5 (23)
T_9 – 50% RDF + 50% through PM	4.97 (22.8)	5.69 (27)	3.16 (8)	5.29 (26)	5.65 (30)	5.09 (24)	2.64 (5)	4.47 (18)
T_{10} – 50% RDF + 50% through 1/3 FYM+1/3VC+ 1/3 PM	4.89 (22.0)	5.77 (35)	4.89 (22)	6.08 (35)	5.65 (30)	6.63 (42)	2.69 (8)	4.79 (21)
LSD (P=0.05)	0.180	0.650	0.368	0.275	0.265	0.306	0.128	0.136

*Square root transformed value; Figures in parentheses are original values

CONCLUSION

Application of poultry manure either applied alone or in combination with chemical fertilizers significantly reduced the weed biomass in maize-maize cropping system.

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Weed suppression and biomass production in two cover crop mixture system

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Cover crop is used as green manure, and it has many functions; weed suppression, prevention of soil erosion, supply of organic matter to soil. In the United States, two kinds of crops; Poaceae and Fabaceae are often used as cover crops to get higher effect, although there are not many studies which used plural cover crops in Japan so far. In Japan, rice-wheat-soybean crop rotation is usually employed. And now, it is expected to incorporate vegetable cultivation into the system for improvement of profitability. But the approach has some problems such as decreasing soil fertility, increase of microbes and weed infestation before planting of crop.

Here, we focused on cover crop especially mixed seeding of Poaceae (rye) and Fabaceae (hairy vetch).We tested field experiment to check two points: 1) effects of mixed cover crops on weed suppression during growth of them(before seeding of summer crop) and 2) biomass production of cover crops as green manure. We used cold resistant cultivars because cover crops were sowed in autumn or early spring. Moreover we carried out seeding three times per one experiment and investigated function of cover crops in each seeding time. This study is useful for establishment of conservation cultivation system by using multifunctional cover crop in the future.

METHODOLOGY

A field test was carried out at an experimental field of NARO Agricultural Research Center, Tsukuba (36° 1' 31"N, 140° 6' 56"E) from winter (November) to early summer (June) from 2013 to 2015.We used two kinds of hairy vetch cultivars 'Fujiemon' (medium maturing) and 'Kantaro' (late maturing) and a rye cultivar 'R-007' (late maturing) as cover crops. Six treatments were tested as follows: single seeding of Kantaro, single seeding of Fujiemon, single seeding of rye, mixed seeding of Kantaro and rye, mixed seeding of Fujiemon and rye and no-treatment. Amount of seeds of hairy vetch and rye for single seeding were 5 and 8 kg/10a (standard amount of seeding), respectively. Half of the above-mentioned amount was seeded for each crop in mixed seeding. Broadcast seeding was used for all treatments. Treatments were arranged in a randomized design with two replications in each seeding time. Cover crop seedings following tillage were performed in November, March and May. Plant measurements were performed in following April, May and June. Coverage, plant height and dry weight of cover crops and weeds within a quadrat of 0.3mx0.3m were measured. Multiplied dominance ratio (MDR) of crops, which is known to be highly correlated with dry weight, was calculated as follows:

MDR (m^3/m^2)=coverage(m^2/m^2) x height (m)

In addition, relative yield total (RYT) of crops was calculated to assess yield advantages as a result of treatment as follows.

RYT =£(production of each cover crop in each treatment/production of each cover crop in single seeding).

RESULTS

In case of November seeding, dry weight of weed in mixed seeding were lighter (1.7 to 3.3 g/m^2) than that of weed in no-treatment or single seeding of hairy vetch (2.6 to 31.2 g/m^2) in April. In addition, RYT of mixed seeding treatment was over 1.0 in both April and May, 2014. Moreover, MDR of both mixed seeding and single seedingof rye were over 0.9 m^3/m^2.

In case of March seeding, dry weight of weed in mixed seeding and single seeding of rye were also lighter than those in both no-treatment and single seeding of hairy vetch. Thus, the result suggested mixed seeding and seeding of rye in March have high weed suppression efficacy because of shading effects. RYT of mixed seeding treatment was over 1.0 in May, 2014, however, the value decreased in June.MDR of each treatment in May, 2014 was over 0.3 m^3/m^2 except single planting treatment of Kantaro.

In case of May seeding, RYT of mixed seeding treatment was over 1.0 in 2014. However, dry weight of weed did not show clear effect, 2014.Thus, there was a possibility that seeding in May did not have enough effects on weed suppression.

These results showed cover crop especially mixed seeding treatment can help both weed suppression and improvement of biomass production. On the other hand, this effect was changed depending on kind of crop and/or seeding time. Previous study also showed amounts and kinds of weeds were changed with seeding time (Kobayashi and Oyanagi, 2006). Thus, we can suppress weed and get higher biomass effectively by choosing suitable timing of cover crops seeding.

CONCLUSION

It was suggested that mixed seeding of two kinds of cover crops had higher effect of weed suppression and more biomass than single seeding of hairy vetch, at least in April.

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Weed management in groundnut under organic farming

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Groundnut is a major crop of Saurashtra region and demand of organic groundnut is increasing day by day due to health consciousness of customers. Groundnut is highly susceptible to weed infestation because of its slow growth in the initial stages up to 40 DAS, short plant height and underground pod bearing habit. Unlike other crops, weeds interfere with pegging, pod development and harvesting of groundnut during different stages of crop growth besides competing for essential resources. Therefore, an experiment was conducted to find out most effective and viable combination of preventive, mechanical, physical and cultural methods of weed control to manage the weeds in *Kharif* organic groundnut.

MATERIALS AND METHODS

The field experiment was conducted on medium black calcareous clayey soil at Junagadh (Gujarat) during *Kharif* season of 2013 and 2014 to evaluate organic weed management practices in groundnut. The experimental soil was clayey in texture and slightly alkaline in reaction with pH 8.0 and EC 0.60 dS/m. It was medium in available nitrogen (232 kg/ha), low in available phosphorus (21 kg/ha) and high in available potash (375 kg/ha).The experiment comprised pre-sowing treatments (Deep ploughing, Stale seedbed and Soil solarization) as main plots and post-sowing treatments (Wheat straw mulch at 5 t ha, Hand weeding and interculturing at 15, 30 and 45 DAS, Weed free check and Unweeded control) as sub plots were laid in a split plot design with four replications. The groundnut variety 'Gujarat Groundnut 20' was sown in June at spacing of 60 x 10 cm using seed rate of 120 kg/ha.

RESULTS

Experimental field was infested with monocot weeds, *viz. Cynodon dactylon*, *Brachiaria* spp., *Asphodelus tenuifolius*, *Indigo feraglandulosa*, *Dactyloctenium aegyptium* and *Echinocloa colona* , dicots weeds, *viz. Digera arvensis*, *Chenopodium album*, *Amaranthus viridis*, *Physalis minima*, *Portulaca oleracea*, *Euphorbia hirta* and *Leucasaspera* and sedge weed *Cyperus rotundus*. Stale seedbed recorded significantly higher pod yield (1.21 t/ha) and haulm yield (2.81 t/ha), however it remained statistically at par with soil solarization (Table1). Significantly lower pod yield (0.87 t/ha) and haulm yield (2.10 t/ha) were achieved with deep tillage. Among post sowing treatments significantly higher pod yield (1.31 t/ha) and haulm yield (3.21 t/ha) were registered under weed free treatment, however it was comparable to HW and IC at 15, 30 and 45 DAS in case of pod yield and haulm yield . Wheat straw mulch and 5 t/ha also gave higher pod and haulm yields over the unweeded check.

Table 1. Pod and haulm yields of groundnut under organic weed management practices

Treatment	Pod yield (t/ha)	Haulm yield (t/ha)
Pre-sowing		
Deep ploughing	0.87	2.10
Stale seedbed	1.21	2.81
Soil solarization	1.10	2.60
LSD (P=0.05)	0.13	0.30
Post-sowing		
Straw mulch	1.03	2.34
Hand weeding	1.28	2.96
Weed free	1.31	3.21
Unweeded	0.63	1.51
LSD (P=0.05)	0.08	0.23

Different pre-sowing weed management treatments exerted significant effect on dry weight of weeds. Stale seedbed resulted into the lowest weed dry weight followed by the soil solarization. Among post-sowing treatments weed free registered significantly lowest dry weight of weeds followed by hand weeding & interculturing at 15, 30 and 45 DAS.

CONCLUSION

It could be concluded that effective management of weeds with higher production of groundnut under organic farming on clayey soil under south Saurashtra agro-climatic conditions can be obtained by adopting stale seedbed supplemented with hand weeding and interculture at 15, 30 and 45 DAS.

Improvement in the herbicidal activity of eugenol against barnyard grass upon supplementation with leaf extracts of some allelopathic plants

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Essential oils from aromatic plants possess phytotoxic potential against a range of plants especially weeds. Monoterpenes, identified as their major components have been known to be responsible for the essential oil caused phyotoxicity. Monoterpenes, therefore, find a significant utility in the management of weeds. They are being explored extensively for the use as bioherbicides since they do not persist in soil for long or contaminate ground water. They are eco-friendly and cause no mammalian toxicity. Among these, eugenol, a major constituent of clove (*Syzygium aromaticum*) oil, is a well known bioactive compound. Studies have pointed to the phytotoxic potential of eugenol against the growth and development weeds (Ahuja *et al*. 2015), due to membrane disruption (Tworkoski 2002). The present work was focused on the improvement of the herbicidal potential of eugenol upon supplementation with water extracts of some known allelopathic plants, *viz*. *Callistemon viminalis*, *Eucalyptus citriodora* and *Chenopodium ambrosioides*.

METHODOLOGY

In order to improve its herbicidal potential and keep it safe in relation to synthetic herbicides, eugenol (E) was combined with leaf extracts (LE) of some allelopathic plants. The experiment was carried out in pots in an experimental dome maintained under natural conditions. Seeds of *Echinochloa crus-galli* were mixed in the soil taken in 15-cm polypropylene pots each filled with 1 kg of garden soil (soil:sand:manure 2:1:1, *w/w*). The soil was spray treated with 30 ml of 1% E alone; 2% LE alone; 1% E + 1% LE; 1% E + 2% LE of *Callistemon viminalis* or *Eucalyptus citriodora* or *Chenopodium ambrosioides*. This was repeated thrice at 1st, 3rd and 5th day after sowing. A set-up with distilled water treatment served as control. At two and four weeks after soil treatment (WAT), the growth (root and shoot length), total chlorophyll content, cellular respiration and seedling dry weight were measured.

RESULTS

The results indicated that application of E+LE declined the growth of *E. crus-galli* more severely compared to E and LE alone. The root length declined significantly over control by 56, 61 and 65%, 4 WAT. The shoot length declined by 47, 49 and 53% upon exposure to 1% E + 2% LE of *C. viminalis*, *E. citriodora* and *C. ambrosioides*, respectively. The decline was also significant at 1% E + 2% LE with respect to 1% E and 2% LE alone. With treatment of 1% E + 2% LE of *C. viminalis* or *E. citriodora* or *C. ambrosioides*, 4 WAT, total chlorophyll content was also found to decrease significantly over control as well as over 1% E and 2% LE alone. In contrast, a significant increase in the cellular respiration was observed upon exposure to 1% E + 2% LE of the three allelopathic plants. An alteration in the chlorophyll content and cellular respiration in *E. crus-galli* indicated an adverse impact on the photosynthetic machinery and energy metabolism. The dry weight decreased by 65, 69 and 70% at 1% E + 2% LE of *C. viminalis*, *E. citriodora* and *C. ambrosioides*, respectively, over control, 4 WAT. This suggested a possible positive synergy between eugenol and the constituent allelochemicals against the weed growth. The formulations with allelopathic leaf extracts were effective against the weed growth on a pre-treatment. Although the three allelopathic plants improved the inhibitory potential of eugenol, yet a combination with water extracts of *C. ambrosioides* exhibited greater phytotoxicity. The results clearly indicated a better potential of eugenol when formulated with leaf extracts of allelopathic plants. At a lower dose of eugenol, significant growth retardation in the test weed was achieved. The combination treatments of eugenol, therefore, improved the efficacy of eugenol and provided a cost-effective solution to the use of natural plant products as herbicides in comparison to the synthetic ones.

CONCLUSION

The study concluded that the herbicidal potential of eugenol can be improved upon supplementation with leaf extract of *Chenopodium ambrosioides*. Thus the combination may be used as an eco-friendly bioherbicide for sustainable weed management.

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Theme 12

Strategic farmers participatory approaches to weed management

Integrated approach to manage weedy rice menace in Kerala, India

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Rice is the staple food for the people of Kerala. It was commonly grown by manual transplanting of seedlings after tillage, in puddled soil. In recent years, however, farmers are practicing direct-seeding of rice due to the labor and water scarcity and increased production costs. Direct-seeded systems have several advantages; however, weeds, including wild rice, are the major problem in these systems. Farmers are procuring rice seeds from Department of Agriculture supplied by National Seed Corporation (NSC). Rice seeds contaminated with wild seeds procured from government agencies resulted in spread of weedy rice throughout Kerala State of India. Chemical control measures to manage weedy rice in conventional rice cultivars are not an easy option, due to similar physiological and morphological traits between wild rice and cultivated rice. Therefore, managing weedy rice is an increasingly challenging problem for farmers in Kerala. In the absence of selective herbicides, cultural weed management strategies may help reduce the problem of wild rice. According to farmers, managing weedy rice menace through chemical method alone amounts to high cost of cultivation at Rs. 12,000/ha. This prompted KVK to formulate an integrated weed yrice management strategy.

METHODOLOGY

Stale Seedbed Technology: In stale seedbed practice. Paddy field is kept ready one month prior to cultivation. After drying the field, spraying glyphosate 1 kg/ha on emergence of weeds and later water was allowed to stand for 10 days. After field preparation, oxyflurofen 23.5 EC 0.147 kg/ha was sprayed on 2 cm standing water and after 2-3 days when water dry off, the germinated rice seeds were broadcasted.

RESULTS

The following depicts the result of Front Line Demonstration conducted at Pathanamthitta District by KVK. Demonstration on using Glyphosate/ha, sprayed after land preparation Oxyfluorfen/ha before sowing to control wild rice (Table 1).

Table 1. Front demonstration on farmers' fields in Pathanamthitta district, Kerala

Parameters	Check Plot	Demonstration Plot
Number of weedy rice before sowing/m^2	68	72
Number of weedy rice 20 days after sowing/m^2	17	6
Rice yield (t/ha)	4.1	4.3
B.C Ratio	1.23	1.32

In certain fields, chemical control did not control effectively the weedy rice due to untimely rain. Rainfall during application has reduced the efficiency of the herbicide. Weedy rice attains panicle initiation at 50-55 days after emergence. Weedy rice that had grown taller than rice could be treated with foliar systemic herbicides such as glyphosate at 10 percent concentrations, by using wick/wiper applicators (Stroud and Kempen, 1989). The equipment can be mounted on self-moving machines, the front of a tractor or handheld equipment. It was proved that by taking advantage of 15-20 cm height difference between rice and wild rice plants, effective control of weedy rice can be obtained by selective killing of weedy panicles by direct contact application with broad spectrum herbicides, *viz*. glyphosate at 15-20% concentration using thespecially designed wiper device at 60-65 DAS (Abraham 2012).

CONCLUSION

Integrated management strategies like stale seed bed technique to wear out soil seed bank, pre plant application of herbicides to prevent the early emergence, and use of wiper device to selectively dry the panicles of weedy rice in standing crop to prevent buildup of soil seed bank are viable technologies for managing weedy rice in rice. Effective management of weedy rice is possible by following other management options like higher seed rate, use of pigmented rice varieties, straw burning, appropriate tillage practices, adoption of mechanized transplanting or dibbling, scientific water management, and hand weeding in an integrated approach. Participatory technology demonstrations have confirmed that weedy rice infestation in farmers' fields requires adoption of integrated management strategies.

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Effect of organic materials application on nitrogen levels and weeds in tropical semi-arid sandy loam soils of North Eastern Nigeria

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Mineralization is the conversion of organically-bound nutrient in organic matter into inorganic forms that can be used by plants. Mineralization rate is the amount of nutrients mineralized and release into the soil overtime which is expressed in percentage. Mineralization rate could be affected by temperature, moisture, types of organisms and the nature of materials added, as well as cultural practices. In sandy loam soils of tropical semi-arid region, soil temperatures may be high enough while soil moisture may limit microbial activities and such the rate of mineralization could be variable.Experiments were conducted inLaboratory of the Department of Soil Science, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria in 2011 and 2012 cropping season to estimate the mineralization rates and release pattern of ammonium (NH_4-N) and nitrate nitrogen (NO_3-N) from cow-dung, sheep dropping and millet straw. The experiment was conducted using factorial design, consisting of three main plots and three sub-plots. Using the combined means of the 2011 and 2012 seasons result, ammonium and nitrate nitrogen mineralization rates from cow-dung werenegative between 2-4WAI (weeks at incubation) and 10-12WAI, highest level of ammonium (3.85%) and nitrate nitrogen (1.99%) were recorded at 6WAI.Mineralization rate of ammonium nitrogen from sheep dropping was negative from 4 to 6 and also at 12WAI, but nitrate nitrogen was positive from 2 to 10WAI and wasnegative only at 10WAI. Highest mineralization rate of ammonium nitrogen (1.92%) from sheep dropping was recorded at 6WAI, while highest mineralization rate of nitrate nitrogen (4.19%) was recorded at 8WAI. For millet straw, both ammonium and nitrate nitrogen were negative throughout the period of incubation (12 weeks). Among the three organic materials used for the experiment, highest level of ammonium nitrogen was released by cow-dung, sheep dropping released the highest amount of nitrate nitrogen while millet straw released the least amount of both ammonium and nitrate nitrogen. Application of cow-dung and sheep dropping could be recommended for someincrease in the amount of ammonium and nitrate nitrogen on sandy loam soils of tropical semi-arid regions.

Organic Weed Management Strategies in Field Crops

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Agronomic practices and management decisions can have a significant impact on the type and number of weeds on the farm. Organic crop production requires a high level of management to successfully culture a healthy and productive balance in the field environment, minimizing the number of weeds to the benefit of the crops seeded. In approaching weed management within an organic system, it is important to reduce weed competition and reproduction to a level that the farmer can accept. Weeds are any undesirable plants that can be both a nuisance and a hazard in agriculture. Weeds compete with field crops for soil nutrients, light and water and also harbour insect and disease pests. Weeds interfere with agronomic operations such as fertilizer application and harvesting. Weed management should reduce competition from current and future weeds by preventing the production of weed seeds and perennial propagules. Consistent weed management can reduce the costs of weed control and contribute to an economical crop production system.

Scientific approaches of organic weed management strategies have beneficial impact on crop production as well as environment. Weed monitoring is an essential aspect for the successful and economic control of weeds. It is continuous process throughout the growing season and from year to year. The previous cropping systems may influence weed pressure during the current growing season depending on the type of crop produced. Preventing weeds from emerging and spreading stage through crop rotations, cover crops, stale seedbed preparation, soil solarization, proper sanitation, and composting are important. Increasing crop competitiveness by choosing the right cultivar, using transplants, seeding correctly, ensuring crop health, and applying mulches can give crops a competitive advantage.

Weed management within an organic farm relies on an integrated cropping-system approach. An organic farming system should be designed in such a way to create a balance between crop plants and weeds. Within such a system, farmers can take action to tip the balance in favor of crop plants through cultural practices that puts weeds at a disadvantage. These practices can also have secondary benefits for soil fertility, disease, and pest management. Annual cover crops may be killed or left to die naturally and used as mulch. By altering light, soil moisture, and soil temperature, mulches limit the germination and growth of weed seedlings. The most significant challenge a farmer faces in using living mulch systems for crop production is competition between the living mulch and the market crop. Using organic materials as mulch can help to increase soil organic matter, promote soil biological activity, and enhance soil structure, water infiltration, and aggregate stability. The integration of animals into an organic farming system also offer benefits, such as enhanced nutrient cycling and conservation, effective use of crop residues, and an alternative source of income for the farm. The organic post-emergence, post-directed, and burndown herbicides are all non-selective, non-translocated, contact herbicides which need to be applied, either prior to crop emergence or transplanting, or post-directed to establish crops to assure the herbicides do not injure the crop plant.

Despite the serious threat offers by weeds to organic crop production, relatively little attention has so far been paid to research on weed management in organic agriculture. It is certain that weed management should be tackled in an extended time domain and needs deep integration with the other cultural practices, aiming to optimize the whole cropping system rather than weed control *per se*. It is stressed that direct (physical) weed control can only be successful where preventive and cultural weed management is applied to reduce weed emergence (e.g. through appropriate choice of crop sequence, tillage, smother/cover crops) and improve crop competitive ability (e.g. through appropriate choice of crop genotype, sowing/planting pattern and fertilization strategy).

Controlling weeds is an essential aspect of successful crop production. The lack of weed control can result in the total yield loss due to weed competition and with weeds acting as a reservoir for pathogens through disease and insect damage. Weed control should be considered a continuous endeavor not just a seasonal effort. It is more cost effective to prevent an infestation than eliminating a weed species once the production area is infested. Successful weed management uses a multifaceted approach (rotating crops and herbicides, cover crops, mulches, cultivation etc.) rather than relying solely on herbicides to control the weeds.

Field demonstrations on chemical weed control in transplanted rice

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In Madhya Pradesh rice is grown on 18.02 lakh ha area during 2013 with average productivity of 1.82 t/ha, which is below the national level. In *Kharif* rice constitute more than 58.64 % of total net sown area in the Gwalior district in which it is predominantly grown in Dabra and Bhitarwar blocks. One of the major production constraints in rice production in the district is the poor management of weeds due to scarcity of labour during weeding peak and transplanting. Hence effective weed control is essential for obtaining optimum yield of rice (Hussain *et al*. 2008). Some farmers in the K.V.K. adopted villages were using butachlor at 2-3 DAT. However this PE herbicide was not giving effective control of few BLWs, viz. *Ipomoea aquatica*, *Cyperus difformis*, *Alternanthera sessilis*. Moreover, in *Kharif* season, due to incessant rains the manual weeding is problematic and uneconomic. Under such situations herbicidal weed control play a significant role in controlling the weeds and thereby increasing the rice production.

METHODOLOGY

The field demonstrations were carried out in transplanted rice with chloromuron-ethyl + metsulfuron-methyl and bispyribac-sodium established new generation post emergence herbicides at K.V.K. adopted villages *Simaria Tekari*, *Salwai* and *Mustura*, *Kishanpur* in Dabra and Bhitarwar blocks respectively in the district Gwalior during *Kharif* season of 2012 to 2014. Five farmers in these adopted villages in each seasons were selected for the demonstrated carried out. The selected farmers were belongs to small and medium category. The soil of the farmer's fields was clay-loam in texture. The soil samples from each adopted farmers were analyzed and found to be low in organic carbon (0.3-0.48 %) and available N (201-242 kg/ha), medium in available P (24.6-25.20 kg/ha) and available K (220-294 kg/ha). Chloromuron-ethyl + metsulfuron-methyl at 4 g/ha, bispyribac-sodium 10% SL at 25 g/ha were demonstrated in the farmers fields.

The grain yield of the crop with the economics of the treatments in each demonstration were recorded and compared with the farmers' practice. The data were calculated and analyzed to draw the valid inferences.

RESULTS

All the herbicides under chosen for field demonstrations were found effective in controlling weeds growth (Table 1). The population of weeds was found higher in FP in all the locations of field demonstrations. The average highest grain yield of 5.66 t/ha was found to be at locations with the application of bispyribac -sodium at 25 g/ha followed by chloromuron-ethyl + metsulfuron-methyl (4.89 t/ha). The increase grain yield was attributed mainly to the timely and effective control of weeds during initial stages of crop growth (Mukherjee and Singh, 2005). The average yield of all the locations of FP was found to be below 5.0 t/ha. The demonstrations indicated that grain yield of rice along with economical benefits due to the treatment of herbicides was higher than the farmers' practice. These findings corroborate the findings reported by Mishra and Dash (2013). The application of herbicides have registered higher B:C ratio in comparison to FP in all the locations. Among all the herbicides demonstrations during various years, bispyribac sodium at 25 g/ha gave the highest B:C ratio of 4.83 followed by chloromuron-ethyl + metsulfuron-methyl application (4.80).The cost of herbicide including cost of application varied from Rs.1595-2250 was less than the FP, while resulting yield advantage of 12.0-17.5% at different locations.

CONCLUSION

The field demonstrations through farmer's participations play a key role in transfer of technology generated on research farms. As the rate of adoption of herbicides use in the district and state as well in rice fields is very much poor in comparison to other agrochemicals particularly insecticides used by the farmers, it is pertinent to conduct result demonstrations to get more benefit from the technology along with its rapid dissemination.

Table 1. Effect of different herbicides on weed growth, yield and economics of transplanted rice at farmers' fields

No. of demonstration / Farmers' practice	Herbicidal treatment/ Farmers practice	Weed count (no./m^2) at 60 DAT	WCE (%) 60 DAT	Grain yield (t/ha)	Yield increase over FP (%)	B:C ratio	Cost of treatment (Rs./ha)	Benefit over FP (Rs`/ha)
Year 2012 (05)	Chloromuron-ethyl +Metsulfuron-methyl at 4g/ha	15.0	82.35	4.89	17.50	6.08	1595	18980
	FP (Butachlor at 1.5 kg/ha)	85.0	-	4.16	-	5.78	1780	-
Year 2013 (05)	Bispyribac sodium 10% SL at 25 g/ha	6.0	86.66	4.56	12.00	4.83	1970	14400
	FP (Butachlor at 1.5 kg/ha)	45.0		4.08	-	4.53	2080	-
Year 2014 (05)	Bispyribac sodium 10% SL at 25 g/ha	6.50	92.40	5.66	13.48	4.70	2190	18090
	FP (Butachlor at 1.5 kg/ha)	85.60	-	4.99	-	4.36	2250	-

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Impact of technological intervention on tribal maize growers

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In India maize is the third most important food-grain crop and has been considered as a promising option for diversifying agriculture in upland area. The total area for maize in India is 94 lac hectares and 70% of it, is cultivated under rain fed conditions (India maize summit 2014). The state of Madhya Pradesh is one of the traditional maize growing states, and accounts for 13 % of the total maize area. However, its productivity when compared to other maize growing states is very low. The low productivity level of maize in Madhya Pradesh is primarily due to inability of the majority of farmers particularly in tribal localities, to follow the recommended package of practices either due to high cost or lack of awareness. In recent years, severe weed menace in maize resulted in reduced productivity and income to farmers (Aye and Mungatana, 2010). Therefore, an attempt was made to address the improved technological interventions including weed management issues through on- farm research trials (OFRT) in the field of some tribal farmers.

METHODOLOGY

Initially, survey was made in maize growing tribal locality of Kundam tehsil (Khukham, Ranipur and Ragertola villages) of Jabalpur (MP). The soils were very poor having very low fertility level and organic carbon. Farmers were illiterate and backward in terms of modern agricultural technologies. They used to grow only local varieties of maize without any application of fertilizers and modern weed management practice. Twenty five OFR- cum-demonstration trials on improved technologies including weed management were laid out at purposively selected farmer's field in a participatory mode in maize crop during *Kharif* 2012- 2014. The objective of this OFR trial was to make aware/educate the tribal farmers about improved agricultural technologies.

RESULTS

The improved technologies including weed management under OFR-cum-demonstration were found effective in increasing grain yield of maize by 60-85% over farmers practice depending upon the intensity and growth of weeds, and gave an additional economic benefit of 12000-14000/ha over farmer's practices. Weed control efficiency and benefit-cost ratio of the imposed treatments were 70-75 % and 1.93-2.15, respectively. It was observed that farmers practice, *i.e.* manual weeding at inappropriate stages of crops (at later stages of crop growth so that they can use weed biomass as fodder), has no relevance over the crop yield and economy. It was also observed that few resourceful farmers were aware of the role of recommended dose of fertilizer, line sowing and improved weed management technology in enhancing the overall crop productivity but still continuing the conventional practice of unbalanced use of fertilizer, broadcast method of sowing and manual weeding owing to various social, economical and other constraints prevailing in tribal localities. A general comparison of the costs of cultivation of traditional and hybrid cultivars has revealed that the cost increases on using the improved cultivars due to higher requirements of fertilizers, irrigation, herbicides and plant protection chemicals as compared to that needed for the traditional varieties. However, with the significant increase in yield, the cost of production per unit amount of grain yield has been much lower in case of the improved cultivars. Thus, the maize yield and farmer's income of these localities can be increased through adoption of proper technologies.

CONCLUSIONS

The result of OFR- cum- demonstration trials brought out that majority of the tribal farmers could not adopt the recommended variety, seed rate, line sowing, fertilizer dose, and improved pest management practices due to lack of knowledge, non availability of inputs and fear factors prevailing in the mind of tribal farmers regarding improved production technologies. The OFR- cum- Demonstration at farmer's field in a participatory mode played a very important role to disseminate and convince the tribal farmers about the improved maize production technologies. It would also help to remove the hurdles including the fear factor that is preventing the adoptability of modern agriculture technology.

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On-farm research on weed management in wheat in tribal area of Jabalpur

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Technology development and its effective transfer at farmer's fields are equally important. The benefits of technological advances sometimes do not reach the farmers due to lack of communication between research organizations and the end users. This may result in significant gap between available technology and their adoption levels. On-farm research (OFR) is carried out to test a new or improved technology at farmer's field (Sharma and Choudhary, 2014). Tribal farmers in and around Jabalpur are not much aware about the benefits of balanced crop nutrition and recent herbicides for weed management. Therefore, an on-farm research trial was conducted on tribal farmer's fields to test and demonstrate the benefits of crop nutrition and weed management in wheat.

METHODOLOGY

Six tribal farmers were selected in the village Kalyanpur of Khukham area near Jabalpur. On-farm research trials were conducted on wheat 'GW 273' on the selected farmer's fields during the *Rabi* season of 2013-14. The soils were low in available N, P, K and organic C. The trial consisted of (i) Farmer's practice (60 kg N/ha + 2, 4-D 500 g/ha) (ii) RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + unweeded (iii) No RFD + (clodinafop+metsulfuron 60+4 g/ha) and (iv) RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (clodinafop + metsulfuron 60+4 g/ha) compared under individual plot size of 500 m^2. Wheat was sown manually in a well prepared field at a seed rate of 100 kg/ha and with a row spacing of 20 cm. Fertilizer and herbicides were applied as per the treatments. Data on weed density, weed biomass, grain yield and economics were recorded.

RESULTS

The major weed flora observed in the on-farm research field was *Phalaris minor*, *Avena sp.*, *Cichorium intybus*, *Vicia sativa*, *Medicago denticulata*, *Lathyrus sativa*, *Chenopodium album* and others. Results revealed that RFD (120:60:40 N, P_2O_5, K_2O kg/ha) along with the application of pre-mix herbicide (clodinafop+metsulfuron 60+4 g/ha) gave more effective broad spectrum weed control, grain yield and B:C ratio (weed dry weight, 24.8 g/m^2 ; grain yield, 4.14 t/ha; BCR:3.43) over farmer's practice (60 kg N/ha + 2, 4-D 500 g/ha) (weed dry weight, 70.9 g/m^2 ;grain yield, 2.36 t/ha; BCR: 2.25).

Table: Comparison of productivity of wheat in OFR at Kalyanpur (Khukham) during *Rabi* 2013-14(mean of 6 farmer's fields)

Treatment	Weed density (no./ m^2)	Weed biomass (g/m^2)	Grain yield (t/ha)	B:C ratio
Farmer's practice (60 kg N/ha + 2, 4-D 500 g/ha)	157	70.9	2.36	2.25
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + Unweeded	179	90.7	3.09	2.95
No RFD + (clodinafop+metsulfuron 60+4 g/ha)	38	16.6	2.74	2.50
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (clodinafop+metsulfuron 60+4 g/ha)	50	24.8	4.14	3.43

CONCLUSION

It can be concluded that application of balanced crop nutrition (120:60:40 N, P_2O_5, K_2O kg/ha) and broad spectrum herbicide (clodinafop+metsulfuron 60+4 g/ha) can be recommended for higher yields and economic returns in wheat in tribal areas of Jabalpur.

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Improved production technologies under AICRP-Weed Management

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Weed science has a long history of solving weed management problems for farmers. One of the biggest obstacles in increasing agricultural productivity is the problem of weeds in field crops and water bodies. The achievement in growth of agricultural productivity in India has been possible as a result of continuous influx of crop production technologies. All India Coordinated Research Project on Weed Management (AICRP-WM) is focusing on generating technologies for improving productivity and resource-use efficiencyin diversified cropping systems. Its main objective was to develop location- specific weed management technologies and undertake demonstration them on farmers' fields.

METHODOLOGY

During 2014-15, different methods of weed management i.e., preventive, cultural, mechanical, chemical and biological were conducted at the coordinating centres of AICRP on Weed Management. These technologies have been widely included in the package of practices adopted by different states for the benefit of farmers. Research and extension activities of the AICRP-WM were focused on multi-disciplinary programmes such as, weed surveillance and monitoring, weed biology and physiology, weed management in crops and cropping systems, management of problematic weeds, herbicide residues and environmental quality and on-farm research and impact assessment. Awareness among farmers and extension workers was created through personal interaction, on-farm trials, TV programme, lectures, radio talks and distribution of leaflets and bulletins, organizing farmer's training at district and state level.

RESULTS

· Several improved weed management technologies were developed during 2014-15 in crops and cropping system such as rice-rice, rice-wheat, rice-groundnut, rice-mustard, maize-wheat, groundnut-wheat etc. by the AICRP-WM centres which were included in state package of practices.

· In dry-seeded rice, pre-emergence application of butachlor 1.25 kg/ha or oxyfluorfen 0.15 kg/ha or pendimethalin 1.5 kg/ha or pretilachlor 0.75 kg/ha on the same day or within six days of seeding to controlled *Ludwigia parviflora* effectively. Early post-emergence (10-12 days after transplanting) application of penoxsulam at 25 g/ha in 375 litres of water provided effective control of mixed weed flora including grasses, broadleaf and sedges in transplanted rice. Post-emergence application of bispyribac-sodium 20 g/ha at 20 DAP has been recommended in transplanted rice.

Combinations of sulfosulfuron + metribuzin 25 + 105 g/ha and clodinafop + metribuzin 60 + 105 g/ha was effective for the control of mixed weed flora in wheat.

·In groundnut, pre-emergence application of oxyfluorfen 0.02 kg/ha in 500 litre of water at 1-2 days after sowing is recommended to control grassy weeds and problematic weeds like *Celosia argentea*.

Post-emergence application of quizalofop ethyl 0.05 kg/ha at 21 days crop stage along with one hand weeding at 6 week stage was the best weed management schedule in jute. It reduced the cost of weeding by ' 2400/ha.

Application of glyphosate 0.80 kg/ha + oxyfluorfen 0.2 kg/ha just before emergence of sprouts of ginger was found effective in reducing density as well as dry matter accumulation by all three categories of weeds.

Conventional tillage was found better than zero tillage to improve the microbial and biochemical properties of soil at initial stage of experimentation. Conventional tillage significantly increased the nodule biomass of chickpea over zero tillage at 50 days after sowing of crop.

In pineapple, pre-emergence spray of diuron 1.0 kg/ha in 600 litres of water can keep the field free of weeds for about four months. For subsequent weed control, herbicide application may be repeated.

·Neem cake 200 kg/ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAP reduced *Orobanche* shoot density with better weed control and higher tobacco leaf yield.

·Spraying ethrel 25ml/L on *Loranthus* leaves is effective to control loranthus. In case of regrowth, padding with 2,4-D 1g/20 ml water in major attachment points is recommended.

CONCLUSION

AICRP-WM has played a meaningful role in developing and promoting sound weed management technologies in the country, which have helped in reducing cost and drudgery involved in weed management, and increasing crop productivity. The increase in productivity of crops with improved weed management practices ranges from 60-80% over the conventional farmers practice.

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Impact of weed management technology in soybean under on-farm research cum demonstration

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Soybean, the number one oil seed crop in the world has occupied an important place in the edible oil and agricultural economy of the country. Its inclusion in the cropping system of the country in general and in the states of Madhya Pradesh,Maharastra and Rajsthan in particular has resulted in the improvement of socio-economic status of the farmer and provided employment in village as well as in adjoining cities where soya based industries are located (Raj *et al* 2014). One of the most important constraints of its low productivity is the weed infestation. Due to slow initial crop growth, proper soil moisture and congenial temperature, soybean is highly susceptible to weeds which reduce the yield up to 26-30%. The conventional method of weed control (manual weeding) is expensive, time taking and tedious. At the same time because of the continuous rain during *kharif* season, manual weeding becomes less effective, problematic and uneconomic. Therefore, different promising herbicides were demonstrated for weed control in soybean crop under on-farm research cum demonstration programme of Directorate of Weed Science at farmers' fields to show the practicability and profitability with higher yield and income over farmer's practice.

METHODOLOGY

Twenty OFR trials cum demonstrations on improved weed management technology were laid out during *kharif* of 2012 and 2013 in soybean at two villages (Pola and Dhora) of Majhouli block of Jabalpur with the objective to evaluate and demonstrate the advantages and profitability of improved weed management technologies; viz. chlorimuron-ethyl (10 g/ha) + fenoxaprop-p-ethyl at (80 g /ha) and imazethapyr at (100 g /ha) on weed growth and productivity of soybean at farmers' fields. Fields were infested with mixed weed flora such as *Echinochloa colona, Dinebra retroflexa, Digera arvensis, Commelina communis, Euphorbia geneculata, Parthenium hysterophorus* and *Cyperus spp.*

RESULTS

The applied herbicides under OFR cum demonstration were found very effective in increasing grain yield of soybean by 32% with higher benefit: cost ratio over farmer's practice depending upon the intensity and growth of weeds. Economic benefit over the farmers practice was varied from ¹ 10,000/- to ¹ 12,000/ha. During the period of demonstration, it was observed that few resourceful farmers were aware of the role of improved weed management technology in enhancing the overall crop productivity. It was also noted that under farmers practice, i.e. manual weeding was adopted at inappropriate stages of crop, showed no relevance over the crop yield and economy. During the survey of demonstrated area, it was realized that despite of the technological development in the field of weed science, the rational behind the conventional agricultural system is to derive the crop yield only through basic weed management strategies i.e. manual weeding owing to various social, economical and other constraints prevailing in the rural areas.

Table: On farm evaluation and demonstration on weed management technology in soybean during *Kharif*, 2012 and 2013 (Average of two years data).

No of OFR / demonstration and location	Weed Management Technology	WCE* (%)	Grain yield (t/ha)		Increase in yield over FP (%)	Economic benefit due to treatment over FP (? /ha)	B: C Ratio	
			FP*	IP*			FP	IP
(10) Pola andDhora Village	Clorimuron- ethyl 10 g/ha + fenoxaprop-p-butyl 80 g/ha (PO)	59	1.5	1.9	31	10000	1.95	2.34
(10) Pola andDhora village	Imazethapyr 100 g/ha (PO)	60	1.6	2.1	32	12000	2.20	2.73

* FP-farmers practice (manual weeding), IP- improved practice, WCE- weed control efficiency

CONCLUSION

The OFR cum demonstration at farmer's field in a participatory mode played a very important role to disseminate and convince the farmers about the improved technologies because it is the only tool to test the potential of technologies at farmer's level. Under OFR some specific technical information related to weed management like use of proper herbicides, dose, time and method of application were undertaken in a scientific way. The OFR trials resulted an increase in the yield and economic benefit. The farmers of the area under OFR cum demonstration were highly impressed with the results of improved weed management technologies.

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Theme 13

Economics of managing weeds in agro-ecosystems

Weed management in American cotton

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Cotton is an important cash crop of India owing to its pivotal role in agriculture. It is sensitive to weed competition during initial growth stages due to slow growth and wider spacing as they compete for nutrients, water, light and thus reduce the cotton yield substantially (Bukun 2004). With increasing availability of the new chemicals, their weed control efficiency needs to be evaluated. Generation of such information through field experimentation under site-specific conditions is therefore very crucial for guiding cotton growers.

METHODOLOGY

The experiment comprising of 10 weed management treatments was conducted in randomized block design having four replications. Hand hoeing in all the treatments was given at 60 DAS while, in Farmer's practice, one hand hoeing at 60 DAS followed tractor hoeing at 90 DAS and application of glyphosate at 0.5kg/ha was done as directed spray to emerged weeds during rainy season. Weed population and biomass was recorded from quadrat measuring 50 cm × 50 cm and expressed per square meter. Data on growth, yield and other parameters were recorded from five randomly selected plants in each treatment plot while seed cotton yield (SCY) was recorded from whole plot.

RESULTS

Weed management practices differed significantly for seed cotton yield as well as for other characters such as plant height, bolls/plant, boll weight and sympods per plant. Highest SCY was recorded for T_8 *i.e* weed free check (3.55 t/ha), although it was at par with T_6 (pyrithiobac sodium at 62.5 g/ha + quizalofop-ethyl at 50g/ha + one hoeing) with a yield of 3.52 t/ha. However, T_4 (pendimethalin at 1.0 kg/ha + quizalofop-ethyl at 50 g/ha + one hoeing) was further at par with T_6. Significantly least SCY was recorded under weedy check (1.91 t/ha) (Table1).

Wide variation among treatments for weed dry matter as well as WCE. T_6 (pyrithiobac sodium at 62.5g/ha + quizalofopethyl at 50g/ha 20-30 DAS or 2-4 weed leaf stage + one hoeing) resulted in least weed dry matter (98.6 g/m^2) among chemical treatments. However, weed control efficiency was highest under T_8i.e weed free check (90.3%) followed by T_6 (71.0 %) and least under farmer's practice (25.5%) among the evaluated treatments (Table1). Final weed count was also least (24.6) under T_6. Nadeem *et al*. (2013) also reported significant differences for weed control efficiency with different weed control treatments.

Table 1. Growth and yield parameters, weed indices and monetary parameters under different weed management treatments

Treatment	Plant height (cm)	Sympods/ plant	Boll weight (g)	Seed cotton yield (t/ha)	Weed dry matter (g/m^2)	WCE (%)	Net returns (Rs/ha)	B:C ratio
Pendimethalin at 1.0 kg/ha as PE + one hoeing	162.2	22.9	4.07	3.20	174.2 (13.2)	48.8	91404	2.10
Trifluralin at 1.2 kg/ha PPI + one hoeing	160.5	24.5	3.80	2.92	172.0 (13.0)	49.4	81105	1.94
Quizalofop-ethyl at 50 g /ha at 2-4 weed leaf stage + one hoeing	155.5	25.3	3.67	3.06	167.9 (12.9)	50.6	85978	2.00
Pendimethalin at1.0 kg /ha as pre emergence + quizalofop-ethyl at 50g /ha at 2-4 weed leaf stage + one hoeing	165.5	28.3	3.80	3.40	133.2 (11.5)	60.8	97018	2.11
Pyrithiobac sodium at 62.5g /ha at 2-4 weed leaf stage + one hoeing	161.1	25.8	3.75	3.20	216.5 (14.7)	36.3	90883	2.07
Pyrithiobac sodium at 62.5g /ha + quizalofop-ethyl at 50g /ha at 2-4 weed leaf stage + one hoeing	161.1	27.1	3.55	3.52	98.6 (9.9)	71.0	100916	2.14
Glyphosate at 1.0kg /ha as directed spray at 45 DAS	158.3	24.6	3.75	2.91	214.2 (14.6)	37.0	81069	1.95
Weed free check,	149.9	30.0	3.75	3.55	32.8 (5.8)	90.3	98393	1.93
Farmer's practice and	132.2	19.5	3.27	1.91	340.1 (18.4)	-	46093	1.31
Weedy check	154.9	22.7	3.90	3.03	253.5 (15.9)	25.5	85461	2.02
LSD (P=0.05)	9.3	3.1	0.36	0.43	1.4	-	15674	0.26

Data for weed dry matter has been subjected to square root transformation, Figures in parenthesis are means of transformed values.

Significant differences for monetary parameters among tested treatments. Net returns (Rs.100916/ha) were maximum under T6 (pyrithiobac sodium at 62.5 g/ha + quizalofop-ethyl at 50 g/ha 20-30 DAS or 2-4 weed leaf stage + one hoeing). Cost of cultivation was also significantly highest for weed free check (T_8) owing to labour intensive inter culture work besides more picking charges incurred to pick the SCY. However, highest B:C ratio (2.14) was exhibited under T_6 closely followed by T_4 (pendimethalin at1.0 kg /ha + quizalofop-ethyl at 50g /ha + one hoeing) followed by(2.11). Contrarily, least B:C ratio (1.31) was observed for weedy check(T_{10}) (Table1).

CONCLUSION

Among tested chemicals, pyrithiobac-sodium at 62 g/ha + quizalofop-ethyl at 50 g/ha 20-30 DAS or 2-4 weed leaf stage + one hoeing was found to be promising for better weed management and realization of higher cotton productivity.

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Chemical weed control in groundnut at central Vidarbha zone of Maharashtra

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Groundnut (*Arachis hypogaea*) production minimizing due to severe weed problem of weed infestation especially in the early stages of growth, because the seedling emerges 7 to 10 days after sowing coupled with the slow growth in the initial stages. The weeds emerge fast and grow rapidly competing with the crop severely for the resources namely nutrients, light, and space and also transpire lot of valuable conserved water from the soil. On an average the loss of groundnut production in the country due to weeds has been estimated to the tune of 33 and 70%. Under such conditions, the chemical weed control plays an important role in groundnut and enhances the groundnut yield substantially. Looking to the above facts the experiment is planned to manage the weeds in groundnut with post emergence herbicides. Keeping this in view, the present studies on chemical weed control in groundnut at Central Vidarbha Zone of Maharashtra was initiated at Oilseeds Research Unit, Akola.

METHODOLOGY

A field experiment was conducted during Kharif 2013-14 and 2014-15 at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) in RBD design. The gross and net plot size were 3.60 X 3.0 m^2 and 3.0 X 2.80 m^2 respectively. The crop variety *'AK 159'* was sown at 30 x 10 cm^2. The RDF 25:50:0 NPK Kg/ha were used. The 100 per cent nitrogen and entire P_2O_5 and K_2O were applied as basal dose. Urea (46 %), SSP (16% P_2O_5) and muriate of potash (60% K_2O) respectively.

RESULTS

Pooled results revealed that herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest weed index (3.65 %) was observed under propaquizafop at 100 g/ha followed quizalofop- ethyl at 100 g/ha (8.44 %). Maximum weed control efficiency (93.7%) was recorded in propaquizafop at 100 g/ha and minimum weed control efficiency recorded under pre emergence application of pendimethalin at 1000/ha (59.7%). This clearly indicated that weeds were controlled effectively under post emergency herbicide. The highest dry pods yield (2.97 t/ha) was recorded with hand weeding (20 and 40 days after emergency) and the lowest (1.48 t/ha) was under weeded check (Table.1). Chaitanya *et al.* (2013) revealed that the pre-emergence application of Pendimethalin at 1.0 kg/ha along with post emergence application of quizalofop -ethyl at 50 g/ha at 25 days after emergency recorded a higher growth and yield of kharif groundnut compared to farmers practice and other weed management practices. Among the herbicidal treatments, in propaquizafop at 100 g/ha recorded maximum gross monetery return, net monetery return which was at par with quizalofop -ethyl at 100 g/ha but significantly higher as compared to other treatments.

Table 1. Weed growth, yield and economics of Kharif groundnut as influenced by different weed control treatments

Treatment	Weed control efficiency (%)	Weed density (no./m^2)	Weed dry matter (g/m^2)	Dry Pods yield (t/ha)	Haulm yield (t/ha)	GMR (Rs/ha)	COC (Rs/ha)	NMR (Rs/ha)	B:C Ratio
Weeded check	0.00	140.3	1006.4	1.48	3.11	49573	24962	24611	1.99
Weed free check	100.0	1.00	1.0	2.97	3.89	99775	32737	67038	3.05
Post emergence application of propaquizafop 10 EC at 100 g /ha	93.7	11.6	52.8	2.86	3.57	96115	28038	68077	3.43
Post emergence application of quizalofop ethyl 5 EC at 50 g /ha	82.1	19.1	77.4	2.48	3.33	83196	27549	55647	3.02
Post emergence application of quizalofop ethyl 5 EC at 100 g /ha	90.7	15.6	61.8	2.74	3.48	92182	27952	64230	3.30
Post emergence application of imazethapyr10 % SL at 50 g /ha	78.3	41.6	188.1	2.50	3.33	83664	27637	56027	3.03
Post emergence application of imazethapyr10 % SL at 100 g /ha	85.4	29.1	144.0	2.63	3.49	88245	28108	60137	3.14
Post emergence application of imazethapyr + imazamox 10% SL at 100 g /ha	78.9	42.1	293.2	2.49	3.28	83561	27792	55769	3.01
Pre emergence application of pendimethalin 30 EC at 1000 g/ha	59.7	88.6	644.7	2.26	3.22	76086	27766	48320	2.74
LSD (P=0.05)	7.70	17.4	57.2	0.33	0.65	8070			

CONCLUSION

It was concluded that post-emergence application of propaquizafop 10 EC at 100 g/ha or quizalofop- ethyl 5 EC at 100 g/ha were most effective for controlling weeds, improving dry pods yield and maximum profitability of *Kharif* groundnut.

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Weed management in wet-seeded rice

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Rice (*Oryza sativa* L.) being major staple food of Karnataka cultivated in 1.48 million ha with annual production of 3.69 million tones. Wet seeded rice, the field was puddled and leveled as done for transplanting but instead of transplanting rice seedlings, pre-germinated rice seeds are broadcasted. In many of the countries where labour is limited and labour cost is very high, sowing of rice is effectively done by direct seeding method (Smith and Shaw, 1966). The direct sown crop matures 8 to 10 days earlier than the transplanted rice as it escapes from the transplanting injury. Thus reducing the dose of the herbicide or use of herbicides in sequence can improve selectivity, timely and adequate weed control in wet seeded rice.

METHODOLOGY

A field experiment was conducted during *Kharif* season 2012 at Agricultural Research Station, Malnoor, Karnataka, to investigate the effect of weed management practices on growth and yield of wet seeded rice. Fifteen treatments consisting of three pre-emergent herbicides sprayed alone followed by three post emergent herbicides and hand weeding 25 DAS compared with hand weeding thrice, weed free and weedy check were laid with randomized block design with three replications. Rice variety of '*BPT-5204*' was wet seeded in the experimental field with recommended package of practices. Fertilizers were applied uniformly through urea, single super phosphate and muriate of potash at 150 kg N, 75 kg P_2O_5 and 75 kg K_2O/ha, respectively. Observation on weed growth and yield performance were recorded.

RESULTS

Results revealed that, application of butachlor *fb* bispyribac sodium, 2, 4-D sodium salt and hand weeding at 25 DAS recorded significantly lower weed density, dry weight and grain yield which proved to be superior over rest of treatments except weed free and hand weeding thrice. Maximum weed density and dry weight was recorded in weedy check. Maximum net returns and B:C ratio was recorded in butachlor *fb* 2, 4-D sodium salt followed by butachlor *fb* bispyribac compared to hand weeding which is due lower cost of herbicides, thus indicating that lower cost of cultivation and better weed control was ensured in sequential application of herbicides.

Table 1. Weed parameters, yield and economics of wet seeded rice as influenced by different weed control treatments

Treatment	Weed density (no./0.25 m²)	Weed dry weight (g/0.25 m²)	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (Rs/ ha)	BC ratio
Butachlor 50 EC at 8 DAS	8.30 (68.3)*	4.16 (16.3)*	40.4	3.71	4.19	23,647	2.44
Anilophos 30 EC	8.35 (69.3)	4.25 (17.4)	37.2	3.63	4.11	22,796	2.39
Oxyfluorfen 23.5 EC	8.77 (76.0)	4.63 (21.0)	26.5	2.39	2.82	9,457	1.58
Butachlor 50 EC *fb* 2,4-D sodium salt 80 WP	4.75 (22.7)	2.63 (6.44)	76.1	4.80	5.22	34,708	3.04
Anilophos 30 EC *fb* 2,4-D sodium salt 80 WP	5.32 (27.3)	2.75 (7.6)	74.1	4.56	4.99	32,194	2.89
Oxyfluorfen 23.5 EC *fb* 2,4-D sodium salt 80 WP	7.25 (52.2)	3.56 (12.6)	55.8	2.82	3.30	13,366	1.78
Butachlor 50 EC *fb* bispyribac sodium 10 SC	4.45 (19.3)	2.58 (6.18)	77.4	4.87	5.26	34,154	2.87
Anilophos 30 EC *fb* bispyribac sodium 10 SC	5.57 (30.0)	2.81 (7.37)	73.1	4.53	4.99	30,578	2.67
Oxyfluorfen 23.5 EC *fb* bispyribac sodium 10 SC	6.93 (47.0)	3.47 (11.2)	58.7	3.07	3.55	14,773	1.80
Butachlor 50 EC *fb* hand weeding at 25 DAS	4.98 (24.3)	2.70 (6.77)	75.1	4.67	5.10	32,166	2.77
Anilophos 30 EC *fb* hand weeding at 25 DAS	5.84 (33.6)	2.87 (7.72)	71.7	4.48	4.97	30,222	2.67
Oxyfluorfen 23.5 EC *fb* hand weeding at 25 DAS	7.09 (49.8)	3.52 (11.8)	57.3	2.94	3.31	13,104	1.70
Hand weeding (thrice) at 20, 40 and 60 DAS	2.07 (3.83)	0.90 (0.32)	98.7	5.07	5.44	33,352	2.57
Weedy check	13.07 (173.0)	5.44 (29.6)	0.0	1.86	2.27	4,723	1.31
Weed free check	0.71 (0.00)	0.71 (0.0)	100.0	5.10	5.46	32,832	2.48
LSD (P=0.05)	0.91	0.42	9.07	0.49	0.54	5191	0.27

*Values in parentheses are original, Data transformed to square root transformation

CONCLUSION

Finally concluded that application of herbicides in sequence was more useful for better controlling of weeds and recorded higher grain yield and maximum profitability of wet seeded rice.

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Efficacy and economics of herbicides against *Phalaris minor* weed in wheat

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Weeds are the most important factors which adversely affects the yield of wheat crop. They compete with wheat plants for nutrients, light, moisture and other growth requirements. The better grain yield of wheat crop is not possible without proper weed management in the crop . The intensive use of selective herbicides for weed has increased the problem of narrow leaved weeds especially the *Phalaris minor* in cotton zone of Punjab. *P. minor* is predominant and wide spread, which are usually more aggressive and strong competitors for water, nutrients, light *etc*. To manage this problem the chemical method for controlling weeds is most effective, efficient, up-to-date and time saving. Hence the present study was undertaken.

METHODOLOGY

The experiment was conducted at the Krishi Vigyan Kendra, Sri Muktsar Sahib (30°.27'10" N, 74°.30'34" E) during the *Rabi* season 2014-15. In this experiment five different herbicides namely isoproturon, clodinafop, pinoxaden, sulfosulfuron and pendimethalin and a check plot was left unweeded. The experiment was laid out in randomized block design with three replications. Wheat variety '*HD 2967*' was sown with a seeding rate of 100 kg/ha. Recommended fertilizer dose of 125- 62.5-30 kg NPK per hectare was applied during study period and irrigations were applied according to the requirement of the crop. The data on weed growth, yield performance were recorded. Economic analysis was also carried out on the basis of Benefit-cost ratio.

RESULTS

P. minor is the common narrow leaved weed found during the experimental study. All the herbicides treatments have significant affect on the weed population. Among the five herbicides treatments, the lower weed density was observed under the pinoxaden herbicide (2.6/m^2) which was statistically at par with clodinafop (2.7/m^2), sulfosulfuron (3.4/m^2) and isoproturon herbicides (4.1/m^2). The results were significantly differs from the pendimethalin (7.6/m^2) and unweeded check plot (9.5/m^2). Ali *et al.* (2004) also find the similar results. Similarly the numbers of effective tillers/m^2 were also more under pinoxaden (354.6/m^2), clodinafop (353.2/m^2), sulfosulfuron (356.6/m^2) and isoproturon (352.7/m^2) herbicides but significantly differ from the pendimethalin (334.9/m^2) and unweeded check plot (3256/m^2). However all the treatment failed to produce any significant effect on the performance of plant height, ear length, number of grains per ear and 1000 grain weight.

Table 1. Weed growth, yield and economics of wheat crop as influenced by different herbicides

Treatment	No. of weeds/m^2	Plant height (cm)	No. of Effective Tillers/m^2	1000 grain wt. (g)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (Rs)	Benefit: Cost Ratio
Isoproturon at 1250g/ha	4.1	96.2	352.7	42.6	4.28	7.03	24270	1.56:1
Clodinafop at 400g/ha	2.7	93.5	353.2	41.9	4.60	7.58	24545	1.72:1
Pinoxaden at 1 litre/ha	2.6	95.0	354.6	43.2	4.69	7.50	25146	1.70:1
Sulfosulfuron at 32.5g/ha	3.4	95.4	356.6	42.4	4.58	7.45	24519	1.71:1
Pendimethalin at 2.5 L/ha	7.6	94.5	334.9	43.0	4.07	7.09	24675	1.39:1
Unweeded check	9.5	96.5	325.6	42.2	3.92	6.74	23630	1.41:1
LSD (p=0.05)	1.6	NS	12.4	NS	0.24	0.45	-	-

Among different herbicides treatment the higher grain yield was recorded with application of the pinoxaden (4.69 t/ha) which was 19.6% higher over the control treatment. The grain yield with clodinafop (4.6 t/ha), sulfosulfuron herbicide (4.58 t/ha) also recorded at par with pinoxaden herbicide but significantly higher as compared to isoproturon (4.28 t/ha), pendimethalin (4.07 t/ha) and unweeded check plot (3.92 t/ha). The results are in conformity with the findings of Mueen-ud-Din *et al*. (2011). As we consider the B:C ratio, it was found maximum in clodinafop followed by sulfosulfuron and pinoxaden herbicide and lower B:C ratio found in unweeded check and by applying pendimethalin herbicide.

CONCLUSION

It was concluded that the herbicide pinoxaden, clodinafop and sulfosulfuron produced the higher grain yield and found most effective for controlling *P. minor* weed in wheat crop in the south western district of Punjab.

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Chemical weed management in spring-planted sunflower

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Sunflower (*Helianthus annuus* L.) is one of the edible oilseed crops making rapid strides in the oilseeds scenario of the Indian subcontinent due to its wide adaptability to different agro-ecological niches and cropping systems. Sunflower is a poor competitor with weeds on an account of its slower initial growth and lower planting densities providing enough spatio-temporal opportunities for weeds to establish, compete and cause significant yield losses. Selective application of herbicides to weeds at an early stage in crop growth is an important aspect of site-specific management, both economically and environmentally. Herbicide options have expanded in the recent past, but there is dire need to explore weed management strategies *vis-a-vis* quantified yield losses in sunflower to find out convenient and practically feasible alternative options to use herbicides alone or in combination with hand weedings.

METHODOLOGY

The experiment was conducted during *spring* seasons of 2009 and 2010 on well drained typic ustipsamment at PAU, Ludhiana in the Indo-Gangetic alluvial plains in the state of Punjab, northwestern India. The study comprised 11 treatments (Table 1) involving combination(s) of hand weedings with pre-emergence application of oxydiargyl and alachlor allocated in randomized block design with three replications. The sunflower hybrid '*PSH 569*' was hand dibbled in the first fortnight of February and was fertilized with 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha based on state recommendations. Species-wise weed seedlings and their dry weight at 45-50 DAS was counted and the data on weed population was subjected to square root transformation prior to statistical analysis.

RESULTS

On an average, broad-leaved weeds constitute about 39% of the total weeds infestation followed by sedges (34%) and grassy (27%) weeds. Herbicide based weed management either alone or in combination with hand weeding (4 WAS) drastically reduced the weeds population and their dry weight in comparison to weedy check (Table 1). Season long competitional stress with weeds reduced the mean seed yield of sunflower by 43.5%. Highest seed yield of 2.65 t/ha was recorded with two hand weedings done 3 and 6 WAS indicating 76.8% yield superiority over the unweeded control. Among herbicides, yield improvement to the tune of 5.5-12.5% was observed with weed management through either of the pre-emergence herbicide (oxydiargyl/alachlor) applied alone when compared with recommended herbicide application of pendimethalin at 0.75 kg/ha. Beneficial effect of integrated approach for better weed control and higher crop yields have been reported by Sheoran *et al.* (2012).

Table 1. Weed dynamics and dry weight in relation to weed management practices in sunflower (pooled mean)

Treatment	Weeds parameters at 45-50 DAS			Seed yield (t/ha)	Net returns (INR, x10³/ha)	B:C ratio
	Density (no./m²)	Dry weight (g/m²)	WCE (%)			
Two HWs; 3 and 6 WAS	1.00 (0.0)	-	100.0	2.65	40.7	3.39
Pendimethalin (Stomp 30 EC) at 0.75 kg/ha, PE	5.39 (28.7)	20.5	73.3	2.29	34.3	3.20
Oxydiargyl (Raft 6 EC) at 0.1 kg/ha, PE	4.24 (17.1)	15.2	80.2	2.46	37.6	3.35
Oxydiargyl (Raft 6 EC) at 0.1 kg/ha, PE + 1 HW 4 WAS	2.34 (4.5)	3.3	95.7	2.56	38.6	3.24
Oxydiargyl (Raft 6 EC) at 0.15 kg/ha, PE	4.22 (16.3)	12.9	83.2	2.48	37.3	3.23
Oxydiargyl (Raft 6 EC) at 0.15 kg/ha, PE + 1 HW 4 WAS	2.32 (4.50)	3.8	95.1	2.56	37.8	3.10
Oxydiargyl (Raft 6 EC) at 0.175 kg/ha, PE	3.94 (14.5)	14.1	81.6	2.41	35.5	3.07
Alachlor (Lasso 50 EC) at 1.5 kg/ha, PE	4.02 (15.1)	13.8	82.0	2.55	39.7	3.49
Alachlor (Lasso 50 EC) at 1.5 kg/ha, PE + 1 HW 4 WAS	2.22 (4.00)	4.9	93.6	2.63	40.2	3.33
Alachlor (Lasso 50 EC) at 2.0 kg/ha, PE	3.78 (13.3)	11.5	85.0	2.57	39.6	3.41
Weedy check	8.99 (80.0)	76.7	-	1.50	39.9	3.25
LSD (P=0.05)	4.70	4.91		0.09		

Figure in parentheses indicate the actual values WAS: weeks after sowing; DAS-days after sowing; WCE: Weed control efficiency; PE: Pre-emergence application 1 DAS

CONCLUSION

Sole application of herbicides either through alachlor 1.5 kg/ha or oxydiargyl 0.1 kg/ha was found to be the practically feasible and economically best alternative strategy for reducing weed infestation and achieving better yields under semi-arid irrigated conditions in sunflower growing areas of India and similar environments.

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Wed management in sesame with post-emergence herbicides

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Sesame [*Sesamum indicum* (L.)] popularly known as Til, Tilli, Gingelly etc. is important oilseed crop and belongs to the family *Pedaliaceae*. The area under the crop in India is about 1901 thousand hectares and total production is 810 thousand tonnes. In M.P. total cultivated area and production of sesame are 295 thousand hectares and 155 thousand tones, respectively. Average yield in India and Madhya Pradesh is 426 and 525 kg/ha, respectively. Severe weed competition is one of the major constraints in lower productivity of sesame. Though the conventional methods of weed control, *viz*. hand weedings, hand hoeing etc. are very much effective but due to high wages and non-availability of labourers during the critical weeding season (15-30 DAS) and incessant protracted rains, use of herbicides and their combination with cultural practices could be more time saving, economical and efficient to check early crop-weed competition.

METHODOLOGY

The present experiment was conducted at the Research Farm, College of Agriculture, Gwalior during the *Kharif* season of 2013-14 under the edaphic and climatic conditions of Gwalior (M.P.). The topography of the field was uniform with proper drainage. The soil of the experimental field was sandy clay loam in texture. The experiment was conducted in randomized block design with 3 replications and 7 treatments. The treatments of weed control include propaquizafop 10% EC (PoE) at 50 g/ha (T_1), propaquizafop 10% EC (PoE) at 62.5 g/ha (T_2), propaquizafop 10% EC (PoE) at 100 g/ha (T_3), quizalofop-p-ethyl 5% EC (PoE) at 50 g/ha (T_4), fenoxaprop-p-ethyl 9% EC (PoE) at 100 g/ha (T_5),two hand weedings at 20 and 40 DAS (T_6) and control/weedy check (T_7). The sesame crop variety *'TKG-22'* was sown on 01-07-2013 and was grown with all recommended practices except weed control measures which were applied as per treatments undertaken for investigation. The nutrients were applied at the rate of 60 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha.

RESULTS

The weed control practices significantly affected the yield and yield attributes in sesame crop. The highest plant height, number of branches/plant, number of leaves/plant, number of capsules/plant, grains/capsule, plant dry weight (g), 1,000 grain weight (g), grain yield/plant (g), grain yield (t/ha), stalk yield (t/ha) and harvest index (%) observed in treatment two hand weedings at 20 and 40 DAS, followed by propaquizafop at 50 g/ha (Kushwah and Vyas 2005). The highest weed control efficiency (95.50%) was recorded in treatment Two hand weedings at 20 and 40 DAS. The next effective treatment was propaquizafop at 100 g/ha (73.03%). This may be attributed to better control of weeds under various treatments under investigation which might had provided comparatively stress free environment to crop. All the weed control treatments gave higher income over control/weedy check. The highest net return and B:C ratio were obtained under treatment Two hand weedings at 20 and 40 DAS, followed by treatments propaquizafop at 50 g/ha, while lowest B:C ratio with control/weedy check. Under all weed control treatments B:C ratio were found low due to abnormal weather conditions in crop growth and maturity period (Vijayalaxmi *et al.* 2012).

Table 2. Effect of weed control practices on weed control efficiency, grain yield, stalk yield, harvest index, net income and B:C Ratio of sesame

Treatment	Weed control efficiency (%)	Grain yield (t/ha)	Stalk yield (t/ha)	Harvest index (%)	Net income (/ha)	B:C Ratio
Propaquizafop 10% EC (PoE) at 50 g /ha	68.3	0.51	2.58	16.6	36988.97	2.76
Propaquizafop 10% EC (PoE) at 62.5 g /ha	70.6	0.43	2.36	15.6	28034.06	2.32
Propaquizafop 10% EC (PoE) at 100 g /ha	73.0	0.41	2.27	15.4	25048.29	2.14
Quizalofop-p-ethyl 5% EC (PoE) at 50 g /ha	64.0	0.50	2.52	16.5	34761.79	2.61
Fenoxaprop-p-ethyl 9% EC (PoE) at 100 g /ha	72.1	0.40	2.25	15.3	24194.6	2.10
Two hand weedings at 20 and 40 DAS	95.5	0.67	2.94	18.6	48703.32	2.81
Control/Weedy check	-	0.20	1.86	10.0	4060.36	1.21
LSD (P=0.05)	-	0.04	0.17	0.87	-	-

CONCLUSION

On the basis of above findings, it may be concluded that treatment two hand weedings at 20 and 40 DAS, followed by treatment propaquizafop 10% EC (PoE) at 50 g/ha are most effective and remunerative weed control practices for controlling the weeds in sesame under sandy clay loam soils of Northern M.P. The higher grain yield and net return were obtained from treatment two hand weedings at 20 and 40 DAS.

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Efficacy of post-emergence herbicides for weed control in wheat

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Wheat is widely grown winter cereal and is the backbone of food security in India. It is grown in about 28.52 million hectares area in the country with the production of 80.71 million tonnes. In Madhya Pradesh, it is grown in 3.96 million hectares area with the production of 58.96 lac tonnes but the productivity is quite low *i.e.* 1.85 t/ha (Agri. statistics, 2009). Many factors affect the yield of wheat but weed infestation is one of the most serious causes of low yield of irrigated wheat due to severe competition between weeds and crop plants for moisture, nutrients, light and space. Therefore, essential to control weeds in order to get higher yields of wheat.

METHODOLOGY

The present experiment was conducted under the edaphic and climatic conditions of Jabalpur (M.P.). The topography of the field was uniform with proper drainage. The soil of the experimental field was clayey in texture. The experiment was conducted in randomized block design with 4 replications and 9 treatments. The treatments of weed control include clodinafop-p-propargyl 60 g/ha and 120 g/ha (T_1 and T_2), metsufuron 4 g/ha (T_3), sulfosulfuron 25 g/ha (T_4), metribuzin 150 g/ha (T_5), pyroxasulfone 150 g/ha (T_6), pyroxasulfone + pendimenthalin 50 + 910 g/ha (T_7), one hand weeding (T_8) and weedy check (T_9). The wheat crop variety '*GW-273*' was sown on 17-12-2009 and was grown with all recommended practices except weed control measures which were applied as per treatments undertaken for investigation.

RESULTS

The post emergence combined application of pyroxafulfone 50g + Pendimethalin 910 g/ha gave better activity against broad and narrow leaved weeds could be assigned the reason for lower density and dry weight of both the weeds. However, the hand weeding excelled to all the herbicidal treatments in reducing the density and dry weight of all the weeds due to complete elimination of weeds from the wheat field (Kumar *et al.* 2007). The herbicides were found most effective in reducing weed growth. Higher weed control efficiency was observed in under combined application of pyroxasulfone 50g + pendimethalin 910 g/ha (62.29%). However, the hand weeded plots had the maximum weed control efficiency and proved better to all the herbicidal treatments in eliminating all the weeds during critical period of crop weed competition in irrigated wheat (30-43 DAS) (Yadav *et al.* 2009). The grain yield was minimum under weedy check plots due to maximum density of weed flora but was increased in the higher under combined application of pyroxasulfone 50 g + pendimethalin 910 g/ha due to better control of all weed flora.

Table 1. Effect of weed control practices on species-wise weed population, weed dry weight, WCE and grain yield of wheat

Treatment	Species-wise weed population			Dry weight (g/m^2)			WCE	Grain yield
	P. minor	*M. hispida*	*T.fragiferum*	*P. minor*	*M. hispida*	*T .fragiferum*	(%)	(t/ha)
T_1- Clodinafop propargyl 60 g/ha	3.63	6.87	6.98	3.96	5.29	4.77	20.0	4.52
	(12.7)	(46.7)	(48.2)	(15.2)	(27.4)	(22.2)		
T_2- Clodinafop propargyl 120 g/ha	3.08	6.34	6.47	3.54	4.74	4.52	45.7	5.01
	(9.00)	(39.7)	(41.5)	(12.0)	(22.0)	(19.3)		
T_3- Metsulfuron 4 g/ ha	7.71	3.31	3.44	4.77	3. 76	3.24	43.4	4.72
	(59.0)	(10.5)	(11.5)	(22.2)	(13.6)	(10.0)		
T_4- Sulfosulfuron 25 g/ha	3.31	6.55	7.09	3.54	5.47	4.72	22.2	4.84
	(10.5)	(42.5)	49.7)	(12.0)	(29.4)	(21.7)		
T_5- Metribuzin 150 g/ ha	3.84	4.21	4.11	4.06	3.73	3.17	51.9	4.42
	(14.2)	(17.2)	(16.5)	(16.0)	(13.4)	(9.58)		
T_6- Pyroxasulfone 150 g/ha	4.11	7.03	7.11	4.18	5.37	4.53	19.5	4.35
	(16.5)	(49.0)	(50.0)	(17.0)	(28.3)	(20.0)		
T_7- Pyroxasulfone + Pendimethalin	2.78	2.11	2.22	3.23	3.54	3.01	62.2	5.14
50 + 910 g/ha	(7.25)	(4.00)	(4.50)	(10.0)	(12.0)	(8.58)		
T_8- Hand weding 30 DAS	2.17	1.79	1.70	2.99	2.88	2.72	71.3	5.21
	(4.25)	(2.75)	(2.50)	(8.50)	(7.83)	(6.95)		
T_9- Weedy check	8.18	7.73	8.09	5.48	5.83	4.83	-	3.82
	(66.5)	(59.2)	(65.0)	(29.5)	(28.3)	(22.8)		
LSD (P=0.05)	0.36	0.30	0.49	0.19	0.27	0.20	-	0.01

CONCLUSION

Treatment hand weeding at 30 DAS recorded significantly higher grain yield and WCE, followed by PoE application of treatment pyroxasulfone + pendimethalin 50 + 910 g/ha, which were statistically at par for the above traits.

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Weed management in transplanted rice

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Rice (*Oryza sativa* L.) is the predominant crop of Odisha with a total coverage of 4.0 million hectare. Area under rice crop in Angul district of the state is 0.084 million hectare with a production of 0.17million tones. In India rice is grown over 42.4 million ha area with the production of 104.4 million tons and a productivity of 2.46 t/ha. The weed flora of rice under transplanted condition is very much diverse and constists of sedges, grasses and broad leaf weeds causing yield reduction up to 76%. Herbicides like pretilachlor applied alone is more effective against grasses, but less effective against sedges. While bensulfuron methyl is found more effective against sedges than other weeds. Hence, the present investigation was under taken to study the effect of weed management practices on weed growth, yield and economics in *Kharif* transplanted rice.

METHODOLOGY

A field trial was conducted during *Kharif* season of 2014 in farmer's field in Ragudiapada village of Angul district in Odisha to study the effect of weed management practices on weed growth, yield and economics in *Kharif* transplanted rice. Four treatments consisting bensulfuron methyl 60 g/ha + pretilachlor 600 g/ha at 3 DAT, bispyribac-Na 25 g/ha at 20 DAT, farmers practices (2 hand weedings at 20 and 40 DAT) and unweded check were arranged in randomised block design with ten replications. The soil of the experimental site was sandy loam in texture with slightly acidic in reaction (pH - 5.9), medium organic carbon (0.61%) , nitrogen (290.5 kg/ha), potassium(190.2 kg/ha) and low in phosphorus (10.1 kg/ha) content. Rice variety '*Pooja*' was transplanted in the experimental field with recommended package of practices. Data on weed growth, yield performance and economics were recorded. The data were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05.

RESULTS

The floristic composition in weed flora of the study area was dominated with grasses *i.e. Digitaria sanguinalis, Cynodon dactylon;* broad leaved weeds *i.e. Cleome viscosa, Ageratum conyzoides* and sedges *i.e. Cyperus rotundus*. At 60 DAT, grasses, broadleaved and sedges on an average constituted 36.7, 53.9 and 9.4% of total weed population respectively. Unweeded control recorded (Table 1) significantly the higher weed density (48.61/m^2) and weed dry weight (152.45 g/m^2) at 60 DAT where as the maximum WCE (78.44%) was registered under hand weedings twice. Among the herbicidal treatments, bensulfuron methyl 60 g/ha + pretilachlor 600 g/ha recorded the lower weed density (11.2/ m^2) , weed dry weight (35.5 g/m^2) with WCE (76.7%) which was at par with bispyribac-Na 25 g/ha.

Table1. Weed growth, yield and economics of rice as influenced by different weed management practices

Treatment	Weed density (no./m^2)	Weed dry weight (g /m^2)	Weed control efficiency (%)	Grain yield (t/ha)	Straw yield (t/ ha)	Net Return (x10^3 Rs/ ha)	B:C Ratio
Farmers practice (2 hand weeding at 20 & 40 DAT)	3.12(9.76)*	5.73(32.8)*	78.44	5.27	5.87	34.22	1.82
Bensulfuron methyl 60g/ha + Pretilachlor 600 g /ha at 3 DAT	3.35(11.2)	6.0(35.5)	76.7	5.19	5.34	35.99	1.90
Bispyribac-Na 25g/ ha at 20 DAT	3.67(13.4)	6.44(41.4)	72.8	4.73	5.43	29.29	1.72
Unweeded check	6.97(48.6)	12.5(152.4)	-	3.55	3.68	14.17	1.38
LSD(P=0.05)	0.25	0.33	-	0.27	0.49	3437.12	0.09

*Values in parentheses are original, Data transformed to square root

The highest grain yield (5.27 t/ha) and straw yield (5.87 t/ ha) was obtained under hand weedings twice and at par with bensulfuron methyl + pretilachlor. Application of bensulfuron methyl + pretilachlor recorded the highest net return (x10^3 Rs.35.99/ha) and B:C ratio (1.90) due to higher grain and straw yield with lower cost of cultivation over hand weeding . These results were in conformity with findings of Teja *et al.* (2015).

CONCLUSION

Thus, pre-emergence application of bensulfuron methyl 60 g/ha + pretilachlor 600 g/ha at 3 DAT appeared to be effective, economically viable for weed control, crop growth, higher seed yield and net profit.

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Integrated weed management in sunflower

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Sunflower is one of the important oilseed crop of India because of its high yielding ability, wider adoptability and drought tolerance. It can be grown in all the seasons. Global average yield is of about 1.49 t/ha. However productivity of sunflower in India is much less (0.791 t/ha) compared to other countries. Weeds compete with the crop for soil moisture, nutrients, light and space. Heavy weed infestation reduced the yield of sunflower by 62% (Sumathi *et al*. 2009). The conventional method of weed control is laborious, inefficient and costly. Hence, neither herbicides nor cultivations are adequate for consistent and acceptable weed control. Therefore integrated weed management is the best for higher productivity, using pre and post-emergence herbicides in combination with hand weeding or inter-cultivation with implements.

METHODOLOGY

A field experiment was conducted to study the "Integration of pre and post-emergence herbicides and cultural practices for weed management in sunflower (*Helianthus annuus* L.)"during *Kharif* 2014 at All India Co-ordinated Research Project on sunflower, Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru-560 065. Field experiment was designed using RCBD consisting of 9 weed management treatments with three replications. The soil of the experimental plot was red sandy loam. The sunflower hybrid '*KBSH-53'* was fertilized with 90:90:60 N, P_2O_5, K_2O kg/ha through urea, single super phosphate and murate of potash respectively.

RESULTS

Treatment that received Pendimethalin 1 kg/ha PE + Quizalofop-ethyl 37.5 g/ha POE recorded (Table1) significantly higher seed and oil yield (1.79 t/ha and 0.67 t/ha, respectively) which was found to be on par with weed free (1.82 and 0.697.4 t/ha, respectively) and farmers practice (1.88 and 0.72 t/ha, respectively). These treatments were also recorded lower total weed dry weight at harvest (10.00, 7.39, 5.51 g/m^2, respectively), weed index (4.89, 0.00 and -3.38%, respectively) and higher weed control efficiency (93.5, 95.2 and 96.4%, respectively) (Legha *et al.*1992). Though highest net return (35,099 Rs./ha) was recorded in farmers practice, highest marginal return to marginal cost (10.75) and B: C ratio (2.73) were recorded in pendimethalin 1 kg/ha PE + Quizalofop-ethyl 37.5 g/ha POE.

Table 1. Weed dry weight, seed yield and economics of sunflower crop as influenced by weed control treatments

Treatment	Seed yield (t/ha)	Oil yield (t/ha)	Total weed dry weight at harvest g/m^2	Weed control efficiency (%)	Weed index	Net return (Rs./ha)	Marginal return/ marginal cost	B:C ratio
Pendimethalin at 0.75 kg /ha as PE	1.39	0.52	1.76 (56.4)*	62.0	25.9	23139	9.38	2.23
Pendimethalin at 0.75 kg /ha as PE + one IC at 30DAS *fb* HW at 40 DAS	1.65	0.62	1.14 (11.8)	92.1	12.4	28839	2.63	2.39
Pendimethalin at 1 kg /ha as PE + Quizalofop-ethyl 10 EC at 37.5 g /ha as POE	1.79	0.67	1.07 (10.0)	93.5	4.89	34157	10.75	2.73
Pendimethalin at 1 kg/ha as PE +Propaquizapof at 62 g/ha as POE	1.57	0.59	1.51 (30.6)	85.8	16.5	27059	6.39	2.34
Pendimethalin at 1 kg /ha as PE +Fenoxoprof ethyl at 37.5 g /ha as POE	1.47	0.55	1.57 (35.7)	70.0	21.7	24529	5.98	2.24
Quizalofop-ethyl at 37.5 g /ha + Chlorimuron ethyl at 9 g/ha as POE	1.26	0.47	1.80 (62.2)	59.6	33.1	18658	4.52	1.98
Farmers practice (two IC at 20 and 40 DAS + one HW at 30 DAS)	1.88	0.72	0.83 (5.51)	96.4	-3.38	35099	4.33	2.63
Weed free (three HW at 15, 30 and 45 DAS)	1.82	0.69	0.97 (7.39)	95.2	0.0	32178	3.01	2.43
Unweeded control	1.02	0.38	2.19(153.7)	0.00	46.0	13079	-	1.75
LSD (P=0.05)	0.22	0.08	0.20	NA	NA	6060	4.38	0.31

*Values in parentheses are original, *Data transformed to log(X+2), DAS: Days after sowing, HW: Hand weeding, PE: Pre-emergence, POE: Post emergence, NA: Not attended

CONCLUSION

Pendimethalin 1 kg/ha PE + Quizalofop-ethyl 37.5 g/ha POE is the most efficient weed management practice for obtaining higher productivity and profitability in sunflower.

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Theme 14

Alien invasive weeds and their management

Characterisation of soils of fallow lands invaded by *Prosopis juliflora* in Tamil Nadu

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Prosopis juliflora is a major dominating invasive weed species in India and having capacity to suppress the native species which results serious environmental and social costs (Goslee *et al.* 2003). The *Prosopis juliflora* is a heavy feeder which requires about 1000 kg of water to produce one kg of dry wood. Most of the fallow lands in Tamil Nadu were heavily infested with *Prosopis juliflora* which resulted fertile lands become unproductive barren lands. Identification and characterisation of lands invaded by *Prosopis juliflora* helps to arrest the further expansion and also to suggest alternate land use option .In this context, the present study was aimed to delineate and characterise the fallow lands infested with *Prosopis juliflora* using remote sensing techniques.

METHODOLOGY

The study area is Sivagangai and Kalayarkoil block of Sivagangai district. Multidate (three season) Resourcesat-2 LISS IV data of 2011-13 of the study area were used for delineation and mapping. Toposheets, forest survey of India maps and soil map of Tamil Nadu (NBSS&LUP) were used for reference. A tentative fallow land map invaded by *Prosopsis* was prepared by online visual interpretation and finalized after ground truth. The soil and site characteristics were recorded and Soil samples were collected from representative profiles for laboratory characterization. Organic carbon, the soil reaction (1:2.5 soil water suspension), electrical conductivity and CEC were determined by standard procedures. The results of morphological and physic-chemical properties were evaluated for different alternate land use in the study area.

RESULTS

Resourcesat-2 LISS IV data was interpreted and the fallow lands invaded by *Prosopis juliflora* were delineated. *Prosopsis* cover have dark red colour, brownish red colour and dark pink tone in the standard false colour composite images depending on its date of acquisition since *Prosopis juliflora* remained evergreen throughout the year. The morphological and physiochemical characteristics are presented in Table.1. Melapoongudi soils are very deep, dark yellowish brown, somewhat poorly drained, non-calcareous, clayey soils. The organic carbon content ranges from 0.26 to 0.15%. The EC is less than 1dS/m. In contrast to Melapoongudi soils, Nalukottai soils are moderately deep, dark greyish brown, poorly drained, strongly calcareous, very strongly alkaline, sodic soils with clayey texture. The organic carbon content ranges from 0.29-0.56%. The pH is more than 9.0, EC is ranged from 1.8-3.5ds/m and ESP is more than 15. Kilathari Soils are very deep, greyish brown, poorly drained, calcareous, very strongly alkaline, sodic, clayey soils. Calcium carbonate nodules increase with depth. The organic carbon in surface soil is 0.44 and sub-surface soil is 0.38 %. The pH is more than 9.0, EC is more than 1.4-1.7 ds/m and ESP is more than 15. Nalukottai and Kilathari soils are mostly under fallow and heavily infested by Prosopis whereas part of Melapoongudi soils was cultivated with paddy and sugarcane.Morphological and physiochemical properties of soils of *Prosopis* infested areas are evaluated for alternate land use as per Naidu *et al.* (2006).

Table 1. Soil physio-chemical characteristics of fallow lands invaded by *Prosopis juliflora*

Location	Depth (m)	Drainage	pH		EC (ds/m)		OC (%)		ESP		CEC (c mol p+ /kg)		Free CaCO3 (%)	
			S	SS	S	SS	S	SS	S	SS	S	SS	S	SS
Melapoongudi	>150	Imperfectly drained	7.4	7.63	0.14	0.14	0.26	0.15	3.5	3.5	26.8	27.9	-	-
Nalukottai	75-100	Poorly drained	9.5	9.7	1.8	3.5	0.56	0.29	20.4	23.0	13.7	23.3	2.4	7.7
Kilathari	100-150	Poorly drained	9.3	9.4	1.4	1.7	0.44	0.38	22.0	23.9	26.1	27.4	1.3	1.8

S- surface; SS-sub-surface; EC-electrical conductivity; OC-Organic carbon, ESP- Exchangeable sodium percentage; sc-sandy clay, scl- sandy clay loam

CONCLUSION

Remote sensing technologies can be effectively used for delineation of *Prosopis juliflora* invaded fallow lands. Results of physio-chemical properties showed that the soils are affected by high sodium saturation leads to severe alkalinity. High pH and ESP in studied soils are unsuitable for cultivation of most of the field crops results in increasing fallows and further invasion of *Prosopsis*. The state government should take necessary steps to arrest the invasion of *Prosopis* in fallow lands and promote cultivation of different salt tolerant crops with suitable land reclamation measures.

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Assessment of weed flora in Raipur district of Chhattisgarh

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Import of food grains had always been the entry of alien weed species as evidenced in case of *Parthenium hysterophorus; Eichhornia crassipes, etc*. In recent past also, Government of India has imported 6288890 metric tons of wheat during 2006-07 from 11 countries and this wheat has been distributed in Chattisgarh also along with other 10 states through public distribution system. Along with this wheat, seeds of 5 weeds are of alien nature, namely, *Ambrosia trifida, Cenchrus tribuloides, Cyanoglossum officinale, Solanum carolinence and Viola arvensis* have also entered in our country. With this view a surveillance programme had been initiated in 2008, so that, identification of 5 new suspected entries of alien weeds be done timely and strategies be evolved to control these weeds at the initial period of spread in the state.

METHODOLOGY

Initially, a grid map of Raipur district was prepared to conduct an effective survey of weed flora of *kharif*, and *rabi*seasons in the district. 10 blocks and 497 villages (300 villages in *khari*f and 197 villages in *Rabi*) were covered during 2008-10. Fields of three farmers from each village were chosen for study. With each farmer, his cropped and non-cropped area was considered for conducting the survey. At each point of survey, for taking weed observation through quadrate method, quadrate of 0.5 m (0.25 sq.m.) was used. Total number of all types of weed species occurring in each quadrate was recorded. The weed species uprooted during the observation were dried at room temperature initially and finally were dried in the oven and dry weight was recorded accordingly for each species of weeds. Accordingly, density of weed per sq.m; dominance, frequency %, relative density, relative dominance, relative frequency and IVI were calculated.

RESULTS

In Raipur district, the major crops in the area during *Khari*f was rice and vegetables and during *Rabi*, the main crops in the district were vegetables, wheat, gram, orchard crops and flower. Type of crop and soil properties has greatest influence on the occurrence of weed species (Andreasen *et al*. 1991). In *Kharif* season, a total number of 55 weed species in Rice and 26 weed species in vegetable and 10 in rice-fallow were identified and in *Rabi* season a total number of 13 weed species in Gram, 11 weed species in Orchard, 8 weed species in Flower, 34 weed species in Wheat, 41 weed species in each Vegetables and Rice-fallow were identified during the survey in cropped area of Raipur district.

Echinochloa colona registered with highest density (10.17), dominance (10.48), frequency (40.59), relative density (23.21), relative frequency (12.91), relative dominance (0.31) and IVI (36.43) among the 55 weed species in the rice crop of Raipur district during survey. However, ecological parameters of weed *Mimosa pudica* were found to be lowest amongst the 55 weed species in the rice crop of Raipur district during survey. Three dominant weed species with highest IVI in different crops of Raipur district during Kharif 08-10 are as follows:-

Cropped Area	3 Dominant Weeds
Rice	*Echinocloa colona; Cynodon dactylon; Cyperus iria*
Vegetables	*Amaranhus viridis; Parthenium hysterophorus; Echinocloa colona*
Rice-fallow	*Allternanthara sessilis; Cynodon dactylon; Parthenium hysterophorus*

Cynodon dactylon registered with highest density (120.471), dominance (79.51), frequency (125.22), relative density (29.93), relative frequency (15.85), relative dominance (0.36) and IVI (46.15) among the 41 weed species in vegetable during *Rabi* season. However, ecological parameters of weed *Cyperus irria* and *Elephantopus scaber* were found to be lowest amongst the 41 weed species in the vegetable crop of Raipur district during survey.

A total number of 67 weed species during *Kharif* season and 71 weed species during *Rabi* season were identified during the survey in non-cropped area of Raipur district,. Three dominant weed species with highest IVI in non-cropped area of Raipur district during *Kharif*'08-10 are *Alternanthera sessilis; Cassia tora; Parthenium hysterophorus* and during *Rabi* 08-10 are *Alternanthera sessilis; Cynodon dactylon; Euphorbia geniculata.* On the contrary, *Merremia emarginata* during *Kharif* had the lowest different ecological parameters of weed.

CONCLUSION

Echinochloa colona and *Alternanthera sessilis* recorded as major weed in rice crop and non-cropped area of Raipur district of Chattisgarh, respectively.

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Andreasen JC, Streibig JC and Hass H. 1991. Soil properties affecting the distribution of 37 weed species in Danish fields. *Weed Research* **31**: 181-187.

Major weed flora in Durg district of Chhattisgarh

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In recent past, Government of India has imported 6288890 metric tons of wheat during 2006-07 from 11 countries and this wheat has been distributed in Chhattisgarh along with other 10 states through public distribution system. Along with this wheat, seeds of 5 weeds of alien nature , namely, *Ambrosia trifida, Cenchrus tribuloides, Cyanoglossum officinale, Solanum carolinence and Viola arvensis* have also entered in our country. There is serious threat to native flora from exotic invasive weeds and urges the scientific community to take steps for their control and eradication (Rao and Kavitha 2012). With this view a surveillance programme had been initiated in 2008 for identification of 5 new suspected alien weeds and strategies to control these weeds at the initial period of spread in the state.

METHODOLOGY

Initially, a grid map of Durg district was prepared to conduct an effective survey of weed flora of *Kharif,* and *Rabi* seasons in the district. 12 blocks and 421 villages (213 villages in *Khari*f and 208 villages in *Rabi* seasons) were covered during 2008-10. Fields of 3 farmers from each village were chosen for study. With each farmer, his cropped and non-cropped area was considered for conducting the survey. At each point of survey, for taking weed observation through quadrate method, quadrate of 0.5 m (0.25 sq.m.) was used. The weed species uprooted during the observation were dried at room temperature initially and finally were dried in the oven and dry weight was recorded accordingly for each species of weeds. Accordingly, density of weed per sq.m.; dominance, frequency %, relative density, relative dominance, relative frequency and IVI were calculated.

RESULTS

In Durg district, the major crops in the area during *khari*f was rice, vegetables, Soybean, Orchard and Sugarcane and during *Rabi*, the main crops in the district were Rice, Gram , wild pea, linseed, wheat, Rice-fallow and Vegetables. Critical period of crop weed-competition has been identified as 20-30 DAS in upland capable to reduce the yield production by 47 to 92 % (Bhadoria *et al.* 2000). A total number of 37 weed species in Rice, 53 weed species in vegetables, 22 weed species in soybean, 5 weed species in Orchard and 4 weed species in sugarcane were identified in kharif season and in *rabi* season a total number of 21 weed species in rice, 10 weed species in gram, 12 weed species in wild pea, 05 weed species in linseed, 17 weed species in wheat, 30 weed species in Rice-fallow fields and 25 weed species in vegetables were identified during the survey in cropped area of Durg district. *Cynodon dactylon* registered with highest density (7.04), dominance (4.65), frequency (36.50), relative density (11.43), relative frequency (8.70), relative dominance (0.10) and IVI (20.22) among the 53 weed species in vegetable. 3 dominant weed species with highest IVI in different crops of Durg district during *Kharif*'08-10 are as follows:

Cropped Area	Three Dominant Weeds
Rice	*Echinocloa colona; Cyperus rotundus; Cynodon dactylon*
Vegetables	*Cynodon dactylon; Cyperus rotundus;Parthenium hysterophorus*
Soybean	*Echinocloa colona; Commelina bengalensis; Cynodon dactylon*
Orchard	*Alternanthra sesslis; Cynodon dactylon; Parthenium hysterophorus*
Sugarcane	*Euphorbia hirta; Echinocloa colona; Parthenium hysterophorus*

Three dominant weed species with highest IVI in vegetable crops of Durg district during *Rabi*'08-10 are *Cynodon dactylon; Amaranthus viridis* and *Alternanthera sessilis.* A total of 56 weed species during *Kharif* and 44 weed species during *Rabi* seasons were identified in non-cropped area of Durg district. *Alternanthera sessilis* during *Kharif* and *Rabi* seasons registered highest density/m^2, frequency, relative density, relative frequency and IVI. On the contrary, *Phaseolus trilobus* during *Kharif* and *Spheranthus spp* during *Rabi,* had the lowest different ecological parameters of weed.

CONCLUSION

Cynodon dactylon recorded as major weed in vegetables cropped area and *Alternanthera sessilis* in non-cropped area of Durg district of Chattisgarh.

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Important weed flora in Jagdalpur district of Chhattisgarh

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Indian government has imported 6.2 millon metric ton of wheat during 2006-07 from 11 countries and this wheat has been distributed to 10 states including Chhatisgarh through public distribution system. This imported wheat played a major role in entry of 5 alien weeds in India, namely, *Ambrosia trifida, Cenchrus tribuloides, Cyanoglossum officinale, Solanum carolinence and Viola arvensi.* Initial control of these alien weeds is of utmost importance to avoid their epidemic spread as has happened in case of *Parthenium hysterophorus.* With this view a surveillance programme had been initiated in 2008, so that, identification of 5 new suspected entries of alien weeds be done timely and strategies be evolved to control these weeds at the initial period of spread in the state.

METHODOLOGY

In Jagdalpur district, during *Kharif* season, total 367 villages of 12 blocks, during rabi 6 blocks and 142 villages were surveyed in the year 2008-10. Fields of 3 farmers per village were chosen for study. With each farmer, his cropped and non-cropped and Garbage area were considered for conducting the survey. At each point of survey, for taking weed observation through quadrate method, quadrate of 0.5 m was used. Accordingly, density of weed per sq.m.; dominance, frequency%, relative density, relative dominance, relative frequency and IVI were calculated.

RESULTS

In Jagdalpur district, during *kharif* total number of 27 weed species in Vegetable, 22 weed species in Sugarcane, and 50 weed species in Rice, during *Rabi* season, 27 weed species in rice,15 weed species in gram, 29 weed species in vegetable, and 30 weed species in rice-fallow were identified during the survey in cropped area. The infestation of weeds is significantly influenced by cropping pattern, weed control measures, moisture availability period and environmental factors (Saavendra *et al.* 1980). *Cyperus rotundus* registered with highest density, dominance, frequency, relative density, relative frequency, relative dominance and IVI among the 50 weed species in rice. However, ecological parameters of weed *urochloa platiginea* were found to be lowest amongst the 50 weed species in the rice crop during survey in *Kharif*. In *Rabi Cynodon dactylon* registered with highest density, dominance, frequency, relative density, relative frequency, relative dominance and IVI among the 30 weed species in rice-fallow. However, ecological parameters of weed *Phyllanthus amarus* were found to be lowest amongst the 30 weed species in the rice-fallow field of Jagdalpur district during survey. A total number of 60 weed species during *Kharif* season and 52 weed species during *Rabi* season were identified during the survey in non-cropped area of Jagdalpur district. *Cassia tora* during *Kharif* and *Cynodon dactylon* during *Rabi* registered highest density/m^2, frequency, relative density, relative frequency and IVI. On the contrary, *Centella asiatica* during *Kharif* and *Argimone mexicana* during *Rabi,* had the lowest different ecological parameters of weed in the Jagdalpur district during the survey. Three dominant weed species with highest IVI in different crops of Jagdalpur district during *kharif* and *Rabi* seasons in different areas are as follows:

Cropped Area	Three Dominant Weeds
Kharif	
Vegetable	*Cynodon dactylon; Euphorbia geniculata; Cyperus rotundus*
Sugarcane	*Paspalum conjugatum; Commelina benghalensis;Portulaca oleracea*
Rice	*Cyperus rotundus ; Cynodon dactylon; Echinocloa colona*
Rabi	
Rice	*Ageratum conyzoides; Commelina benghalensis; Cyperus rotundus*
Gram	*Leucas aspera; Melilotus alba; Medicago denticulata*
Vegetable	*Cynodon dactylon; Chloris barbata; Cyperus rotundus*
Rice-fallow	*Commelina bangalensis ; Ageratum conyzoides; Cyperus rotundus*
Non-Cropped Area	
Kharif	*Cassia tora; Lantana camara; Cynodon dactylon*
Rabi	*Cynodon dactylon; Lantana camara; Chloris barbata*

CONCLUSION

Cyperus rotundus registered as major weed in rice crop during *kharif*. *Cassia tora* during *kharif* and *Cynodon dactylon* during *Rabi in non-cropped area* of Jagdalpur district of Chattisgarh.

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Major weed flora in Mahasamund district of Chhattisgarh

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Import of food grains had always been the entry of alien weed species as evidenced in case of *Parthenium hysterophorus; Eichhornia crassipes, etc*.. In recent past also, government of India has imported 6.2 million metric ton of wheat during 2006-07 from 11 countries and this wheat has been distributed in Chattisgarh also along with other 9 states through public distribution system. Along with this wheat, seeds of 5 weeds are of alien nature, namely, *Ambrosia trifida, Cenchrus tribuloides, Cyanoglossum officinale, Solanum carolinence and Viola arvensis* have also entered in our country. Initial control of these alien weeds is of utmost importance to avoid their epidemic spread as has happened in case of *Parthenium hysterophorus*. With this view a surveillance programme had been initiated in 2008, so that, identification of 5 new suspected entries of alien weeds be done timely and strategies be evolved to control these weeds at the initial period of spread in the state.

METHODOLOGY

Initially, a grid map of Mahasamund district was prepared to conduct an effective survey of weed flora of *kharif*, and *Rabi* seasons in the district. Four blocks and 241 villages (174 villages in *kharif* season and 67 villages in *Rabi* season) were covered during 2008-10. Fields of 3 farmers from each village were chosen for study. With each farmer, his cropped and non-cropped area was considered for conducting the survey. At each point of survey, for taking weed observation through quadrate method, quadrate of 0.5 m (0.25 sq.m.) was used. Accordingly, density of weed per sq.m.; dominance, frequency %, relative density, relative dominance, relative frequency and IVI were calculated.

RESULTS

In Mahasamund district, the major crops in the area during *kharif* was rice and rice-fallow and during *Rabi*, the main crops in the district were wheat, gram, vegetables and rice-fallow. Type of crop and soil properties has greatest influence on the occurrence of weed species (Andreasen *et al*., 1991). In *Kharif* season, a total number of 37 weed species in Rice and 5 weed species in rice-fallow were identified and in *rabi* season a total number of 15 weed species in wheat, 14 weed species in gram, 24 weed species in vegetable and 39 weed species in Rice-fallow fields were identified during the survey in cropped area of Mahasamund district. *Cyperus rotundus* registered with highest density (6.57), dominance (5.32), frequency (42.92), relative density (4.06), relative frequency (12.95), relative dominance (0.17) and IVI (24.30) among the 37 weed species in rice. However, ecological parameters of weed *Phyllanthus amarus* (IVI 0.08) were found to be lowest among the 37 weed species in the rice crop of Mahasamund district during survey. Three dominant weed species with highest IVI in different crops of Mahasamund district during *kharif* are as follows:-

Cropped Area	Three Dominant Weeds
Rice	*Cyperus rotundus; Echinocloa colona; Commelina benghalensis*;
Rice-fallow	*Portulaca oleraceae; Argemone maxicana; Imperata cylindrica*

Cynodon dactylon registered with highest density, dominance, frequency, relative density, relative frequency, relative dominance and IVI among the 39 weed species in rice-fallow fields. However, ecological parameters of weeds *Argemone maxicana and Chenopodium album* were found to be lowest among the 39 weed species in the rice-fallow fields of Mahasamund district during the survey.A total number of 39 weed species during *Kharif* season and 42 weed species during *Rabi* season were identified during the survey in non-cropped area of Mahasamund district. *Cassia tora* during *Kharif* and *Amaranthus viridis* during *Rabi* registered highest density/m^2, frequency, relative density, relative frequency and IVI. On the contrary, *Corchorus olitorius* during *Kharif* and *Datura metel* during *Rabi,* had the lowest different ecological parameters of weed in the Mahasamund district.

CONCLUSION

In cropped area *Cyperus rotundus* registered as major weed in rice crop, during kharif. In non-cropped area *Cassia tora* during *Kharif* and *Amaranthus viridis* during *Rabi* identified as major weeds of Mahasamund district of Chattisgarh.

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Andreasen JC, Streibig JC and Hass H. 1991. Soil properties affecting the distribution of 37 weed species in Danish fields. *Weed Research* **31**: 181-187.

Environmental weeds in Telangana: Utilization as Management Approach

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Environmental weeds are those unwanted species which enter and invade the natural ecosystems and threaten the nature conservation. An attempt is made here to enlist the environmental weeds for Telangana district-wise to prioritize them for their control and management. Of the several management options, the utilization of weeds globally has been patchy over the past five decades (Kim and Shin, 2012). An attempt is made here to adopt utilization approach to control these environmental weeds.

METHODOLOGY

To gather the phytosociological data, line transects and quadrats were laid. The most problematic weeds (first three) are identified for terrestrial, aquatic and semi-aquatic ecosystems of Telangana. The weed species were identified based on standard Floras and efloras and the nomenclature is updated. The local people were enquired about the utility of these weeds and documented them for further exploitation as a control measure.

RESULTS

The present study helps to prioritize the list of environmental weeds for developing a governmental policy for their control and management in natural environments. The study looked at the utilization of these environmental weeds for soil and water conservation, manure, food/fodder, medicinal plants, phytoremediation, pesticides, etc. In terrestrial ecosystems, *Hyptis suaveolens* (Lamiaceae) is the worst environmental weed in all districts in the extent of its spread and occupation (Table 1). In Hyderabad, Rangareddy and Mahaboobnagar districts, *Lantana × aculeata* (Verbenaceae) is second to none. *Parthenium hysterophorus* (Asteraceae) is conspicuous in the margins of forest (ecotones) and open lands where the species of *Senna* (*S. uniflora, S. occidentalis, S. oblongifolia*, etc. Fabaceae) are abundant though seasonally. *Chromolaena odorata* (Asteraceae) is emerging as the greatest threat in Khammam district while it entered and fast-spreading into Eturnagaram wildlife sanctuary (Warangal district). The problematic and pernicious weed in aquatic systems is *Eichhornia crassipes* (Pontideriacee) which is now closely competed neck-to-neck by *Alternanthera philoxeroides* (Amaranthaceae). The third in position is occupied by *Pistia stratiotes* (Araceae). *Ipomoea carnea* ssp. *fistulosa* (Convolvulaceae) and *Typha* spp. (Typhaceae) are highly competitive and congest the standing waters in shallow canals and, streams and ponds/ tanks.

CONCLUSION

Ten environmental weeds of concern to the natural habitats of Telangana are identified and assigned ranking as per the negative-threat status. These are largely herbs (60%), a few are undershrubs (30%) and one tree (10%). The chemical and biological methods are used to control and manage these weeds had their positive (success) and negative (failure) stories. The utilization these weeds by the local people is documented for analysis and recommendation based on their merits. These ten environmental weeds are found to be used as medicines and manure (compost), food and fodder (alligator weed), fuel (species of *Chromolaena*, *Lantana*, *Prosopis*), fencing of huts (shoots of *Chromaolaena*, *Hyptis*, *Ipomoea* and *Prosopis*), biopesticide (*Impomoea carnea* ssp. *fistulosa*) and phytoremediation (Alligator weed, cattail) and bioenergy (*Lantana*). Apart from these uses, these environmental weeds are reportedly used for extraction of pulp, production of biogas, etc. elsewhere which can be tried locally.

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Parthenium: a noxious and rapidly spreading weed of India

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Parthenium hysterophorus commonly known as congress grass is an annual herbaceous weed which has spread like a wild fire in almost every state of India. *Parthenium* introduced first with milo grain in India and was first noticed in Pune in1955 (Rao, 1956). In India it has spread in about 35 million hectares of land (Sushil kumar 2014). It is a weed of national significance because of its invasiveness, potential for spread and economic and environmental impacts. Its large and persistent soil seed bank, fast germination rate and ability to undergo dormancy make it well adapted to semi-arid environments. The concept of 'One year seeding, seven years weeding' is true for *Parthenium* as it produces about 5000-10000 seeds per plant, which are viable even at immature stage. In dry summer months parthenium appears in a rosette form while, during rainy season it grows up to 90 cm height, with profuse flowering and green foliage. It flowers throughout the year. Earlier parthenium was restricted to only in fallow and waste land but now it has also spread in cultivable land. Till 1990' its impact was not known on crops but now it has major cause for loss of crop production not only in rainy season but also in *Rabi* season. At present it is one of the most troublesome and obnoxious weed of wasteland, forest, pasture, agricultural land and cause nuisance to mankind. Chemically parthenin is the toxic substance present in the weed is the causative factor for many problems in humans namely contact dermatitis, skin irritation, nausea, giddiness and respiratory problems like bronchitis and asthma, eye irritation and sinusitis. It also causes acute toxicity in cattle and milk becomes bitter in taste due to the presence of parthenin. If it is present in animal diet it causes dermatitis with pronounced skin lesions and a significant amount (10–50%) of *P. hysterophorus* in the diet can kill cattle and buffalo (Veena and Maurya, 2012). In India, *P. hysterophorus* causes a yield decline up to 40% in agricultural crops and due to the invasive capacity and allelopathic effects, it inhibits the germination and growth of plants. Control of parthenium has been tried by various methods but no single management option would be adequate to manage the parthenium hence, there is a need to integrate various management options. Mannual uprooting of parthenium before flowering and seed setting is the most effective but it is not cost effective due to its continuous germination in field. In infested cultivated land, normal crop can be rotated with marigold during rains. Exploitation of allelopathy and competition through cultivation of competitive plant species such as *Cassia sericea, Abutilon indicum and Cassia tora* in non cropped area pre occupied by parthenium has shown encouraging results. Another important aspect of parthenium management is its use in beneficial way in crop production and other men made activities. Attempts should be made to use parthenium for biopesticides, biogas generation and green manuring. Parthenium plants before flowering stage can be a good option to be used as mulch especially in dryland areas. Recent researchers have identified several potential herbicides for control of parthenium in cropped and non cropped situations. Timing of chemical weed control is critical and these should be applied when the plants are small and have not produced seeds. In non-cropped areas, application of 2,4-D esters 1.0-1.5 kg/ha along with wetting agent, glyphosate 1.0-1.5 kg/ha before flowering stage can effectively control this weed. Whereas, in cropped areas, pre-emergence herbicides such as atrazine can be used in maize, sorghum and sugarcane (0.5-1.5 kg/ha), pendimethalin in almost all cereals, pulses and oilseeds (0.75-1.5 kg/ha) and metribuzin in soybean, potato and sugarcane (0.5-1.0 kg/ha) are the most suitable selective herbicides for its control. *Zygogramma bicolorata,* a leaf eating beetle is a potential bio control agent which controls *Parthenium* weed by feeding on the foliage. Recently a rust pathogen *Puccinnia abrupta var. parthenicola* was identified, which is also capable of controlling this weed. Some other insects which can be used against this weed are *Bucculatrixparthenica* (leaf-mining moth), *Smicronyx lutulentus* (seed-feeding weevil) and *Listronotus setosipennis* (Robert 2011). Mass awareness about these weeds among all the section of people of society is a need of today. Government should also take initiatives of parthenium eradication awareness programmes at mass scale to acquaint the public about its horrible effect on mankind, animals, biodiversity and crop production. Keeping in view the high reproductive potential and survival ability of parthenium possible integration of various methods including biological based management options should be taken into consideration for its viable solution.

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Parthenium: a weed of national significance and its biological control

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In India, *P. hysterophorus* causes a yield decline of up to 40% in agricultural crops and Due to the invasive capacity and allopathic effects of allelochemicals, phenolics and sesquiterpene lactones, mainly parthenin, it inhibits the germination and growth of plants including pasture grasses, cereals, vegetables and other plant species (Veena *et al.* 2012). Biological control is an environmentally sound and effective means of reducing or mitigating pests and pest effects through the use of natural enemies. In the last three to four decades, a great deal of emphasis has been given to control parthenium through various bio control agents like microbial pathogens, insects, and botanicals. Of the various bio control strategies, biological control of weeds by insect and plant pathogen has gained acceptance as a practical, safe, and environmentally beneficial method applicable to agro ecosystem.Two types of bacteria namely *Ralstonia solanacearum* and *Xanthomanas campestris* were found attacking Parthenium. These type of bacteria generally infest seeds through roots and in a survey done in Mexico, Argentina, Trinidad and Cuba during 1983-84 and 1995-97 by the scientists of International Institute of Biological control (IIBC), about 26 species of fungi were recorded on Parthenium out of which rust *Puccinia abrupta variety parthenicola*, and *P. melampodi* to be suitable for biological control purpose. Based on the success in Australia, three insects namely defoliating beetle *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae), the flower feeding weevil *Smicronyx lutulentus* Dietz (Coleoptera: Curculionidiae) and the stem boring moth *Epiblema strenuana* (Walker) (Lepidoptera: Tortricidae) were imported in India in 1983 to 1985. Both the adults and larvae of *Zygogramma bicolorata* feed on leaves. The early stage larvae feed on the terminal and auxiliary buds and move on to the leaf blades as they grow. The fully-grown larvae enter the soil and pupate. An insect density of one adult per plant caused skeletonization of leaves within 4–8 weeks but little success has been achieved as the weed has very high generative potential, and moreover the insect is not a species specific and is found to attack sunflower in India. Saxena and Kumar, 2010 worked on the myco herbicidal potential of *Alternaria alternata* ITCC (LC # 508) in northern India to control parthenium weed and reported 50% damage of plants in vitro detached leaf and whole plant bioassay at 96 hours after treatment at a concentration of 1×10^6 spores/mL. Although, the pathogen is responsible for severe damage to the weed, but the wide host range of the species creates doubt about its suitability as mycoherbicides. *Cercospora parthenophilia* a leaf spot pathogen isolated from parthenium at Kurukshetra, has shown several characteristics that make it a potential biological control agent of this weed in India such as wide natural distribution; *Cladosporium sp.* ('MCPL-461'), a floral leaf pathogen of parthenium, produces symptoms on the flowers, buds, and inflorescences, and causes sterility and reduces seed viability. The severity of pathogen to the reproductive organs led to serious damages of the parthenium plants and may be used as a potential mycoherbicide against this weed (Kumar 2009).

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Phytotoxic effects of *Chenopodium ambrosioides* and its exploitation as a bioherbicide in sustainable weed management

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Chenopodium ambrosioides L. (Mexican tea or wormseed) has been found as an invasive weed throughout the world (Duke *et al.* 2002). Leaves constitute bulk of the plant, therefore, contribute more towards phytotoxic effects in the soil medium. A study,therefore, was designed to assess phytotoxicity of *C. ambrosioides* leaves (mulch) and its potential utilization to control harmful weeds.

METHODOLOGY

Aqueous extracts (at 0.5–4%; w/v) of *C. ambrosioides* leaves were used to assess the phytotoxic effects towards seed germination and seedling growth of *Oryza sativa* and *Echinochloa crus-galli* under laboratory conditions. Under natural conditions, leaf powder of *C. ambrosioides* was used as mulch at 75, 150, 300 and 600 g in plot (1 × 1.5 m^2) so as to have treatments 0.5, 1, 2 and 4 t/ha, respectively. These plots were sown with seeds of *O. sativa*. For each concentration, total 5 plots were prepared and maintained under experimental dome conditions for four months.Four months after treatment, number of weeds emerged, their types and biomass was determined in each treatment plot. Further, in the end of September, *O. sativa* plants were harvested and their height, yield and biomass were also determined.

RESULTS

Under laboratory conditions, leaf extracts of *C. ambrosioides* severely inhibited seed germination and early seedling growth of *E. crus-galli*. In general, a dose response effect was observed where inhibition increased linearly with increase in concentration. In, *O. sativa*, inhibition was observed in response to highest concentration only. Further, inhibition was more in roots compared to shoots particularly in *E. crus-galli*.Under experimental dome conditions, application of different doses of leaf mulch of *C. ambrosioides* significantly inhibited weed density as well as biomass accumulation (Table1).

The weed density suppressed by up to 95% in *O. sativa* plots treated with 2 t/ha mulch. In these plots, mostly grassy weeds were found and their size was also very small. In response to highest dose of leaf mulch (4 t/ha), the plots were seen to be totally free from any weed and weed density was inhibited by 100%. The dry biomass of weeds also decreased markedly with increasing doses of leaf mulch of *C. ambrosioides*. It decreased in the range of 48–97% over control. Further, application of lower doses of leaf mulch of *C. ambrosioides* enhanced the growth and yield of *O. sativa* whereas at higher concentrations, an inhibition was observed. The growth inhibitory effects of leaf mulch towards weed growth may be attributed to the presence of water soluble phenolics.

Table1. Effect of leaf mulch of *C. ambrosioides* on weed composition, density and dry weight.

Conc. (ton/ha)	Weed density (per/m^2)	Major weeds	Weed dry weight (g)
0.5	104.43 ± 7.63 b	*Phyllanthusniruri* L., *Oxalis corniculata* L., *Amaranthusgracilis* Desf., *Cyperus rotundus* L., *Echinochloa crus-galli* (L.) P. Beauv.	113.10 ± 9.10 b
1	41.47 ± 3.58 c	*Cyperus rotundus* L., *Echinochloa crus-galli* (L.) P. Beauv.	30.77 ± 4.04 c
2	9.54 ±1.57 d	*Oxalis corniculata* L., *Cocciniaindica*Wight &Arn.	6.85 ± 0.92 d
4	0.00 ± 0.00 d	None	0.00 ± 0.00 d
0 (Control)	185.26 ± 10.66 a	*Phyllanthusniruri* L., *Launaeanudicaulis* (L.) Hook.f, *Euphorbia hirta*L. *Mazusrugosus*Lour. (mazus), *Vernoniacinerea*(L.)Less, *Cyperus rotundus* L., *Echinochloa crus-galli* (L.) P. Beauv.	217.33 ± 10.78 a

CONCLUSION

Leaf extracts of *C. ambrosioides* are highly phytotoxic towards test plants. Leaf mulch especially at 2 and 4 t/ha holds a good promise for controlling *E. crus-galli* and other weeds in rice fields under natural conditions. Such studies hold significance as a huge amount of herbicide is required to control the weeds which deteriorate soil quality also.

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Parthenium problem and management in India: current status and prospects

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Parthenium hysterophorus L., globally known as feverfew, ragweed or Parthenium is a weed of world significance. This paper present the available information on its distribution and spread in India, its menace in different agro-ecosystems, and its management with various prevalent methods.

Biological attributes responsible for *Parthenium* dominance: Plant completes its one generation within 15 to 18 weeks and may complete 4 to 5 overlapping generations in a year depending on the climatic conditions of the area (Sushilkumar and Varshney, 2007). The plant has unique characteristics of achieving 'rosette form' in want of water which may grow normally on availability of water to produce seeds.

Spread and infestation of *Parthenium* in India: India has become one of the most *Parthenium* affected countries in the world as now this weed is occurring in all of her states and presenting a major problem in many those states) that have large areas of non-cropped and pastures rain-fed land. *Parthenium* occurs throughout the country in about 35 million hectares of land (Sushilkumar and Varshney, 2010).

Impact of *Parthenium* in crop, orchards, pasture and forest ecosystems and human and animal health: The harmful effects of Parthenium have been reported world over in different ecosystems with different intensity (Adkins and Shabbir, 2014. Now it has become a serious problem on grass availability in pastures land. Earlier, it was not considered a weed of orchards and forests but now it has spread rapidly in these areas too (Sushilkumar 2012). In India this weed has been considered as one of the greatest source of dermatitis, asthma, nasal-dermal and naso-bronchial types of diseases.

Manual, mechanical and cultural management: Cultural managementmethod may be applicable in crop ecosystem. It has been observed that in some crop fields, *Parthenium* grows profusely. To reduce the seed bank in such crop field, some fast growing crop species of fodders like barseem and sorghum can be taken to suppress *Parthenium* and its seed bank in the field.

Chemical management: In wasteland situation, if grasses are to be saved and *Parthenium* is to be killed, metribuzin (0.3 to 0.5%) should be used. 2,4-D (1 to 1.5 kg/ha) and metribuzin (0.3 to 0.5%) can safely be used in crops of grass family like sorghum, sugarcane, wheat, rice etc. Now farmers are coming forward to manage *Parthenum* in various crops by herbicides.

Biological management: Biological control has been considered most effective approach against *Parthenium* in waste land, pasture, orchards and forest ecosystems by releasing of bioagent *Zygogramma bicoloraa.* Among botanicals, *Cassia serecia* and *C. tora* are used to suppress *Parthenium* along the road side and waste land (Sushilkumar 2009).

Parthenium management through its utilization: Compost and vermi-compost making from *Parthenium* may be one of the most economical and practical methods for farmers. Study done at Directorate of Weed Research showed that compost prepared by mixing *Parthenium* with dung slurry, soil and urea in layers in at least 90 cm deep pit in anaerobic conditions could kill the *Parthenium* seeds and compost quality was superior than the farm yard manure.

Prospects of *Parthenium* management: Biological control by *Z. bicolorata* has been found most effective among all the methods, therefore, immediate attention is required to import other effective bioagents on the line of Australia where nine insect and two fungus species were imported and released. To overcome Parthenium menace at national level, integrated management involving people participation is must. Involvement of all ICAR institutes, SAUs, KVKs and State Agricultural Departments under ATMA. Involvement of labours under 'MNREGA' scheme of Govt. of India should be implemented in every village with formation of "*Parthenium* Management Committee" for uprooting of *Parthenium* during wet season and making compost out of it, and spot treatment of chemicals during non-wet season and encouraging people's participation with the mandate to create "*Parthenium* Free Village.

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SEAMEO BIOTROP data base development on invasive alien plant species in Indonesia

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Regional center for Tropical Biology (SEAMEO BIOTROP) has been working on weeds since the beginning of their establishment in 1968. At present not only working on weeds that cause considerable agricultural losses, degrading catchments areas and fresh water ecosystem, but also invasive alien plant species which constitute one of the leading threats to natural ecosystem and biodiversity. The records on Invasive Alien Plant Species (IAPS) in Indonesia have fragmented in many publications, and there are very few comprehensive information on IAPS. There were 1736 alien plants recorded by Tjitrosoedirdjo (2005), among the total record 339 species were indicated as invasive. An interactive project on Indonesian IAPS database was developed in 2006-2007 (Tjitrosoedirdjo *et al.* 2007).This interactive database project aimed at collating, organizing and making available on the internet all published information on relevant aspect on the species, biology, ecology, origin, invaded habitat, distribution, control, references, etc. of Indonesian's IAPS in user friendly type. In 2008 there were 173 species of IAPS created in the database and appeared at the BIOTROP database website: http://www.biotrop.org. Revision and update of the data is being conducted in 2015, there are 158 species at the data base. It is expected that the revise version will be available at the BIOTROP website at the late 2015.

METHODOLOGY

Software of Microsoft SQL 2000 (My SQL 2000) is used for the data base. The field included : family, genus, species, synonym, common name, origin, invaded habitat, distribution, ecology, control, description, photograph/ illustration, distribution map, and references. Among the 173 species of the previous database, only 144 species are included and addition of 14 species are added at the revise version. All of the included species are being check for the data completeness for each of the field. In total there are 158 species included at the revise database.

RESULTS

There are 48 families included with 158 species at the revise version of the database. The highest number of species shown at the family Asteraceae (32 sp.), follow by Poaceae (31 sp.), Amranthaceae (8 sp.), Euphorbiaceae (7 sp.), 27 families represented only by one species and other families represented by 2, 3, 4 and 5 species (Table 1).

Table 1. List of families and their number of species

No.	Families	No. of species
1.	Asteraceae	32
2.	Poaceae	31
3.	Amaranthaeae	8
4.	Euphorbiaceae	7
5.	Convolvulaceae, Mimosaceae, Onagraceae	5
6.	Lamiaceae, Rubiaceae, Verbenaceae	4
7.	Cyperaceae, Oxalidaceae, Passifloraceae, Solanaceae	3
8.	Acanthaceae, Elatinaceae, Hydrocharitaceae, Malvaceae, Melastomataceae, Piperaceae, Scropulariaceae	2
9.	Mimosaceae, Araceae, Arecaceae, Asclepiadaceae, Bignoniaceae, Boraginaceae, Caecalpiniaceae, Capparaceae, Caryophyllaceae, Cecropiaceae, Cucurbitaceae, Gleicheniaceae, Haloragaceae, Lamiaceae, Limnocharitaceae, Lythraceae, Muntingiceae, Myrtaceae, Nyctaginaceae, Phytolacaceae, Polygalaceae, Pontederiaceae, Portulacaceae, Rhamnaceae, Salviniaceae, Sapindaceae, Turneraceae, Vitaceae	1
	Total	158

CONCLUSION

It is expected that the revise database of Indonesian weeds and IAPS will be available at the web-site of BIOTROP at the late 2015.

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Studies on the floristic composition of invasive alien weeds in Dhenkanal district of Odisha

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Invasive alien weeds have become a problem in every continent of the globe, causing a huge economic loss in agricultural sector, decline in species diversity; acute respiratory illness and encroachment to every type of ecosystem and the current status of IAWS indicate their spread in large area with ability to dominate the vast landmass in just a few years. The situation in United States is also no better and about 125-150 billion US Dollar is lost in each year due to foreign pests and weeds (McNeely *et al.* 2001). In the context of Odisha very less work was done and more extensive work was necessary to evaluate the diversity and effect of IAWS on agriculture in the state so that a comprehensive measure can be taken to eradicate the menace. In view of this the present investigation was undertaken to document and evaluate the diversity of Invasive Alien Weed Species in Dhenkanal district of Odisha.

METHODOLOGY

The study was conducted during 2013-14 to compile a comprehensive list of invasive alien weed species of the study area. Plant samples were collected and photographed from their natural habitat including agricultural field, water bodies, marshes, pathways and adjoining area of forest patches of the district and identified by referring "Flora of Orissa"(Saxena and Brahmam, 1994-96) and other available literatures. Collected plant specimens were processed to prepare herbaria by following the standard procedure (BSI) and were deposited in the Herbarium of P.G. Department of Botany, Utkal University, Bhubaneswar, Odisha. After an extensive review of literature, history, diversity and sources of exotic invasive weed species were analyzed.

RESULTS

From the study it was revealed that 107 species with 81 genera included under 34 different families were invasive alien weeds. Analysis of habit revealed that the herbs were dominant with 101 species (94.39%) followed by shrubs (5), and climbers (01). The dominant family was Asteraceae with 21 (19.23%) species followed by Amaranthaceae (08), Caesalpiniaceae (07), Convolvulaceae (07), Euphorbiaceae (06), Fabaceae (05), Poaceae (05), Solanaceae (05), Cleomaceae (04), Tiliaceae (04), Mimosaceae (03), Asclepiadaceae (02), Cyperaceae (02) and Lamiaceae (03). These families included most invasive weed species, such as *Chromolaena odorata*, *Lantana camara*, *Hyptis suaveolens*, *Ageratum conyzoides*, *Parthenium hysterophorus*, *Eichhornia crassipes*, *Alternanthera philoxeroides*, *Mikania micrantha* and others. The dominance of Asteraceae species among all invasive alien weeds found in this region was resulted due to higher potential of the species for adaptability and capacity for rapid growth.

The review of literature (Reddy *et al.* 2008)indicated that different native places of invasive alien weeds of Dhenkanal district were Tropical America (69), Tropical Africa (09), Tropical South America (07), Europe (03), Brazil (3), Tropical north America (3), West Indies (2), Mediterranean (2), Tropical Central South America (2), Tropical Central America (1), Tropical East Africa (1), Peru (1), Mascarene Islands (1), Mexico (1), Temperate South America (1), Madagascar (1),West Asia (1), Afghanistan (1) and Tropical West Asia (1).

CONCLUSION

The findings of the present study indicated that Dhenkanal district of Odisha is having a large number of IAWS in both forest area as well as in agricultural fields and if immediate steps are not taken, there will be huge biodiversity loss as well as loss in agricultural output.

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Prediction of potential distribution area of *Microstegium vimineum* in the United States based on Maxent Model

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Microstegium vimineum (Trin.) A. Camus (Poaceae), an annual C4 grass from south-eastern Asia, was introduced to the United States (U.S.) in the early 1900s and is spreading rapidly in the eastern U.S. which is currently invasive in more than 25 states (USDA and NRCS 2010). Its invasions create dense, mono specific stands that reduce the diversity and productivity of native woodland and herbaceous communities, inhibit forest regeneration, and threaten to alter forest species composition and successional trajectories. *M. vimineum* frequently invades moist areas such as bottomland hardwood forest, riparian areas, roadsides, and stream banks, but it is also commonly found on ridge tops and in wildlife openings, blow downs, and areas recently harvested for timber. Here, we apply MaxEnt model(Phillips *et al.* 2006),one of the most popular tools for species distribution and environmental niche modeling,to predict the potential distribution of *M. vimineum*, and to estimate the risk of introduction of *M. vimineum* to other uninvaded parts of the U. S. as well as offer some insights into the factors controlling the invasion.

METHODOLOGY

The occurrence locations of *M. Vimineum* obtained were based on relevant literature, herbarium specimens and the database (http://www.lifemapper.org/).The longitude and latitude of occurrence points were obtained by using the Geographic Names Database, and the geographical coordinates of collection localities were recorded using a Global Positioning System receive. Excluding the records that lack of the geographical coordinates or specimen information, or repeated ones, total of 815 occurrence records of *M. vimineum* in the world were collected. Seventy global environmental variables were used in our study, among them 68 global bioclimatic variables were downloaded from Worldclim (http://www.worldclim.org), representing bioclimatic variables, derived from monthly temperature and rainfall recorded worldwide. Based on altitude variable, aspect and slope variables were obtained by using the 3D analyst tools of ArcGis software. We used the 2-5 m database, which is approximately equal to 22 km^2 cells. Occurrence data of *M. vimineum* was divided into training data (75%) and test data (25%), and set the other parameters as default. The area under the curve (AUC) was used a measurement of the model prediction. The importance of each environmental variable in the model was evaluated using a jackknife test.

RESULTS

The predicted potential geographical distribution area of *M. vimineum* was more extensive than it had been found (Fig. 1). The natural breaks were used to reclassify the risk index of *M. vimineum* distribution in the U.S. and five scales were used, they are unsuitable area (0-0.07), low suitable area (0.08-0.19), margin suitable area (0.20-0.29), suitable area (0.30-0.41), and high risky area (0.42-0.64).

According to the statistical analysis of percentage of grades of every suitable area for *M. vimineum*, we found that the high risky area for *M. vimineum* occupied 2.34% of the total area of the U.S., suitable area occupied 7.32%, margin suitable area occupied 7.29%, low suitable area occupied 7.66% and unsuitable area occupied 75.39% (Table 2). Though the unsuitable area for *M. Vimineum* covered most regions of the U.S., *M. vimineum* has the great potential for an outbreak in the eastern U. S. as we predicted. Meanwhile, the potential suitable area for *M. vimineumin* in the U. S. was much larger than its current distribution. In this study, the AUC value for the training data was 0.967 and the AUC value for the test data was 0.968, indicating a high level of accuracy for the MaxEnt predictions. These results suggested that MaxEnt had a high predictive power. In the Jackknife procedure, annual mean temperature, mean temperature of driest quarter, mean temperature of coldest and warmest quarter, min temperature of November to March the next year, max and mean temperature of October to April the next year, precipitation of May to August had the higher gain when used in isolation. This indicated that these bioclimatic variables were the important environment variables influencing the distribution of *M. vimineum*. While the altitude, aspect and slope had less effect on the distribution of this species.

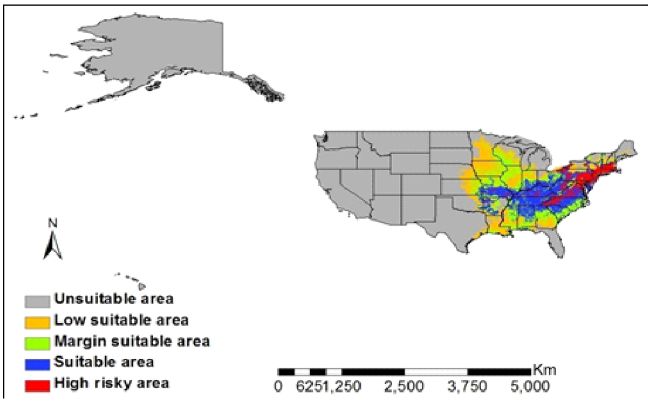

Fig.1. Prediction of potential distribution regions of *M. vimineum* in the U.S.

CONCLUSION

The modelling results showed that *M. vimineum* has the potential to invade more areas than its current distribution in the eastern U.S. and indicated the bioclimatic variables, such as air temperature and precipitation could be the main factors affecting the species' potential distribution.

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Impact of invasive alien weeds on native flora –A study from Mysore, Karnataka

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Problem of biological invasions has received considerable attention (Rao and Kavitha, 2012). While it is important to obtain baseline data on their correct taxonomic identification and distribution, it is also equally important to know the impact of invasive weeds on the local flora/native biodiversity in weed invaded and non-invaded areas. Many agriculture fields associated with many important medicinal flora were observed to be infested heavily with siam weed and congress grass, which prompted us to take up a detail investigation on the impact of the invasive species on the quantitative loss of medicinal and other native species in those localities.

METHODOLOGY

Total six ecologically and topographically similar sites were selected. Site-1 (Elachipalya near Chennapatna of Mysore district) experienced the infestation of Siam weed (*Chromolaena odorata* (L.) King & Robinson) and site-2 (foothills of Chamundi temple, Mysore) and site-3 (Shambhudevanapura near Malavalli, Mysore district) was heavily invaded by Congress grass (*Parthenium hysterophorus* L.). In each of these areas, 30 quadrates were laid by random quadrate method. All the plant species encountered were collected in flowering and fruiting conditions and herbarium specimens were prepared following the standard procedure. The vegetation data collected for abundance, frequency and density were calculated using the following ecological method of Curtis and Mclntosh (1950) with following formulae:

$$\text{Frequency (\%)} = \frac{\text{Total No. of quadrates in which the species occur}}{\text{Total number of quadrates studied}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates studied}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates in which the species occurred}}$$

RESULTS

From the results it was evident that in non infested sites, most of the native flora fall under A-D (Site 4), A (Site 5), A-D (Site 6) frequency classes, hence the vegetation of local flora was semi heterogeneous. In infested sites, the native flora fall under A, B, C, D, E, hence was flora was categories as heterogeneous. The impact of Siam weed and Congress grass on native flora is deleterious and both are the worst weeds as already recognized. Elimination of native flora is an indication that if these two invasive alien weeds are not eradicated / checked at the earliest, there is a fear of losing many of these plants of medicinal importance. Since Siam weed and Congress grass are resistant to plant diseases and pests and moreover seeds of these plants do not germinate at once rather in different time periods, they have established well in these study areas which might have made hard to control these weeds.

CONCLUSION

The present report is a result of a short study of one year, and in this short span most of the native plants at the end of one year was not seen in the test sites. If this is the severity of impact of siam weed and congress grass on native flora, then the situation may worsen in the next coming years. Hence it is suggested to carry out comprehensive studies to check the spread/ removal of these weeds, before a heavy loss of native flora is experienced.

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Theme 15

Herbicide tolerant crops: role and future in Asian-Pacific region

Alfalfa transgene dispersal and adventitious presence: understanding grower perception of risk

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Alfalfa (*Medicago sativa* subsp. *sativa* L), the world's most important forage crop, routinely ranks as in the top five crops in terms of economic value and total acreage in the United States (NASS 2014). In 2011, GR alfalfa received final approval for commercial production. GE low-lignin alfalfa is expected to be available to farmers in 2016. Feral alfalfa, both naturalized populations and field escapes, are commonly observed along roadsides, irrigation ditches, and unmanaged habitats in alfalfa growing regions. According to Bagavathiannan *et al*. (2009), characteristics such as perenniality, outcrossing, high genetic diversity, quick regrowth potential, symbiotic nitrogen fixation, deep tap root system, drought and cold tolerance, and seed dormancy and longevity allow for the establishment of alfalfa outside of fields, although it is not considered a weed. Alfalfa is a perennial, highly out-crossing crop, pollinated mainly by bees. Other potential sources of AP include seed admixture due to inadequate equipment cleaning and transgene pollen escape from GE hay fields. Industry has published best management practices (NAFA 2014) to support coexistence, but how well do hay and seed growers understand the risk and how prevalent are coexistence practices?

METHODOLOGY

The 2010 U.S. Agriculture Consensus was used to identify survey participants in three alfalfa seed production areas (Fresno Co., CA, Canyon Co., ID, and Walla Walla Co., respectively) in the Western U.S., growing over 25 acres of alfalfa (either hay or seed). This area coincided with the roadside survey of feral alfalfa plants conducted by Greene *et al.* (2015). A questionnaire was developed that focused on acreage, production practices, and perception of risk due to pollen and seed transgene flow, and mitigation practices (Fig. 1). Responses were tabulated and percent response calculated.

RESULTS

A total of 530 survey participants were identified; 167 from California, 289 from Idaho, and 74 from Washington. A total of 176 questionnaires were returned (33%). Twenty eight percent of hay growers grew GR hay. Average GR hay field size was 151 acres and ranged from 4 to 520 acres. Average field size for conventional alfalfa was 318 acres and field size ranged from 7 to 1500 acres. Most growers grew either conventional or GR hay, however 14% grew both. Only four producers grew GR seed. Average seed field size was 387 acres and ranged from 12 to 1700 acres. Only two producers grew both conventional and GR seed. Although it's been suggested that AP in conventional alfalfa hay and seed may be due to the presence of AP in planted seed, only 4% of respondents tested alfalfa seed for AP before planting it.

Seed escape can serve as an avenue for the establishment of transgenic feral plants. Seventy one percent of respondents planted alfalfa fields using a drill which suggested that seed escape due to planting is probably low. When asked how likely seed was to escape when moving planting equipment from shop to field or from field to field, 86% of respondents indicated escape was not likely or impossible. When asked about the likelihood of seed escaping from combines, 55% of respondents indicated it was not likely, 40% indicated it was likely and 5% indicated it was highly likely.

Sharing equipment and hiring operators may cause inadvertent admixture, if machinery is not thoroughly cleaned. Only 16% of respondents shared haying equipment with neighbors and 26% of respondents hired custom hay operators to plant and harvest fields. Fifteen percent of seed producers shared combines and 32% hired combine operators. However, equipment was cleaned between planting/harvesting GR and conventional fields. Only 8% of respondents indicated that they did not clean equipment. Pollen flow from GR hay fields into conventional seed fields may also be a reason why conventional seed may have AP. When asked when they generally cut hay, 54% indicated hay was cut at 10% bloom and 46% indicated pre- to mid-bud stage. However, 69% stated they delayed cutting due to weather or other reason, 1 to 5 times in the last 5 years. Twenty one percent delayed cutting greater than five times. Control of feral plants is an important coexistence strategy and 56% of respondents indicated they controlled feral plants, mainly on their own property.

CONCLUSION

GR feral alfalfa plants were detected in all three counties (Greene *et al*. 2015) four years after the 2007 injunction, suggesting the GR transgene has dispersed into non-agricultural areas, and that it can persist in the environment. Feral plants were not randomly distributed but spatially clustered in both seed and hay production areas. No environmental or climatic variable was strong enough to explain the occurrence of feral plants. However, our results showed that GR feral plants were more likely to be found in proximity to GR seed fields and roads leading to conditioning plants. Our survey suggested that producers may underestimate the risk of seed spillage. In areas where AP sensitive seed is produced, GR hay may be contributing to AP, since 54% of hay growers cut at 10% bloom, and most respondents indicated cutting was routinely delayed due to weather or other events. The results of our grower survey suggest that further efforts to educate growers about transgene flow risk, and the importance of mitigation strategies, including controlling feral alfalfa plants and testing for AP prior to planting may strengthen coexistence among alfalfa producers targeting GE and non-GE markets.

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Simple sequence repeat analysis of acetohydroxy acid synthase L1 locus reveals resistance to sulfonylurea and imidazolinone in *Helianthus* wild species

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Sunflower (*Helianthus annuus* L.) cultivars have very few herbicides for controlling broad leaved weeds. Identification of wild sunflower plants resistant to two classes of AHAS (Acetohydroxy acid synthase) inhibiting herbicides, namely, imidazolinone (IMI) and sulfonylurea (SU), paved way for the wide use of these herbicides for weed control in cultivated sunflower. The IMI resistance traits 'IMISUN' (contributed by *Ahasl1-1* allele) and CLPLus (*Ahasl1-3*) as well as the SU resistance trait, 'SURES' (*Ahasl1-2*) have, since then, been used for developing hybrids and lines for commercial cultivation and molecular markers like SSRs and SNPs within *AHASL1* gene have been effectively utilized for phenotyping commercial sunflower lines for the resistance trait. This study uses SSR markers to identify IMI and SU resistant accessions among wild *Helianthus* species and reaffirms the results phenotypically by spraying the plants with the herbicides.

METHODOLOGY

Fifty accessions of 21 wild *Helianthus* species and 29 CMS and R lines of commercial sunflower hybrids were tested for allelic variations at *AHASL1* SSR locus. An IMI resistant sunflower line, PI 617099 (*Ahasl1-1* type) was included as a reference. Using total genomic DNA as template, the microsatellite region was amplified by Polymerase Chain Reaction using Ahas16 (5'CCCCGTTTCGCATTACCCATCACT3') and Ahas17 (5'ACCAACACGTCTGCGCCTTTTCTC3') primer pair. According to Bulos *et al*. (2013), this primer pair would amplify a 186 bp fragment in the wild type plants and in plants with *Ahasl1-3* allele (CLPLus) while it would amplify a 177 bp fragment (9 bp deletion) and 195 bp fragment (9 bp addition) in *Ahasl1-1* (IMISUN) and *Ahasl1-2* (SURES) alleles, respectively. The recommended field dose (1X) of IMI herbicide of imazethapyr class and SU herbicides belonging to the classes, ethoxysulfuron, pyrazosulfuron ethyl and sulfosulfuron were used for spraying.

RESULTS

Allelic variation was found between species as well as between accessions within the same species in wild *Helianthus*. Accessions showing distinct size variation, namely, MAX07, MAX11, MAX1631, MAX2010, MAX30, MAX33001, NUT05, NUT1517, PRA1823 and parental lines, CMS7-1A, RHA6D-1, ARM243A and E00292A along with PI 617099 were sequenced. When none of the wild species showed *Ahasl1-1* type allele with 9 bp deletion as that of PI 917099, E00292A and ARM243A sequences were similar to it. All *H. maximiliani* accessions except MAX11 showed a 12 bp deletion while MAX11 and NUT1517 showed a 3 bp deletion. NUT05 had a deletion of 15 bp and PRA1823 had a 3 bp addition at the SSR locus. PI 617099 plants were completely resistant to IMI spray in the field, but the parental lines having similar sequence were found susceptible. All *H. maximiliani* accessions were sensitive to IMI spray. NUT05 showed more resistance to IMI spray compared to the wild type and remained healthy even after 18 days of spraying. The *H. praecox* accession PRA1823 was completely resistant to all three classes of SU herbicides but got wilted easily on IMI application.

CONCLUSION

The new allele found in PRA1823 with a 3 bp addition at the *Ahasl1* SSR locus gave complete resistance to SU based herbicides and the 15 bp deletion found in NUT05 imparted partial resistance to IMI herbicide. These sources of herbicide resistance identified from wild *Helianthus* species can be utilized in breeding programmes for imparting herbicide resistance in cultivated sunflower.

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Prospects and avenues of genetically-modified herbicidal tolerant crops in India

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Despite significant achievements in food grain production since independence, Indian agriculture continues to face serious challenges from ever increasing population. Our population is still going uphill at an enormous rate necessitating tremendously increased production of food grains in coming years. As per the available estimates, India's population will reach 1.7 billion in the year 2050 AD, requiring about 70% increase in food grains production, besides other food commodities. Also by 2020 AD, India would need about 300 million tonnes of food grains to feed for basic food security (Anonymous 2012). Crop pests (insects, diseases, weeds *etc.*) cause losses about 18% in crop production which at current price is equivalent to Rs. 1,60,000/-cores annually. Weeds as per the available estimates cause up to one-third of the total losses in yield, besides impairing produce quality and various kinds of health and environmental hazards. Weed control through manual/mechanical methods though very effective, has certain limitations such as unavailability of labour during peak crop growth periods, high labour cost and unfavourable environment, particularly in rainy seasons *etc*. Biological weed control although is considered environmental friendly and less expensive but this method is slow, often less effective and cannot be used in all situations. Hence, herbicidal weed management remains the only most reliable and economically viable method for keeping the weeds below threshold levels. The development of safe, effective and relatively inexpensive herbicides coupled with advances in application technology have provided many successful weed management options in crop production. Herbicide consumption in India is about 67054 mt mainly used in food grain crops (Bhattacharyya *et al***.** 2009). Despite several advantages, many concerns similar to, food safety, ground water and atmospheric contamination, increased weed resistance to herbicides are to be taken care of. Imparting herbicide resistance to normally applied herbicides insusceptible crops to produce herbicide resistant crops has been the most extensively exploited area of plant biotechnology that has a great potential for shifting selectivity pendulum in favour of crops rather than weeds.

Genetic modification of crop genotype to tolerate higher or lethal doses of an herbicide shall be handy to make us increase the dose that shall kill the hardy weeds in a crop-weed situation. Genetic modification involves altering an organism's DNA. This can be done by altering an existing section of DNA, or by adding a new gene altogether *i.e.* by inserting a foreign gene in the plants own genes. This might be a gene from a bacterium resistant to pesticide or from similar other sources. The result is that the plant receives the characteristics held within the genetic code. Consequently, the genetically modified plant also becomes able to withstand pesticides. Genetically engineered crops for developing resistance to existing non-selective herbicides may be a more economically viable option for agro- chemical industries than the huge costs associated with the discovery, development and commercialization of new herbicides (Reddy 2001). Herbicide resistance in crops can also be achieved by; altering the target site of action so that the herbicide no longer binds to the site or over expressing a target enzyme so that the effect of the herbicides is overcome and detoxifying the herbicide so that it is no longer a lethal to the plant. A record of 17.3 million farmers in 28 countries, planted 170.3 m ha in 2012, a sustained increases 6% or 10.3 m ha over 2011 (James 2012). Most genetically modified cultivation in the world is under herbicide-tolerant crops; herbicide-tolerant soybean occupies nearly 81 m ha of the total biotech crops, biotech maize, which is also herbicide-tolerant, is at 50 m ha and herbicide-tolerant canola at 21m ha (Anonymous 2012).

CONCLUSION

The technology of genetic engineering has been deployed to create herbicide-tolerant GM crops, which will allow farmers to spray herbicides, usually of the broad spectrum kind, on a standing crop and destroy weeds without affecting the main crop. Development of herbicide-resistant crops has resulted in significant changes in agronomic practices, one of which is the adoption of effective, simple, low-risk, crop-production systems with less dependency on tillage and lower energy requirements. Thus, as a technology, herbicide-resistant crops offer opportunity for efficient control of weeds. This experience of genetic modified crop culture in India also gives impetus to adoption of herbicide-tolerant genetically modified crops for reducing losses caused by weeds to the national exchequer

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Assessment of weed control efficiency and crop productivity of herbicide-tolerant transgenic maize

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Season long weed competition alone reduces the grain yield of maize in as much as 70 % (Malviya and Singh, 2007). Current weed control methods are less effective, costly and time demanding as well as need to be repeated at frequent intervals. Genetic engineering is one form of biotechnological tool that is used to enhance the agronomic characteristics of plants by inserting a gene or sequence of genes that express desirable traits. Herbicide resistant maize plants that confer tolerance to glyphosate by production of the glyphosate-tolerant CP4 5-enolpyruvylshikimate-3phosphate synthase (*CP4-EPSPS*) proteins. Hence the present investigation was undertaken to assess the transgenic maize hybrids (MON89034XNK603).

METHODOLOGY

Field experiments were conducted during *Kharif*, 2009 and *Rabi*, 2009-10 at the experimental site of Tamil Nadu Agricultural University, Coimbatore to evaluate the weed control and crop productivity. Early post emergence application of glyphosate was done various doses (900, 1800 and 3600 g/ha) in two transgenic hybrids named Hishell and 900 M.Gold these were compared with non-transgenic counterpart maize hybrids with pre-emergence application of atrazine at 0.5 kg/ha followed by manual weeding at 40 days after sowing. Observations on crop growth, yield parameters and yield were recorded.

RESULTS

Broad leaved weeds dominated over grasses and sedge. *Trianthema portulacastrum* among the Broad leaved weeds, *Cynodon dactylon* and *Dactyloctenium aegyptium* among the grassy weeds and *Cyperus rotundus* in the sedge weed were predominant in the experimental field during both the seasons. Significant variation in total weed density was observed among the weed control treatments. Among the various rates of glyphosate application, 1800 g/ha in transgenic 900 M.Gold (1.0 No's/m^2) and 3600 g/ha in transgenic Hishell (2.3 No's m^2) recorded lesser total weed density during *Kharif*, 2009 and *Rabi*, 2009-10 seasons, respectively at 40 days after sowing. Similarly, considerable reduction in weed dry weight was recorded with the same treatments. This might be due to total weed control as achieved by glyphosate. The findings are in accordance with Reddy and Boykin (2010). Weed control efficiency was highly influenced by different weed control practices treatments. Application of glyphosate at 1800 g/ha in transgenic 900 M Gold and 3600 g/ha in transgenic Hishell recorded higher weed control efficiency of 99.72 and 98.64% during *Kharif*, 2009 and *Rabi*, 2009-10, respectively. Whereas, at the same time pre-emergence application of atrazine in non-transgenic hybrids recorded only 70-80%. Higher grain yield of maize was obtained with post emergence application of glyphosate at 1800 g/ha in transgenic 900 M.Gold (12.01 t/ha) and glyphosate at 3600 g/ha in transgenic Hishell (10.12 t/ha) during *Kharif* and *Rabi* seasons, respectively. This could be attributed to efficient control of weeds during the cropping period.

CONCLUSION

Based on the results of the field experiments, it was concluded that post emergence application of glyphosate at 1800 g/ha at 20 days after sowing could keep the weed density and weed dry weight reasonably at a lower level and enhance the productivity of both *Kharif* and *Rabi* season herbicide tolerant transgenic maize.

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Residual effect of potassium salt of glyphosate applied to preceding transgenic stacked cotton hybrid on succeeding crops

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Many pre-emergence herbicides presently used in cotton for weed control take care of weeds only for a limited period and hence late emerging weeds escape killing. Under these circumstances, Roundup Ready Flex (RRF) Bollgard II cotton hybrid which is resistant to both bollworms and glyphosate would be an added advantage to the cotton growers (Scroggs *et al.* 2007). Hence, the present study has been proposed for efficiency evaluation of weed control methods in transgenic stacked cotton and their residual effect on succeeding crops.

METHODOLOGY

Field experiments were conducted at the experimental site of Tamil Nadu Agricultural University, Coimbatore during *Rabi* season of 2009-10 and 2010-11 to study the carry over effect of glyphosate K salt applied in preceding transgenic stacked cotton hybrid (Mon 15985 x Mon 88913) on the succeeding crops. Trial was conducted in soil with sandy clay loam type of soil with a plot size of 9.0 x 5.4 m. Glyphosate was applied as early post emergence (EPOE) application on 25 and 65 DAS at 900, 1350, 1800, 2700, 3600 and 5400 g/ha in MRC 7347 BG-II RRF test hybrid. These treatments were compared with hand weeding on 15 and 30 DAS and unweeded control. Succeeding crops like sunflower, soybean and pearl millet were sown immediately after the harvest of herbicide tolerant transgenic cotton. Recommended package of cultivation practices were followed to raise the succeeding crops. Observations like germination percentage, visual phyto-toxicity, plant height, total weed density, dry matter production and yield were recorded.

RESULTS

Results showed that, application of glyphosate at 5400, 3600 and 2700 g/ha recorded lower weed dry weight due to better control of weeds at critical stage (50 DAS) of crop growth during *Rabi* 2009-10 and 2010-11, in herbicide tolerant transgenic cotton. During both the years of study, among the treatments, glyphosate at 2700 g/ha recorded higher seed cotton yield. According to Scroggs *et al.* (2007) seed cotton yield was maximized with the applications of glyphosate as POST and also stressed the importance of early-season weed control as well as controlling weeds late in the season. Regarding succeeding crops, germination percentage and vigour of residual crops were not significantly influenced by weed control treatments imposed on the previous cotton crop and also there was no crop phyto-toxicity in residual crops observed with different doses of glyphosate and other weed control treatments applied in transgenic cotton hybrid. During both the seasons, in the succeeding crops, lower density of weeds were recorded with glyphosate at 5400, 3600 and 2700 g/ha compared to other treatments (Table 1). There were no significant influence on plant height, dry matter and grain yield of residual crops by post emergence application of glyphosate in preceding transgenic cotton hybrid. Walker and Oliver (2008) who had reported that, minimum number of glyphosate application effectively reduced the population of weed seed production thus reduced the weed complex.

Table 1. Residual effect of herbicides on weed density and yield of succeeding crops

Treatment	Weed density (no./m^2) at 40 DAS			Grain yield (t/ha)		
	Sunflower	Soybean	Pearl millet	Sunflower	Soybean	Pearl millet
Glyphosate at 900 g/ha	3.05(8.16)	3.32(8.75)	3.14(7.53)	1.36	1.48	0.80
Glyphosate at 1350 g/ha	2.89(6.92)	2.78(6.52)	2.92(7.40)	1.38	1.56	0.83
Glyphosate at 1800 g/ha	2.58(4.74)	2.35(2.75)	2.53(2.80)	1.43	1.54	0.84
Glyphosate at 2700 g/ha	2.42(4.00)	2.07(2.11)	2.24(3.04)	1.47	1.52	0.85
Glyphosate at 3600 g/ha	2.39(3.04)	2.00(1.65)	2.14(2.30)	1.41	1.54	0.82
Glyphosate at 5400 g/ha	2.00(2.24)	1.97(1.24)	2.00(2.00)	1.39	1.63	0.81
HW on 15 and 30 DAS	3.18(12.3)	3.81(23.6)	4.38(25.0)	1.34	1.49	0.76
Unweeded check	5.09(22.7)	5.64(28.4)	5.31(26.0)	1.32	1.47	0.74
LSD (P=0.05)	0.45	0.35	0.36	NS	NS	NS

Figures in parentheses are original values, Data subjected to square root transformation

CONCLUSION

Succeeding crops sown immediately after the harvest of herbicide tolerant transgenic cotton were not affected by the residue of glyphosate. Whereas, weed density of succeeding crops were highly reduced under the treatments that are received glyphosate for weed control when compared to hand weeding and unweeded check.

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The challenge of mitigating adverse impacts from invasive species: is mainstreaming invasive species management in forest quality improvement programs the answer?

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Invasive species cause severe degradation of forests and results in economic losses worth $1.4 trillion globally in terms of productivity declines, availability of non-timber extractive products, wildlife movement and management, threat to indigenous flora and endemics and reducing ecosystem services. Factors like climate change, urbanization, deforestation and degradation, change in land use, habitat fragmentation are only aiding the introduction, establishment and spread of invasive species like *Lantana camara*, *Parthinium hysterophorus, etc* which have converted large cultivable land into green desert by reducing the yield and livestock carrying capacity. While the scale and quality of forests is being deteriorated globally, including in India by invasive species, efforts to address them have remained piecemeal, opportunistic, underfunded and uncoordinated. Invasive species management continues to heavily rely on labour intensive processes of manual uprooting but the spread of invasive is only increasing. We present an opportunity to shift the management of invasive species from a fragmented approach to a mainstreaming approach. As the Green India Mission rolls out, we present a roadmap for mainstreaming the invasive species management through a step-wise approach involving an analysis of current policy and legal framework, investment profiles, use of new technology, mapping and developing new protocols for invasive species management. This will include among others, on one hand, new and innovative approaches of community capacity building and involvement, to use of bio-control measures on the other. We will demonstrate the new approaches in the select forest types in central Indian highland States of Madhya Pradesh (7.64 million hectare of forests) and Chhattisgarh (5.59 million hectare of forests), which have been variously affected by invasive species. This phased road-map approach for mainstreaming invasive management in forest quality improvement program is expected to create a strong base for supporting the science-policy interface in India on preventing the introduction of invasive alien species.

Impact of Invasive Alien Species on Livelihoods

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Globalization, climate change and human mobility are the three major drivers responsible for altering our ecological and economical system. They contribute to or exacerbating human vulnerability, and in some cases foreclosing livelihood and development options. Invasive alien species have large detrimental economic impacts on human enterprises such as fisheries, agriculture and forestry. While the negative impacts of Invasive Alien Species on ecosystem structure and function are undisputed, the précised information on its impact on human well-being and livelihoods is largely missing particularly for the rural poor whose land and waters are most affected by IAS. It is conveniently assumed that the harmful impacts on ecosystem goods and services automatically translate into negative effects on human well-being. Native populations in the interior forest or rural areas have few or no alternative income sources are therefore more sensitive to changes in the availability of local natural resources (e.g. non-timber-forest resources).Apart from forests, for millions in the developing world farming is the sole means of survival. Intensive literature has revealed that there is a lack of adequate documented research evidences highlighting the impacts of weeds on farming livelihoods though there is a plenty of information on crop losses resulting from weed invasions. This shows complete negligence to this sensitive issue which is the key driver of food security and survival. Taking the example of *Lantana camara*, the absence of regenerating woody plants above a critical density of Lantana demonstrates that no understorey vegetation can become established, once Lantana is sufficiently dense. Neither cattle nor goats eat Lantana, and areas traditionally used for grazing can therefore not be used anymore. Another impact on livelihood is of *Prosopis juliflora* which was initially accepted due to quick growth, field fencing and fuelwood property but gradually farmers, ranchers and pastorals learnt about its negative invasive effect of colonization of agri-land, thorns, suppression of grazing flora. There are ample reasons to believe that invasive alien species will perform better than their crop or forest counterpart in light of climate change thus impacting livelihoods manifolds. It is high time that due consideration to livelihood invasion by IAS should be given along with trade and food invasion.

Comparison among three rice establishment methods on cost of cultivation and weed control

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Rice - wheat rotation occupies about 18 m ha in Asia of which 13.5 M ha are in Indo-gangetic plain (IGP) of India (10 m ha), Pakistan (2.2 m ha), Bangladesh (0.8 m ha) and Nepal (0.5 m ha). This system feeds about 1.36 billion people (20% of the world population) (Sahrawat *et al.* 2010). A substantial rice-wheat system (1.06 m ha) exists in Kymore plateau and Satpura hills agro-climatic zone of central India (Madhya Pradesh) outside the Indian (IGP). But evidence is now appearing that the system productivity is plateauing and total factor productivity is declining due to fatigued natural resource base (Ladha *et al.* 2003). The traditional method of crop establishment involves excessive tillage which is painstaking, time and energy consuming, excessive tillage of agricultural soil may result in short term increase in fertility, but will degrade soil in the medium term.

The management of crop residue and soil organic matter is of prime importance in maintaining soil fertility and productivity. After rice and wheat harvest, significant crop residues are left in the field, especially in the combine harvested areas. These residues are mostly burnt *in situ* thus polluting the environment and leading to wastage of precious resources. The farmers resort to have good seed bed and employ excessive tillage resulting in highest cost of cultivation, acceleration of soil erosion and compactness of sub soil. Such harmful effect of excessive tillage can be resolved by the conservation agriculture. It is generally observed that problem of weeds is more under conservation agriculture practices. Therefore, a field study was conducted to compare the three rice establishment methods on cost of cultivation and weed control.

METHODOLOGY

A field study on rice was carried out in the *Kharif* season of 2015 at Research Farm of ICAR-Directorate of Weed Research, Jabalpur. The soil of the experimental field was vertisol, pH 7.4, organic C 0.48%, available N 237 kg/ha, available P 16.8 kg/ha and K 341 kg/ha. The study was carried out in large plotS of 1 acre each. Three treatments of rice establishment i.e. (i) Conventional tillage (ii) Transplanted rice (ii) Conservation agriculture practices [Wheat (ZT +R) - Greengram (ZT + R) Direct seeded rice (ZT+R). Fertilizer application (120 Kg N + 60 Kg P_2O_5) /ha was done uniformly in all the three treatments. The total cost of inputs applied in all the three treatments were analyzed for comparison. Weed density and dry weight was recorded at 60 DAS.

RESULTS

The results of the study revealed that out of 3 rice establishment methods, conservation agriculture [Wheat (ZT +R) - Greengram (ZT + R) Direct seeded rice (ZT+R) was found to be the most economical and with better weed control. In this establishment method saving of ` 5341/acre in cost of cultivation was observed in comparison to conventional tillage, and ` 4454/acre in comparison to transplanted rice, and in respect of weed control also this system was better than other two methods. The total weed density and biomass was 14 and 4.7 g/m^2 under conservation agriculture method as compared to CT (106/m^2, 92.0 g/m^2) and transplanted rice (57/m^2, 57.5 g/m^2).

Table 1: Cost of cultivation (`) of rice establishment per acre in three methods

Operation	Conventional tillage	Transplanted rice	Conservation agriculture
Grass cutter	600	-	600
Buming	500	-	-
Ploughing/puddling	2400	1600	-
Irrigation	-	1000	-
Transplanting/Sowing	800	4000	1000
Seed price	750	750	750
Herbicide	2500	1813	3858
Fertilizer	1776	1776	1776
Hand weeding	5000	2500	1000
Total	14326	13439	8984

Table 2: Weed density and weed dry biomass in 3 rice establishment methods at 60 DAS

Rice establishment method	*Commelina* spp.		*Echinochloa* spp.		*Malacra* spp.		*Alternanthra* spp.		*P.minima*		*Ipomea* pp.		Total	
	D (/m^2)	Wt. (g/m^2)	D (/m^2)	Wt. (g/m^2)	D (/m^2)	Wt. (g/m^2)	D (/m^2)	Wt. (g/m^2)	D (/m^2)	Wt. (g/m^2)	D (/m^2)	Wt. (g/m^2)	D (/m^2)	Wt. (g/m^2)
Conventional tillage	30	15.9	38	35.0	8	15.9	-	-	10	2.3	20	22.9	106	92.0
Transplanted rice	15	10.0	15	10.1	-	-	20	5.2	7	2.2	-	-	57	37.5
Conservation agriculture	3	1.2	8	2.5	-	-	3	1.00	-	-			14	4.7

D=Density, Wt.= Weight

CONCLUSION

1. Lowest cost of cultivation was observed in CA based DSR among three rice establishment methods, with a saving of ' 5341/acre compared to conventional tillage.

2. Lowest weed population and weed dry weight were observed in DSR (CA)

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Co-expression of igrA: Glycine oxidase: CP4 EPSPS enhanced the glyphosate tolerance in rice

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Under aerobic rice cultivation, weeds are the major yield-limiting biological constraint. Most weed control programs rely on selective herbicides, but development of herbicide resistance crops allow to spray non-selective herbicides by bringing the selectivity to crops for effective weed control. Among the non-selective herbicides, glyphosate is a widely used broad spectrum herbicide, which inhibits the function of EPSPS enzyme in shikimic acid pathway. The basic approach in existing commercial glyphosate tolerance crops are the over-expression of insensitive form of 5-Enoylpyruvyl shikimate-3-phosphate synthase (EPSPS). One of the disadvantages of this strategy is that glyphosate persist and accumulate in plant tissues and may decline crop yield by interfering with reproductive organ development. Hence, the removal of glyphosate residue may lead to more robust tolerance and allow the glyphosate spraying at all plant developmental stages without crop damage. Glyphosate detoxifying enzymes like mutated glycine oxidaseand igrA (increased glyphosate Aldo keto reductase) can metabolize the glyphosate to non-toxic compounds and minimize the residue level in plant tissue (Nicolia *et al*. 2014, Fitzgibbon and Braymer, 1990). Glycine oxidasecleaves thecarbon-nitrogen bond of glyphosate and yields amino methyl phosphonic acid (AMPA) andigrA converts glyphosate in to sarcosine and inorganic phosphate and CP4 EPSPS is insensitive to glyphosate. With this back ground in the present study co-expression of different genes (igrA, Glycine oxidase, CP4EPSPS) importing glyphosate tolerance by different mechanisms used an option to develop glyphosate resistant rice transgenics to enhance the tolerance by minimizing the residue level and by managing the oxidative damage.

The multigene construct co-expressing igrA, GO and CP4 EPSPS was developed by modified gate way cloning strategy. Agrobacterium mediated *inplanta* transformation method adopted to develop transgenics in rice genotype AC 39020. The primary rice transformants subjected for stringent glyphosate screening at seedling level with 50 ppm of glyphosate on quartz sand mediumand at whole plant level with 1500 ppm of glyphosate using leaf swab assay. The integration of all the genes in rice transgenics was confirmed by PCR analysis. In few of the T2 rice transgenics bio efficacy against glyphosate was studied based on quantification of shikimic acid, chlorophyll content by using leaf disc bio assay. The oxidative damage of glyphosate in rice transgenic seedlings measured through histochemical NBT staining and MDA quantification by using TBARS assay.

The integration of three genes in rice transgenics was confirmed through PCR analysis by using gene specific primers. Though all the transgenic events were tolerant against glyphosate, 35 promising events were found to be superior in T2 generation. Among the selected transgenic lines, few plantswere subjected for leaf disc assay with 2000 ppm of glyphosate. The transgenics maintained less shikimate levels and high chlorophyll content compared to wild type. This indicates the enhanced glyphosate tolerance and less crop damage in rice transgenics. Glyphosate application leads to oxidative stress in plants and the transgenics showed improved levels of tolerance to oxidative damage as measured by NBT staining and MDA quantification(Fig 1. c).

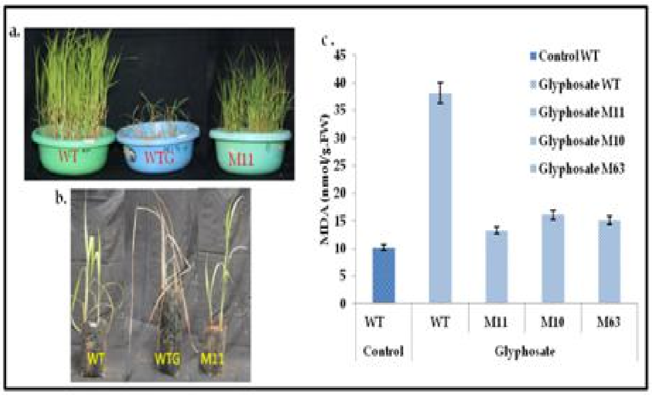

Fig.2 . Rice putative transformants screened on Glyphosate: a) Seedling level screening with 50 ppm of glyphosate on quartz sand. b) Plant level screening by leaf swab bioassay with 1500 ppm of glyphosate. WT: Wild type; WTG: Wild type treated with Glyphosate; M11: Rice transgenics.c), MDA levels in glyphosate treated rice plants.

CONCLUSION

The glyphosate detoxifying enzymes igrA and Glycine oxidase imparts tolerance to glyphosate. Thestacking of three genes with different functionssubstantially increased the glyphosate tolerance in ricetransgenics. The igrA and glycine oxidase degrades glyphosate into sarcosine and AMPA which are non-toxic and less toxic to plants respectively. Therefore co–expression of EPSPS, igrA and Glycine oxidase not only imparts enhanced tolerance and also showed reduced glyphosate phytotoxicity in rice transgenics.

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Herbicide tolerant crops- Current and future technologies

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Crops which are tolerant to herbicides are known as herbicide tolerant crops. Herbicide tolerant (HT) crops are the biggest selling GM crops. These crops have been made to be tolerant to either Monsanto's weed killer RoundUp (glyphosate) or Bayer's weedkiller Liberty (glufosinate ammonium). These are broad spectrum herbicides which kill all green plants except those protected as a result of the genetic modification. Recently the first crops tolerant to Dows 2, 4-D, a more toxic weed killer, also have been approved for commercial growing. Monsanto Roundup Ready Soybeans are the leading product. Other herbicide-tolerant crops include maize, sugar beet, and oil seed rape (canola). In India only trials are there but not commercially cultivated. In America entire crop of soybean and canola are herbicide tolerant. Herbicide tolerant GM crops have been attractive to a number of large- scale farmers because in the early years after adoption they simplified the spraying regimes i.e. farmers only had to spray them once with with one type of herbicide, savinglabour costs. However, repeated blanket applications of the same herbicide have led to evolution of herbicide-resistant superweeds. These superweeds are now reducing crop yields and require repeated applications of multiple herbicides and sometimes even pulling up by hand.

Genetic engineering refers to techniques used to manipulate the genetic composition of an organism by adding specific genes. The enhancement of desired traits has traditionally been undertaken through conventional plant breeding. GE crops are often broken down into two categories, herbicide tolerant and Plant-incorporated protectants (PIPs).Crops are also engineered or stacked to express multiple traits like crops that are resistant to multiple herbicides or are resistant to herbicides and insects.

Monsanto first introduced glyphosate resistant soybean in 1996 and later introduced glyphosate resistant corn in 1998. These crops, commonly called "Roundup Ready", have become ubiquitous in agriculture with 93% of soybeans, 82% of cotton, and 85% of corn planted engineered to beglyphosate resistant. This increase in glyphosate resistant crops has led to an increase in herbicide use, herbicide resistant weeds (also known as super weeds) and numerous other environmental and human health impacts. Recenty departmet of agriculture called for the deregulation of corn and soybeans engineered to tolerate the herbicide 2,4-D. Much like glyphosate, these new varieties of GE corn and soybeans are set to usher in dramatic increase in 2, 4-D. Dow Agrosciences produces these new GE crops under the name "Enlist" which will be stacked with glyphosate resistance.

Growers perceived herbicide resistance as the ideal herbicide trait because glyphosate controls over 300 annual and perennial weeds, has flexible application timings, and does not have any rotational crop restrictions. GR crops allowed growers to use glyphosate as an in-crop selective herbicide and replace more expensive, selective herbicides that controlled a narrower weed spectrum and had other issues (e.g., crop tolerance). The timing, rate, and number of glyphosate applications had to be restricted to ensure crop resistance and there were reports of yield drag. Glufosinate resistant crops have been commercially available but have not been very successful for a number of reasons, particularly because of the higher cost of glufosinate and its more restrictive application timings. Cotton and soybean growers who are troubled by difficult to control GR weeds such as Palmer amaranth and water hemp may rapidly adopt glufosinate- resistant crops and the use of glufosinate. Dual stack crop cultivars that include resistance to both glufosinate and glyphosate are now commercially available in cotton, soybeans, and corn and provide growers a choice between two broad-spectrum herbicides as well as an array of naturally selective herbicides to diversify their weed management practices.

Table1: Herbicide resistant gene and source of gene

Herbicide	Resistant gene	Gene source
Gluphosinate (Liberty)	Bar, PAT (Phosphinothricin acetyl transferase)	*Steptomyces* sp. *Alcaligenes* sp.
Glyphosate	aro A (EPSPS – 5 enol pyruvyl shikimate 3-phosphate synthase gene)	*Agrobacterium* sp.
Bromoxynil	BXN (Bromoxynil nitrilase)	*Klebsiella pneumoniae*
Sulfonamides	DHPS (Dihydropteroate synthase) sul	Plasmid
Sulfonylurea	ALS (Acetolactate synthase)	*Nicotiana tabacum*

Future HR Crop Technologies:

GR crops have been very successful, the evolution of GR weeds was faster and more widespread than many expected. This rapid evolution of GR weeds and the lack of any new selective herbicides with novel MOAs is encouraging HR crop technology to evolve again. The next wave of technologies will combine resistance to glyphosate and other herbicides to provide growers with more herbicide options as well as the possibility of using herbicides with both foliar and soil residual activity. Scientists have discovered a plethora of herbicide traits that can be combined with glyphosate resistance to make multiple HR crops.

Herbicide Resistant Crops - An Indian perspective

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There is an old theory that any technology which replaces labour should not be encouraged. Contrary to the reality, a few NGOs think that labour in India is cheap and plentiful. There can not be a big myth than this. The agriculture in India is highly labour intensive and labour wages alone accounts for 60% of the total cost of production. Assuming the labour requirement of 20 man-days/ha for weeding, we require 5 billion man-days of labour for weeding alone. The implementation of National Rural Employment Guarantee Scheme has serious impact on the availability of labour for agricultural operations particularly for weeding in India. Increased pressure on land and high cost of rearing the animals, the animal power used for weeding is reducing day by day. Further, the hiring charges for the farm machinery used for weeding is escalating due to increased crude oil prices in the international market. So, there is every need to search for alternatives in weed management in agriculture like use of recommended herbicides in combination with good crop husbandry practices or use of Herbicide resistant crops (HRCs) for the management of weeds .Proponents of biotech crops consider that genetic engineering is the panacea to attain the food and fibre needs of the burgeoning population that is expected to reach 9.2 billion by 2050 from the current figure of 7.2 billion.

The term herbicide tolerance or resistance is used to describe the ability of a trait or quality of plants within a species or larger taxon or plant cells in a culture to withstand a particular herbicide at recommended dose that is substantially greater than the wild type of that plant. The concomitant progress in molecular genetics made it possible to incorporate resistance genes from unrelated organisms into an otherwise susceptible crop.

Currently, two transgenic traits dominate the global biotech crops i.e herbicide resistance accounted for 65%, insect resistance 15%, and a combination of the two (stacked) for 15%. This makes the herbicide-resistant transgenic crops for 80% of the global biotech acreage. The area under transgenic cultivation, which is doubling every five years, now accounts for 12% of global arable land (GM Science Update 2014). A genetically modified crop is the fastest adopted technology in the recent agricultural history due to the social and economic benefits of these crops, as it is evident by the Bt-cotton introduced in 2002, it is presently grown over 9.0 m ha (90% of the total) area over 6 million farmers in the world.

Herbicide resistant crops (HRCs) occupy nearly 60% of the total global area of 160 m ha under GM crops. HRCs allows cultivation of crops with no or minimal weeds problem, it also enable the farmers to employ a flexible and easy weed management strategy. The HRCs have broad spectrum weed control, reduced crop injury and reduced carry over effect compared to traditional herbicides. In addition, HRCs facilitate the adoption of resource conservation technologies with minimal disturbance to the soil and there by reduce soil erosion and the loss of organic carbon through oxidation. Stacking up of the genes resistant to herbicides with different modes of action broadens the weed control efficiency and provides more flexibility and options in weed management. Stacking of genes for insect resistance offers effective control of insects and weeds.

In India, the herbicide resistant soybean, cotton and corn have been under controlled trials for quite some time, but the government has imposed 10-year moratorium on commercial release of the these crops stating that data on scientific valuation of biosafety issues are limited.

Glyphosate-resistant soybean has been adopted principally, because it simplifies the weed management options by the use of single herbicide and with a more flexible timing than that of recommended herbicides (AICRPWC 2011). As glyphosate is strongly adsorbed to the soil there is negligible threat of residual effects on succeeding rotational crops. The number of herbicide applications in soybean is estimated to have reduced by 12 percent for the period 1995-1999. However, increase in herbicide use in soybean in the United States may partly be explained by the increased area of soybean. The American Soybean Association stated that glyphosate-resistant soybean protects the environment through dramatic changes in tillage practices and herbicide application technology, and there by improved weed control. Additionally, farmers are producing cleaner crops containing fewer non-grain materials.

Another success of HRCs is Herbicide Resistant (HR) rice, which is becoming commercially available. From an agronomic viewpoint, two main reasons are frequently put forward to justify the development and introduction of herbicide-resistant rice. The first reason is excellent (95%) control of the entire weed flora associated with this crop, including red rice and other herbicide resistant weeds. Secondly, HR rice provides an alternative tool for the management of weeds that have already evolved resistance to particular herbicides, especially grasses such as *Echinochloa* spp. Herbicide tolerant technology is simple to use, does not have major restrictions and it is flexible, extended herbicide application window which is helpful in dealing with rainy and windy days during the optimal periods of weed management. According to AICRPWC (2011) trials, total weed density was significantly reduced due to post emergence application of glyphosate in corn and cotton hybrids when compared to hand weeding plots in transgenic cotton and corn. Similarly, application of glyphosate at 2700g/ha recorded higher seed cotton yield in transgenic cotton over hand weeding twice in India.(Chinnusamy *et al*. 2014) with out any phototoxic effect to crop. On other hand HRCs is the potential threat for the transfer of gene conferring the HR trait to related wild and weedy relatives lead to increased invasiveness. Hence, weed scientist has the greater responsibility in educating the farmers and the extension staff on judicious and sustainable use of herbicides and role of HRCs in India.

CONCLUSION

Herbicide tolerant crops will substantially impact the weed management scenario. Unavailability of labour, coupled with higher wages, herbicides may now find greater acceptance by the farmers. .HRCs have a great potential in the simplification of weed management options if handled judiciously. This technology may be beneficial to the environment by enabling no-till agriculture. However, it must be emphasized that the risk associated with HRCs like genetic drift/contamination and development of superweeds or increased weed invasiveness.

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Empirical evidences support direct evolution of weedy rice from cultivated rice

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Weedy rice has been recognized as one of the worst weeds in paddy fields worldwide. Its origin still is unsolved scientific issue despite this is a theoretic basis to explore control methods for this weed.

METHODOLOGY

We screened 545 weedy rice accessions and concomitant cultivated rice collected from nationwide sampling in China using both genetic and molecular marker tests for the cytoplasmic male sterility (CMS) genes (Wild abortive, WA, and Boro type, BT) most widely used in the production of indica and japonica three-line hybrid rice, as a diagnostic trait of direct parenthood and chloroplast genome.

RESULTS

Sixteen weedy rice accessions contained the unique CMS-WA gene and none contained the CMS-BT gene. These 16 accessions represent weedy rices recently evolved from maternal hybrid rice derivatives, and more than 60% accessions shared same chloroplast haplotypes with local cultivated rice collections, given the primarily maternal inheritance of those traits. Furthermore, we found some newly-evolved weedy rice-likely accessions among F3 progeny populations of two kinds of transgenic herbicide-resistant hybrid rice, which were continuously grown for three years. A serial of descrimination experiments verified that those weedy rice-likely accessions were newly-evolved weedy rice directly from maternal transgenic herbicide-resistant hybrid rice.

CONCLUSION

Our results provided a key direct empirical evidence on the involvement of cultivated rice in the evolution of weedy rice.

Theme 16

New herbicide molecules and products: the role of herbicide industry

25th Asian-Pacific Weed Science Society Conference on "*Weed Science for Sustainable Agriculture, Environment and Biodiversity*", Hyderabad, India during 13-16 October, 2015

Triafamone (Council®) : a flexible new rice herbicide for Asia

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The world population is predicted to reach over 9 billion by 2050, and the FAO estimates that food production will need to increase by 70% to meet demand. Rice (*Oryza sativum* L.) is a staple food in many developing countries, and especially in Asia. In addition, the trend to urbanization is leading to farm labor shortages in a number of Asian rice producing countries. As a result of these trends there is an enormous need for innovation in rice production. triafamone is a new sulfonanilide rice herbicide discovered and developed by Bayer Crop Science AG and sold as Council®. It is effective and selective under many application methods and timings in transplanted and direct seeded japonica and indica rice varieties. Target weeds are the important grasses such as *Echinochloa crus-galli, E. colonum, E. oryzicola, Paspalum distichum* and *Isachne globrosa* and sedges including ALS resistant strains. Triafamone is also being developed with other suitable herbicide mixing partners in order to extend the weed control spectrum even further.

METHODOLOGY

The identity and chemical structure of triafamone are shown below. It has been tested in numerous field trials both solo and in combination with complementary herbicides. Spray and water-surface applications were investigated at various growth stages of crop (name the crops) and weeds. All necessary regulatory studies have been conducted relating to environmental fate, dietary risk, toxicology and eco-toxicology.

RESULTS

Environmental fate, toxicology and ecotoxicology studies indicate that triafamone has a favorable user, consumer and environmental profile. The first registration of triafamone was received in 2014 in Korea, and sales started in 2015. Further registrations across Asia are expected in the 2016. Triafamone at 20-40 g/ha shows efficacy against a wide range of grasses, sedges and broad leaved weeds typically infesting rice fields (Table 1). Regarding tolerance of rice

Bayer CropScience code numbers:	AE 1887196, BCS-BX60309
CAS reg. number:	874195-61-6
Empirical formula:	$C_{14}H_{13}F_3N_4O_5S$
Molecular weight:	406.34
Structural formula:	

@Provide crop yield data for

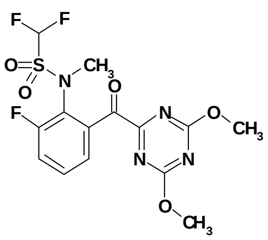

Table 1. Susceptibility to triafamone of typical weeds in rice

Weed species	Percentage control levels at various application timings			
	Pre-emergence	Early post-emergence	Mid post-emergence	Late post-emergence
Echinochloa crus-galli	>95%	>95%	>95%	90-95%
Echinochloa oryzicola	>95%	>95%	>95%	90-95%
Echinochloa colonum	>95%	>95%	>95%	90-95%
Leptochloa chinensis	>95%	90-95%	80-90%	70-80%
Paspalum distichum	>95%	>95%	90-95%	no test
Ludwigia octovalvis	>95%	>95%	90-95%	80-90%
Sphenoceia zeylanica	>95%	>95%	90-95%	90-95%
Commelina diffusa	>95%	>95%	90-95%	no test
Sagittaria pygmaea	>95%	>95%	90-95%	80-90%
Sagittaria trifolia	>95%	>95%	90-95%	80-90%
Aeschynomene indica	>95%	>95%	90-95%	no test
Cyperus difformis	>95%	>95%	>95%	80-90%
Cyperus iria	>95%	>95%	>95%	80-90%
Cyperus serotinus	>95%	>95%	>95%	80-90%
Fimbrystylis miliacea	>95%	>95%	90-95%	no test
Eleocharis kuroguwai	90-95%	>95%	80-90%	70-80%
Scirpus nipponicus	no test	>95%	90-95%	no test
Scirpus planiculmis	no test	>95%	90-95%	no test
Scirpus juncoides	>95%	>95%	80-90%	70-80%

towards triafamone, many years of field testing has shown good selectivity without negative impact on the grain yield under weed free conditions. This crop tolerance was found in direct seeded and transplanted rice after spray and water surface application, and from pre- to late post-emergence. The reason for the selectivity is considered to be due to differential metabolism of triafamone in rice plants and in weeds. By combining triafamone with other herbicides additional weed species can be controlled without losing crop selectivity. For example, Council active® is a WG formulation containing ethoxysulfuron. Designed for "one-pass" control of key grass, sedge and dicot weeds via spray and broadcast application, this product will especially suit the weed control needs in Indian rice growers.

CONCLUSION

Triafamone is a new sulfonanilide herbicide being developed in Asia for weed control in rice. Alone or in co-formulation with other herbicides it will provide highly flexible control of grass, sedge and dicot weeds either by spray or water surface applications. When used according to the product label, it provides crop tolerance to Indica and Japonica varieties and in direct seeded or transplanted situations. The first registration of Triafamone was received in 2014 in Korea, and sales have started in 2015. Further registrations across Asia are expected in 2016.

Dao You 410SE: A novel penoxsulam + butachlor formulation for pre-emergence use in transplanted rice in China

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A new pre-mix rice herbicide formulation,"Dao You 410SE", consists of penoxsulam + butachlor (10 + 400 g/l). Penoxsulam inhibits the plant enzyme acetolactate synthase (ALS) which is essential for the synthesis of the branched-chain amino acids valine, leucine, and isoleucine, subsequently inhibiting cell division. Butachlor is a seedling shoot inhibitor that impacts cell growth and division. Penoxsulam, a triazolopyrimidine sulfonamide herbicide, is sold in many countries for post-emergence broad-spectrum control of broadleaf weeds, annual sedges, and *Echinochloa* spp. grasses in rice while Butachlor, a chloroacetamide herbicide, is used globally as a selective pre-emergence product for the control of annual grasses and certain broad-leaved weeds in rice. In China, Dao You 410SE efficacy and crop tolerance field trials were conducted in transplanted rice from 2008-2014. In these trials, Dao You 410SE demonstrated excellent control of many important rice weeds. In 2015, this product will be launched for use in the transplanted rice market in China.

METHODOLOGY

Dao You 410SE was evaluated at 1, 1.5, 2, and 3 l/ha for weed control efficacy and crop tolerance in multiple field trials in transplanted rice in key rice growing provinces, (Guangdong, Hunan, Jiangsu, Jiangxi, and Zhejiang in central and southern China, and Heilongjiang and Jilin in northeastern China).

RESULTS

Dao You 410SE efficacy and crop tolerance field trials were conducted in transplanted rice from 2008-2014. In these trials, Dao You 410SE demonstrated good to excellent control of many important weeds in transplanted rice in China. When Dao You 410SE was applied at 1.5, 2, and 3 l/ha (600 + 15, 800 + 20 and 1200 + 30 g/ha, butachlor + penoxsulam, respectively) as a foliar application at 3 to 7 days after rice transplanting, it provided very good to excellent pre-emergence control of barnyardgrass (*Echinochloa crus-galli)*, Chinese sprangletop (*Leptochloa chinensis*), annual sedge (*Cyperus difformis*), monochoria (*Monochoria vaginalis*), Indian rotala (*Rotala indica*), common falsepimpernel (*Lindernia pyxidaria*), and needle spikerush (*Eleocharis acicularis*) in central/southern China (Table 1). Under the same application protocol, Dao You 410SE provided very good to excellent pre-emergence control of barnyard grass (*Echinochloa crus-galli*), water plantain (*Alisma plantago-aquatica*), and three leaf arrowhead (*Sagittaria trifolia*) in northeastern China (Table 2). In addition, Dao You 410SE provided 4-6 weeks residual weed control and demonstrated no visual phytotoxicity to transplanted rice.

Table 1. Efficacy of Dao You 410SE as a pre-emergence herbicide by foliar application at 3 to 7 days after rice transplanting in central/ southern China from 2008 to 2014

Chemical	Rate	Weed Control (%)* at 30 to 40 days after application						
		Barnyardgrass	Chinese sprangletop	Annual sedge	Monochoria	Indian rotala	Common falsepimpernel	Needle spikerush
Dao You 410SE**	1.0 L/ha	91.3	80.5	90.7	87.1	96.6	94.5	82.0
Dao You 410SE	1.5 L/ha	93.9	86.7	94.4	92.6	98.0	97.9	89.1
Dao You 410SE	2.0 L/ha	96.1	90.8	97.3	95.1	98.8	98.8	93.0
Dao You 410SE	3.0 L/ha	98.4	***	99.0	97.4	100	100	95.5
Bensulfuron + Butachlor 300WP	2.25 kg/ha	92.2	80.1	93.2	93.1	96.6	97.0	86.4

*Weed control by visual bio-mass comparison to the un-treated. **Dao You 410SE a trade name of penoxsulam + butachlor at 10 + 400 g/L. ***No data for this use rate.

Table 2. Efficacy of Dao You 410SE as a pre-emergence herbicide by foliar application at 3 to 7 days after rice transplanting in northeastern China from 2008 to 2014

Chemical	Weed Control (%)* at 30 to 40 days after application		
	Barnyardgrass	Water plantain	Three leaf arrowhead
Dao You 410SE** (1.0 L/ha)	92.7	77.1	71.8
Dao You 410SE (1.5 L/ha)	98.3	86.6	83.2
Dao You 410SE (2.0 L/ha)	100	92.8	91.1
Dao You 410SE (3.0 L/ha)	100	97.9	97.5
Bensulfuron + butachlor 300 WP (2.25 kg/ha)	99.5	92.5	100

*Weed control by visual bio-mass comparison to the un-treated; **Dao You 410SE a trade name of Penoxsulam + Butachlor at 10 + 400 g/L

CONCLUSION

Dao You 410SE provided excellent control of many important weeds in transplanted rice in central, southern and northeastern China. In 2015, Dao You 410SE will be launched for use in the transplanted rice market in China.

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Performance assessment of Granite™ herbicide through farmer participatory approach in India

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Weeds occur in every rice field in India and pose a major threat to increasing rice productivity. Uncontrolled weed growth causes 33-45% reduction in grain yield of rice (Manhas *et al.* 2012). Farmers, therefore, invest heavily in weed management in rice (Johnson *et al.* 2003). In transplanted rice, even after use of existing herbicide options, farmers must use hand weeding that is challenging because of the shortage and timely availability of labor. Granite™ (penoxsulam 24% SC), a Dow AgroSciences proprietary herbicide, is a unique herbicide expected to deliver better and cost effective weed control with crop safety. It was evaluated under a farmer participatory approach to understand its performance and requirement of hand weeding compared to existing weed management approaches currently used by rice farmers.

METHODOLOGY

Granite™ herbicide was evaluated in 2013 in trials initiated at 361 locations in transplanted rice across key rice growing states in India. Granite was applied at 22.5 g/ha as a foliar spray targeting the 1-3 leaf stage of susceptible weeds [8 to 12 days after treatment (DAT)] and was compared with common farmer practices (FP) where farmers opted for herbicides as per their choice and applied them on their own as per labeled dose. Pretilachlor 625 g/ha and Butachlor 1250 g/ha were applied either as sand-mix (at 20 kg/acre) or as direct sprinkle application in flooded field. Oxadiargyl (100 g/ha) was applied with shaker bottle and pretilachlor + bensulfuron 60 + 600 g/ha was applied by hand broadcasting. Plots were assessed for percent visual total weed control at 15-30 days after application and hand weeding required by manual labor at 35-45 days after transplanting was tracked. To compare Granite™ herbicidewith FP in terms of visual weed control and labor requirement for manual weeding, paired t-tests were performed for each comparison at all three segments: pre-emergence, post-emergence, and pre-emergence followed by post-emergence. The test statistic is calculated as:

$$T = \frac{\bar{x}_D}{s_D/\sqrt{n}},$$

where $\bar{X}_D$ is the mean of the differences between Granite and Farmer Practice, s_D is the standard deviation of those differences, and n is the number of paired observations.

RESULTS

Granite™ herbicide was compared with pre-emergence herbicides applied in 73% of plots (pretilachlor, butachlor, oxadiargyl or pretilachlor + bensulfuron, comprising of 80, 6, 8 and 2% of pre-emergence herbicide treated plots, respectively). In 16% of the plots, Granite was compared with the post-emergence herbicide, bispyribac, while in the remaining 11% of the plots, Granite was compared with the pre-emergence herbicides, pretilachlor, butachlor or oxadiargyl, followed by application of the post-emergence herbicide, bispyribac.

Key weed species observed in the experimental fields were: *Echinochloa crus-galli; Echinochloa colonum; Cyperus difformis; Cyperus iria; Cyperus rotundus; Monochoria vaginalis; Ammannia spp.; Sphenoclea zeylanica; Fimbristylis miliacea; Alternanthera spp. and Bergia spp.*

Percent visual weed control for Granite™ herbicide treated plots was higher than weed control by any of the three FP segments tested (pre-emergence, post-emergence and pre-emergence followed by post-emergence) as indicated by positive mean differences. Results of the two sided paired t-test indicate the mean differences are significant (Table 1).

Table 1. Percent visual weed control and labor requirement for hand weeding with Granite™ herbicide and farmer practice.

Herbicide Type as Farmer Practice	Percent Visual Weed Control					Labor Requirement for Manual Weeding				
	Granite	Farmer Practice	Mean Difference	Test Statistic	Prob > ItI	Granite	Farmer Practice	Mean Difference	Test Statistic	Prob > ItI
Pre-emergence	82.4	58.4	24.0	23.7	<0.0001	2.25	7.04	-4.79	-18.5	<0.0001
Post-emergence	79.5	73.5	5.93	2.52	0.0145	2.19	8.86	-6.68	-7.53	<0.0001
Pre-emergence followed by Post-emergence	85.6	74.2	11.5	6.76	<0.0001	1.73	4.02	-2.29	-7.83	<0.0001

In addition, the labor requirement for manual weeding in Granite™ herbicide treated plots was less as compared to any of the three FP segments tested as indicated by negative mean differences which were highly significant. The reduction in manual weeding observed with Granite application is correlated with the higher weed control that was obtained with Granite treatment.

CONCLUSION

Granite™ herbicide is a broad spectrum herbicide that controls *Echinochloa spp* and provides superior control of sedge and broadleaf weeds when applied as a foliar spray at the 1-3 leaf stage of target weeds. When compared with any of the three weed control categories of farmer practices summarized here, the weed control exhibited by Granite™ was significantly better with a reduced requirement for manual weeding.

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Pyroxsulam + sulfosulfuron for cross-spectrum weed control in wheat

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Wheat (*Triticum aestivum*) is the second most important crop in India, grown in 31.2 million ha with 95.9 million tones of production (Economic survey, 2014 - 2015, Govt. of India). It is the staple food of millions of Indians, particularly in the northern parts of the country. While the grass weed species *Phalaris minor* is a significant problem in this area, wheat fields are infested with diverse weed flora that includes a variety of grass and broadleaf weeds species that can cause a considerable decrease in wheat yields (Chhokar *et al.* 2006). To eliminate this cross-spectrum weed flora, farmers require suitable herbicide options for post-emergence weed control. The present research program was undertaken to evaluate the efficacy of apyroxsulam + sulfosulfuron combination (a productin development by Dow AgroSciences) for weed control in wheat in the Indian states of Uttar Pradesh, Uttarakhand, Punjab and Haryana.

METHODOLOGY

Field trials were carried out to evaluate the efficacy of pyroxsulam [4.5 % oil disperable (OD)] + sulfosulfuron [75% wettable granule (WG)]on grass and broadleaf weeds in wheat during the crop seasons of 2012-13 and 2013-2014. Three application rates (12+12, 15+15, and 18+18 g/ha of the pyrosulam + sulfosulfurom product were compared with a mesosulfuron + iodosulfuron (3.0 + 0.6 % WG) formulation applied at 14.4 g/ha. All treatments were applied at the 2-4 leaf stage of weeds that corresponds to 35-45 days after seeding (DAS). The treatments were arranged in a randomised block design with three replications. Experiments targeting *P. minor* were evaluated in fields with probable ALS-resistant and susceptible *P. minor* based the past performance observed for ALS-inhibitor herbicides (based on discussions with farmers). A knapsack sprayer fitted with a single flood jet nozzle was utilized for treatment application. Weed densities (number/m^2) for each species were measured at 30 days after application to determine levels of control. Weed count data was subjected to percent Abbot transformation to calculate percent control compared to untreated plot weed count.

RESULTS

Major weeds included grasses (*Phalaris minor and Poa annua)* and broadleaf weeds (*Anagallis arvensis, Chenopodium album, Coronopus didymus, Medicago sativa, Melilotus spp., Rumex dentatus, Solanum nigrum, Sonchus spp.*, and *Stellaria media*). At all three application rates, pyroxsulam + sulfosulfuron provided effective control of *Poa annua* (100%) and of *Phalaris minor* (>95%) that had a history of being susceptible to ALS inhibitor herbicides (Table 1). In this respect, it was similar to mesosulfuron + iodosulfuon applied at 14.4 g/ha on these populations. In the case of *Phalaris minor* that had a history of resistance to ALS inhibitor herbicides, efficacy of 15+15 and 18+18 g/ha of pyroxusulam + sulfosulfuron was similar to mesosulfuron + iodosulfuron applied at 14.4 g/ha but was superior to sulfosulfuron alone when applied at 25 g/ha (Table 1). Much lower levels of control were achieved with ALS resistant *Phalaris minor* for all herbicide treatments in this study. At all three application rates, pyroxsulam + sulfosulfuron exhibited broad-spectrum activity against broadleaf weeds found in wheat across the Indo-gangetic plains. Control levels were 100% for a majority of broadleaf weeds and were similar to the control achieved with mesosulfuron + iodosulfuron applied at 14.4 g/ha, but far superior to the control achieved with sulfosulfuron applied at 25 g/ha.

Table 1. Percent weed control against grasses and broad leaved weeds in wheat

Treatment	Pyroxsulam + Sulfosulfuron			Mesosulfuron + Iodosulfuron	Sulfosulfuron
	Application rate (g/ha)				
Weeds	12+12	15+15	18+18	12+2.4	25
Grasses					
Phalaris minor (ALS-resistant)	51	59	62	58	48
Phalaris minor (ALS-susceptible)	95	97	98	95	91
Poa annua	100	100	100	100	71
Broad-leaved weeds					
Anagallis arvensis	100	100	100	100	84
Chenopodium album	100	100	100	100	92
Coronopus didymus	100	100	100	100	0
Medicago sativa	100	100	100	100	79
Melilotus spp.	100	100	100	100	30
Rumex dentatus	100	100	100	100	16
Solanum nigrum	100	100	100	100	89
Sonchus spp.	100	100	100	100	0
Stellaria media	100	100	100	100	60

P.S.- Pyroxsulam + Sulfosulfuron is currently under development in India

CONCLUSION

A new pyroxsulam + sulfosulfuron product in development by Dow AgroSciences will offer Indian farmers an effective single product alternative for cross spectrum weed control in wheat. At its recommended rates of 15+15 to 18+18 g/ha, this new product will provide wheat growers superior control of most important broadleaf weeds and ALS susceptible *Phalaris minor*.

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Weed control effects of tefuryltrione + triafamone paddy fields in South Korea

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Rice (*Oryza sativa* L.) is the most important food crop in South Korea because it is principal source of food. From the nation-widesurvey, 90 weed species in 28 families were identified and classified to 52 annuals, 3 biennials and 35 perennials (Ha *et al*. 2014). Tefuryltrione is a new herbicide in the South Korean market. It belongs to the triketone group and HPPD-inhibitor. Triafamone is a new sulfonylurea herbicide, which causes inhibition of the enzyme acetolactate synthase(ALS) (Rosinger *et al*. 2012). The purpose of this study was to determine whether tefuryltrione + triafamoneGR can be used for control of several grass and broad-leaf weeds in ricepaddy field.

METHODOLOGY

Field experiments were conducted at four field sites(central and south regions of Korea) on sandy loam soils in 2013.We trialled two rates of tefuryltrione + triafamone GR (Council®, 0.67 + 0.17%, Bayer CropScience, South Korea): 201+51 g/ha (measuring herbicidalactivity and phytotoxicity) and 402 + 102 g/ha (measuring phytotoxicity only) and one rate of the herbicide bromobutide + pyrazosulfuron-ethyl + pyriminobac-methyl GR (Sambakja®3 + 0.07 + 0.1 % Sungbo chemical, South Korea) 900 + 21 + 30 g/ha (measuring herbicidal activity only). All treatments were applied at 15 days after transplanting. Experimental design was a randomized complete block design with three replications per treatment and plot sizes of 20 m^2. Weed control evaluations were made at 40 DAT (days after treatment) by percent reduction in dry weight relative to the untreated control. Phytotoxicity was recorded at 10, 20, 30 and 40 DAT by visual assessment using a 0 - 9 scale (0 = no injury, 9 = killed.

RESULTS

Herbicidal Activity

Tefuryltrione+triafamone GR at 201+51 g/ha provided 96.9-99.2% control of annual weeds in paddy fields, with resulting weed dry weights of 0.0-2.7 g and 97.2-98.1% control of perennial weeds, with resulting weed dry weights of 0.2-1.1 g (Table 1). These results were high or similar to bromobutide + pyrazosulfuron-ethyl + pyriminobac-methyl GR at 900 + 21 + 30 g/ha, which provided 86.5-100% control and 0.0-7.4 g weed dry weights of annual weeds, and 94.4-97.0% control and 0.3-1.5 g weed dry weights of perennial weeds.

Table 1. Weed control effect of tefuryltrione + triafamone GR on dry weight of annual and perennial weeds in rice paddy fields

Treatments (Dose[1?])	Annual weeds			Perennial weeds		
	ECCR[2?]	MOVA	LIPR	SATR	ELKU	SCJU
Dry weight (g)						
Tefuryltrione+triafamone GR(201+51)	2.7	0.1	0.0	0.2	1.1	0.4
Bromobutide+pyrazosulfuron-ethyl+pyriminobac-methyl GR(900+21+30)	7.4	7.0	0.0	0.3	1.5	0.7
Untreated Control	90.4	47.0	6.1	13.2	31.3	19.1
Weed control value (%)						
Tefuryltrione+triafamone GR(201+51)	$96.9^{a3?}$	99.2^{a}	99.1^{a}	97.8^{a3}	97.2^{a}	98.1^{a}
Bromobutide+pyrazosulfuron-ethyl+pyriminobac-methyl GR(900+21+30)	91.0^{b}	86.5^{b}	100^{a}	96.9^{a}	94.4^{a}	97.0^{a}

[1?] Dose unit = g a.i./ha; [2?]ECCR = *Echinochloa crus-galli*,MOVA =*Monochoria vaginalis, LIPR =Lindernia procumbens*; SATR =*Sagittaria trifolia*, ELKU =*Eleocharis kuroguwai, SCJU =Scirpus juncoides.; [3?]*Means within columns followed by the same letter were not significantly different at 5% level by Tukey test.

Phytotoxicity

Evidence of phytotoxicity in rice varied depending upon the regions, and some evidence (1-2) was seen at 10, 20 and 30 DAT, however all plants recovered by 40 days after treatment

CONCLUSION

It was concluded that Tefuryltrione+triafamone GR (201 + 51 g/ha) may be useful in general weeds control on rice paddy fields in South Korea.

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A herbicide can also work as a fungicide

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Ginger (*Zingiber officinale* Rosc.) is one of the oldest spices known for its aroma and pungency. India is the leading producer of ginger in the world accounting for about one third of the total world output. Among different diseases, rhizome rot threatens ginger production seriously resulting a total loss of affected clumps. The management options of the disease comprise of selection of a well drained soil, treating the planting material with 0.3% mancozeb, immediate removal of affected clumps and drenching of the field with 0.3% mancozeb which is repeated at 30 days interval. Present investigation was taken up after an unexpected observation of control of the rhizome rot disease in the herbicide metribuzine treated plots in a field experiment conducted to evaluate the performance of different weed management practices in ginger.

METHODOLOGY

In the laboratory, fungus *Fusarium oxysporum*, the causal organism of the disease was isolated from the infected sample of ginger rhizome and the test was carried out for it. Here the fungal test was carried out by poison food technique using Potato Dextrose Agar (PDA) as media. For the test, 20 ml of PDA was melted each in four numbers of 50 ml conical flask. PDA from the first conical flask was poured into the first petriplate and allowed to solidify. In the second conical flask 30 mg of metribuzine was added and shaked well. Thereafter, poured into the second petriplate and allowed to solidify. In the third conical flask 60 mg of mancozeb was added and shaked well and then poured into the third petriplate. In the fourth conical flask both metribuzine 30 mg and mancozeb 60 mg were added, shaked well and poured into the fourth petriplate. Thereafter, small amount of fungus was introduced into the petriplates and incubated for 72 hours and observations were taken for 7 subsequent days.

RESULTS

From the observation, largest colony with full mycellial growth on the 7th day was recorded under control with a diameter of 8.1 cm followed by 6.9 cm diameter under mancozeb treatment. The observation further revealed that metribuzine treatment gave a colony size of 0.9 cm with minute mycellial growth on the 7th day. Whereas, combined application of metribuzine and mancozeb gave a further reduced sized colony with a diameter of 0.5 cm along with a very minute mycellial growth. This might be due the presence of sulphur group in the herbicide. Similar results of effectiveness of sulphur against brown rot in stonefruit (McLaren *et al.* 1996) and root rot in sugarbeet (Ruppel and Hecker, 1983) has been mentioned. Besides sulphur, the herbicide also contains an amide functional group which is common to the recommended fungicide mancozeb which might also be responsible for its efficacy against the fungus.

Table 1. Effectiveness of metribuzine against fungus-*Fusarium oxysporum*)

Days	Control	Metribuzine	Mancozeb	Metribuzine + Mancozeb
Day 1	Mycellial growth started	No mycellial growth	Mycellial growth started	No mycellial growth
Day 2	Enlargement of colony	No mycellial growth, no enlargement of colony	No enlargement of colony	No mycellial growth and no enlargement of colony
Day 3	Further enlargement of colony (dia 3.2 cm) and mycellial elongation	No enlargement of colony, very minute mycellial growth	Mycellial elongation and colony dia 0.9 cm	Very minute mycellial growth
Day 4	Further enlargement of colony (dia 4.5 cm) and mycellial elongation	No further development	Mycellial elongation and colony dia 3 cm	No further development
Day 5	Further enlargement of colony (dia 5.1 cm) and mycellial elongation	No further development	Mycellial elongation and colony dia 4.3 cm	No further development
Day 6	Further enlargement of colony (dia 6.3 cm) and mycellial elongation	No further development	Mycellial elongation and colony dia 5.1 cm	No further development
Day 7	Further enlargement of colony (dia 8.1 cm) and mycellial elongation	Slight enlargement of colony with dia 0.9 cm	Whole pertiplate was occupied with a dia 6.9 cm	No enlargement of colony, dia 0.5 cm

CONCLUSION

It could be concluded from the study that the herbicide metribuzine was effective against the fungus (*Fusarium oxysporum*). However, further investigation is required to confirm the specific action of the functional groups present in the herbicide structure against this fungus causing rhizome rot disease of ginger.

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Calaris Xtra 275 SC (mesotrione 2.27% + atrazine 22.72,w/w): A promising post-emergence herbicide for spring-planted sugarcane

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Productivity of sugarcane in sub-tropics is lower than tropical region. Among the factors responsible for low productivity, negligence towards weed management is one of the most important factors in reducing the cane yield. Sugarcane faces tough competition with weeds between 60 to 120 days of its planting which causes heavy reduction in cane yield ranging from 40-67 % (Chauhan and Srivastava, 2002). Yield losses due to weeds may be checked by either cultural or chemical means, no doubt mechanical means not only control weeds but also create favorable conditions for the growth to crop plants. But due to non-availability of agricultural labors at that time (60-120 days stage) because labors are busy in wheat harvesting/threshing and other works and also cumbersome and hence weeds may be managed by chemical application. On the basis of experiments conducted it was observed that neither pre nor post-emergence herbicide application alone control weeds upto satisfactory level. There is need to develop such herbicide combination which are economically viable, practically favorable and ecologically used weed management, hence the present investigation was under taken for two consecutive years *i.e.* 2013-14 and 2014-15 during spring season.

METHODOLOGY

A field experiment was conducted during 2013-14 and 2014-15 at Norman E. Bourlaug Crop Research Center of Govind Bhallabh Pant University of agriculture & Technology, Pantnagar (Uttarakhand) in spring season (Feb./ march). Nine treatments (Table 1) were tested for weed control and to see their effects on cane yield and quality. Three budded sets of sugarcane variety Co pant 5224 (mid late) were planted on 6.4.2013 during 2013-14 and 10.4.2014 during 2014-15 at 75 cm apart row to row in flat bed planting of sugarcane. Setts were treated with carbendazim at 0.2% before planting to avoid any infection. Post emergence herbicides (Calaris Xtra 275 SC) is a combination of (mesotrione 2.27% + Atrazine 22.72 %) and mesotrione at 48 SC were applied 3-4 leaf stage of weeds. 2,4-D Dimethyl Amine Salt 58% SL was also applied post-emergence 75 DAS at 3500 g/ha. Atrazine 50% WP at 1500 g/ha was applied as pre-emergence (just after planting) alone and in one of the treatment atrazine 1500 g/ha (PE) *fb* 2,4-D at 1000 g/ha applied at 75 DAP. Calaris xtra 275 SC (Mesotrione 2.27% + atrazine 22.72%) was applied at 750, 850, 1000 g/ha (2-4 leaf stage of weeds) and mesotrione at 120 g/ha (2-4 leaf stage of weed growth). Hoeing at 30, 60 and 90 days after planting was also given. All the herbicidal/mechanical treatments were tested along with control (untreated). Experiment was conducted in randomized block design. All the treatments were replicated 3 times. Experimental soil was silty clay loam in texture having organic carbon 1.02% and pH of the soil was 7.3.

RESULTS

Grassy weeds (*Echinochloa colona, Eleusine indica, Brachiaria mutica, Digitaria sanguinalis, Dactyloctenium aegyptium*) contributed 69% and non-grasses (*Trianthema monogyna, Commelina benghalensis, Euphorbia hirta* and *Ipomoea hederacea*) contributed 24.2%. *Cyperus rotundus* was the only sedge contributed 7.0%. Total weeds highest in untreated check, were reduced significantly in all the herbicidal treatments 28 days after herbicide application. Lowest population was recorded in the treatment Calaris Xtra 275 SC applied at 1000 g/ha which was found significantly lower then rest of the treatments. However, there was decreasing trend in Calaris Xtra treated plots and weeds were reduced as the rate of application of Calaris Xtra was increased 750 g/ha to 1000 g/ha. Total weeds were almost the

Table 1. Population, growth of weeds, cane yield and CCS yield influenced by various treatments in spring planted sugarcane (pooled) 2013-14 and 2014-15

Treatment	Weeds/m^2 at 28 days after herbicide application				Weed dry matter g/m^2 at 28 DAHA	Weed control efficiency (%) at 28 DAHA	Weed index (%)	Cane yield (t/ha)	CCS yield (t/ha)
	Grasses	Non-grasses	Sedges	Total					
Untreated check	5.5(262.3)	4.5(91.9)	3.3(26.5)	5.9(178.8)	5.20(178.8)	0.00	21.7	67.7	7.50
Calaris Xtra 275 SC at 750 g/ha	4.4(87.1)	2.6(12.4)	2.2(8.2)	4.7(107.6)	4.40(80.6)	54.9	17.1	71.7	8.30
Calaris Xtra 275 SC at 875 g/ha	2.6(13.3)	2.3(8.9)	1.2(2.2)	3.2(24.5)	2.80(15.2)	91.5	5.50	81.7	8.50
Calaris Xtra 275 SC at 1000 g/ha	1.2(2.20)	0.0(0.00)	0.0(0.0)	1.2(2.2)	0.80(1.10)	99.3	2.80	84.1	8.60
Mesotrione 48 SC at 120 g/ha	5.5(240.0)	1.5(3.40)	1.6(3.9)	5.5(246.8)	5.1(160.5)	10.2	18.0	70.9	8.30
Atrazine 50% WP at 1500 g/ha	3.5(31.5)	3.5(32.3)	0.7(1.0)	4.3(72.8)	3.0(30.8)	82.8	9.70	78.1	8.00
2,4-D Dimethyl Amine Salt 58% SC at 3500 g/ha	5.5(238.7)	2.3(9.60)	1.9(6.1)	5.5(254.6)	3.7(40.5)	77.3	18.5	70.5	7.80
Hoeing at 30, 60 and 90 DAP	2.4(10.3)	1.4(3.00)	2.9(18.3)	3.4(31.3)	2.4(10.2)	94.3	0.0	86.5	8.50
Atrazine at 1500 g/ha PE fb 2,4-D at 1000 g/ha at 75 DAP	3.3(25.1)	1.8(4.90)	2.5(11.4)	3.7(41.3)	4.9(50.3)	71.9	7.3	80.2	8.50
LSD (P=0.05)	0.07	0.10	0.07	0.80	0.09	-	-	2.90	0.40

*Weed data transformed (log X+1), **Original data under parenthesis, DAHA - Days after herbicide application same in mesotrione 48 % SC applied at 120 g a.i./ha and 2, 4-D Dimethyl Amine salt 58 % SC at 3500 g a.i./ha. Because both the herbicide could not controlled grassy weeds effectively and the contribution of grassy weeds was higher (69 %). Hoeing at 30, 60 and 90 days after planting reduced. Total weeds similar to atrazine 1500 g a.i./ha (PE) *fb* 2,4-D at 1000 g a.i./ha at 75 DAP. Calaris Xtra at 1000 g a.i./ha killed grasses, non-grassy and sedges completely at 28 days after herbicide application. Highest weeds control efficiency (WCE %) was recorded in Calaris Xtra 275 SC applied at 1000 g a.i./ha because of the lowest weed dry matter accumulation in this treatment which was significantly lower than rest of the treatments. Highest reduction in cane yield was recorded 22 % in untreated plots and lowest in caleris xtra 275 SC applied at 1000 g a.i./ha. Almost similar CCS yield (t/ha) was recorded in the treatment calaris xtra 275 SC applied at 1000 g a.i./ha, hoeing at 30, 60, 90 days after planting or in the treatment atrazine applied at 1500 g a.i./ha (PE) followed by 2,4-D at 1000 g/ha (75 DAP).

CONCLUSION

For higher productivity in spring season planted sugarcane in sub-tropics, weed may be controlled either by mechanically (hoeing 30, 60 or 90 days after planting) or calaris xtra 275 SC (Mesotrione 2.27% + atrazine 22.72%) applied at 1000 g a.i./ha at 2-4 leaf stage of weed growth. Calaris Xtra at 1000 g a.i./ha controlled grasses, non-grasses and sedges applied at 2,4-D leaf stage of weeds as post-emergence. Reduction in cane yield in untreated plots was recorded 21.7%. Grassy weeds contributed 69% and non-grassy 24.2% among total weed population. *Cyperus rotundus* was the only sedge contributed 7%.

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GF-2819 (Halauxifen-methyl + fluroxypyr-meptyl): A new ALS-R broadleaf weed solution for GALAP and MYTAQ control in Yangtze-river winter wheat area of China

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Galium aparine (GALAP) and *Myosoton aquaticum* (MYTAQ) are two dominate broadleaf weeds in the wheat-rice rotation area in Yangtze River of China. Incidence of resistance for these two weeds to ALS-R herbicides has developed rapidly in the past decade due to continuous and intensive use of tribenuron. Arylex™ Active (halauxifen methyl) is a new systemic auxin herbicide in the new "arylpicolinate" herbicide chemical class under development by Dow AgroSciences. It provides effective control of ALS-R broadleaf weeds such as GALAP, DESSO, and CAPBP. Fluroxypyr is an auxin herbicide first developed by Dow AgroSciences in 1980s that has been widely used to control broadleaf weeds including ALS-R GALAP, MYTAQ, and (EPHHE) in wheat. GF-2819 is a mixture of Arylex + fluroxypyr (12+280 g/l EC formulation) and was tested (2013-2014) in a number of field trials in China to determine the performance and to define the effective use rate for the control of ALS-R GALAP and MYTAQ. Field results indicated that GF-2819 at rate of 131.4 g/ha or higher provides excellent control (greater than 95% control) of ALS-R MYTAQ and GALAP when applied in winter or early spring. Its performance was significantly higher than tribenuron alone at 30 g/ha which provided only 33%-54% control of MYTAQ and 18-23% control of GALAP. GF-2819 is a new herbicide mixture product that will provide an effective management tool for ALS-R GALAP and MYTAQ in the wheat-rice rotation area in Yangtze River of China.

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Comparison of physiological effects between auxinic herbicides quinclorac and 2,4-D in *Arabidopsis thaliana* seedlings

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2,4-dichlorophenoxyacetic acid (2,4-D), one of auxinic herbicides, is recognized in TIR1/AFB auxin receptors. In previous study, TIR1 and AFB2 have shown to play an important role in 2,4-D mediated root growth inhibition (Parry *et al*. 2009). Quinclorac (3,7-dichloro-8-quinolinecarboxylic acid) is also one of auxinic herbicides, but the details of physiological effects and receptors have not got clarified.

METHODOLOGY

1. Quinclorac-induced growth inhibition of *Arabidopsis* and the effects of TIR1/AFB antagonist treatment

Five-days-old seedlings were transferred onto MS media containing different concentrations of quinclorac and 2,4-D. After 5 days, root length was measured and GR_{50} (herbicide dose required to cause 50% reduction in plant growth) values were estimated. TIR1/AFB antagonist was treated in addition to quinclorac and 2,4-D.

2. Auxin-responsive gene expression induced by quinclorac

To clarify auxin-responsive genes expression patterns, *Arabidopsis* transgenic *DR5::GUS* and *BA3::GUS* reporter lines were used. Ten-days-old seedlings were treated with quinclorac and 2,4-D. After the GUS induction, GUS activities were observed.

3. Global gene expression induced by quinclorac

Total RNA was extracted from shoots of *Arabidopsis* seedlings after quinclorac or 2,4-D treatment. After microarray analysis, quinclorac-mediated global gene expression was compared to that induced by 2,4-D.

RESULTS

GR_{50} values of quinclorac and 2,4-D were 30 µM and 0.05 µM, respectively. These growth inhibitions were recovered by TIR1/AFB antagonist treatment, suggesting that quinclorac-mediated root growth inhibition was related to the perception in TIR1/AFB auxin receptors.

Quinclorac induced *DR5::GUS* expression in hypocotyls and leaves, not in roots, whereas 2,4-D induced in hypocotyls, leaves, and also in roots. *BA3::GUS* expression was induced only in hypocotyls by quinclorac. 2,4-D induced in hypocotyls, leaves, and roots. Quinclorac-induced gene expression was different from that induced by 2,4-D.

CONCLUSION

Quinclorac induced auxin-responsive gene expression mainly in hypocotyls. Quinclorac physiological effects may be different from that of 2,4-D in *A. thaliana* seedlings .

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QUELEX™ herbicide (halauxifen-methyl + florasulam): a new post-emergent broad-leaf weed herbicide product for china winter wheat production systems

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Arylex™ Active (halauxifen methyl) is a new systemic herbicide in the new "arylpicolinate" auxin chemical class under development by Dow AgroSciences. Arylex provides post-emergent control of economically pertinent broadleaf weeds including some herbicide-resistant species, low use rate technology, consistent weed control across variable climatic conditions, rapid degradation in soil and plants, and favourable environmental and toxicology profiles. Quelex 20% WG (wettable granule) is a 1:1 ratio of Arylex (ae) and florasulam. It is the first new product to be developed specifically for the control of ALS-resistant broadleaf weeds in wheat in China. Research trials conducted in the field from 2012 through 2014 were designed to determine the efficacy of Quelex against the four most important weeds in winter wheat: *Galium aparine* (GALAP); *Descrainia sophia* (DESSO); *Capsella bursa-pastoris* (CAPBP); and *Stellaria media* (STEME). In addition efficacy on several other locally important weeds was determined. Quelex at 15-20 g/ha provided effective control of GALAP, DESSO, and CAPBP when sprayed in the winter. Quelex did not provide effective control of STEME compared with the commercial standard herbicide product - tank-mixing with florasulam at 9 g/ha, fluroxypyr at 90 g/ha and carfentrazone at 22.5 g/ha. Quelex at 15-20 g/ha applied in the winter or spring provided excellent control of locally important weeds including *Lamium amplexicaule* (LAMAM). Quelex at 15 g/ha applied in the fall provided effective control of *Lithospermum arvense* (LITAR), *Euphorbia helioscopia* (EPHHE), and *Veronica persica* (VERPE); but only moderate control (40-60%) of EPHHE and VERPE when applied in early spring. For LITAR control in early spring applications, 20 g/ha of Quelex was required to give acceptable control. Currently, the increased occurrence of ALS-resistant weed biotypes threatens and limits winter wheat production in China. Quelex will be a useful tool to control ALS-resistant weeds and improve sustainability of cereal crop production systems in China.

Evaluation of bensulfuron-methyl for weed control efficacy and grain yield of transplanted rice

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Rice (*Oryza sativa* L.) is the most important staple food for more than half of the world's population. In India, rice is cultivated over an area of 43.77 million ha under different situations of cultivation with different degree of infestations of weed species. Herbicide selectivity and efficacy in transplanted rice can be improved by adjusting the time of application, reducing the dose of the herbicide, mixing of herbicides *etc*. Considering these situations, a field experiment was conducted to evaluate the efficacy of Bensulfuron methyl 60% DF as pre-emergence (PE), post-emergence (POE) and mixed with Pretilachlor for control of complex weeds in transplanted rice. The use of herbicides offers selective control of weeds right from beginning, giving crop an advantage of good start and competitive superiority over weeds (Saha 2005).

METHODOLOGY

Field experiments were conducted at the experimental site of Tamil Nadu Agricultural University, Coimbatore during *Kharif* and *Rabi* season of 2012 to evaluate the efficacy of Bensulfuron methyl 60% DF as pre-emergence (PE), post-emergence (POE) and mixed with Pretilachlor for control of complex weeds in transplanted rice. Trial was conducted in soil with fine clay loam type of soil and belonging to *Typic chromusterts* soil group with a plot size of 4.0 x 5.0 m. The experiment was laid out in randomized complete block design with seventeen treatments and replicated thrice. Short duration rice variety Co (R) 50 was used in the field experiment. Bensulfuron methyl 0.6% was applied as PE at 60, 90 g/ha and POE at 60, 90 g/ha and Bensulfuron methyl 0.6% + Pretilachlor 6% GR at 60 + 600, 90 + 900 g/ha respectively. These treatments were compared with PE Butachlor 1.0 kg/ha, Bensulfuron methyl 0.6% + Pretilachlor 6% GR (Londax power) at 60 + 600 g/ha, Hand weeding twice at 20 and 40 DAT and unweeded control. Observations like total weed density, dry matter production and yield were recorded.

RESULTS

At 40 DAHS, a remarkable reduction in total weed density was recorded with the application of post-emergence bensulfuron 90 g/ha which was comparable with post emergence of bensulfuron at 60 g/ha and pre-emergence application of bensulfuron 90 g/ha + pretilachlor 900 g/ha. Total weed dry weight was lower with the pre-emergence application of bensulfuron 90 g/ha + pretilachlor 900 g/ha, post-emergence bensulfuron 90 g/ha and post-emergence bensulfuron 60 g/ha. Higher weed control efficiency of 91.10 and 90.73% were registered with the application of PE Bensulfuron at 90 g/ha + Pretilachlor at

900 g/ha and bensulfuron at 90 g/ha, respectively. The result showed that, Grain yield of transplanted rice was obviously higher due to post-emergence application of bensulfuron at 60 g/ha (6.31 t/ha) and it was on par with pre-emergence application of bensulfuron at 60 g/ha (6.01 t/ha), pre-emergence application of

bensulfuron methyl 60 g/ha + pretilachlor (Londax power) 60-100 g/ha (5.90 t/ha) and pre-emergence bensulfuron methyl 60 g/ha + pretilachlor 600 g/ha (5.84 t/ha). Lower grain yield was registered under unweeded check of 3.76 t/ha (Table 1). Saha (2009) reported that, application of bensulfuron methyl either alone at 60 g/ha or tank mixture with pretilachlor at 50 + 450 g/ha produced significantly higher grain yield and it was at par with the recommended practice of hand weeding twice.

Table 1. Weed management treatments on total weed density, dry weight, WCE at 40 DAHS and grainyield in transplanted rice (mean of two seasons)

Treatment	Total weed density (no./m^2)	Total weed dry weight (g/m^2)	WCE (%)	Grain yield (t/ha)
T_1 -PE Bensulfuron at 60 g/ha	3.54 (10.5)	3.48 (10.1)	82.7	6.01
T_2 -PE Bensulfuron at 90 g/ha	3.23 (8.42)	3.35 (9.22)	84.3	5.62
T_3 -POE Bensulfuron at 60 g/ha	2.67 (5.12)	3.04 (7.22)	87.7	6.31
T_4 -POE Bensulfuron at 90 g/ha	2.35 (3.53)	2.73 (5.44)	90.7	5.21
T_5 -PE Bensulfuron at 60 g/ha + Pretilachlor at 600 g/ha	3.50 (10.3)	3.64 (11.2)	80.9	5.84
T_6-PE Bensulfuron at 90 g/ha + Pretilachlor at 900 g/ha	2.76 (5.62)	2.69 (5.22)	91.1	5.42
T_7-PE Bensulfuron at 60 g a.i./ha + Pretilachlor (Londax power) at 600 g/ha	3.68 (11.6)	3.25 (8.56)	85.4	5.90
T_8- Hand weeding twice at 25 and 50 DAT	3.53 (10.5)	3.68 (11.6)	80.2	5.61
T_9 - Unweeded check	6.39 (38.8)	7.79 (58.7)	-	3.76
LSD (P=0.05)	0.96	1.23	-	605

Figures in parentheses are original values, Data subjected to square root transformation

CONCLUSION

Either pre-emergence or post-emergence application of bensulfuron at 60 g/ha and pre-emergence application of bensulfuron methyl 60 g/ha + pretilachlor 600 g a.i./ha were good for higher weed control efficiency and grain yield in transplanted rice.

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Bioefficacy evaluation of new combination herbicide (bispyribac-sodium 4% SE + metamifop 10% SE) on weeds of direct-seeded rice

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Direct seeded rice is gaining momentum in India due to high demand of labour during peak season of transplanting and short period availability of water. Direct seeded rice is subjected to greater weed competition than transplanted rice because both weeds and crop seeds emerge at the same time and compete with each other from germination resulting in lesser grain yield. Choubey *et al*. (2001) reported that, the higher weed infestation is a major problem in direct seeded rice and causes grain yield loss upto 90%. Moreover, the rice herbicides presently used are mainly pre emergence and weeds coming at later stages of crop growth are not controlled as effectively as at emergence stage. This situation warranted for initiating research efforts to evaluate and identify suitable post emergence herbicides. But sometimes continuous use of a single herbicide may lead to build up of herbicide resistance in weeds. Hence, there is a need to focus attention on herbicide combination to enhance the weed control efficiency, broad spectrum of weed control and saving the herbicide and labour requirements.

METHODOLOGY

Field experiment was conducted at the Wetland Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, is the Southernmost State in the Indian Union. The experimental farm is located at 77 E 11ºN latitude 426 metre above mean sea level and the farm receives the normal total annual rainfall of 674.2 mm in 45.8 rainy days. The experiment was laid out in randomized complete block design with ten treatments and replicated thrice. Manually operated rice drum seeder developed by Tamil Nadu Agricultural University, Coimbatore was used for sowing the seeds. It drops the seeds at 20 cm apart in continuous row. At a time, eight rows of rice seeds are sown. New molecule of herbicide combination bispyribac sodium 4% SE + metamifop 10% SE was applied as post-emergence herbicide on 10-15 DAS.

RESULTS

During both the year of study, at 40 DAHS, post-emergence application of herbicide combination bispyribac sodium 4% SE + metamifop 10% SE at 140, 70 g/ha + PIW-111 wetter, bispyribac sodium 4% SE + metamifop 10% SE at 70 g/ha without wetter and bispyribac sodium 4% SE + metamifop 10% SE at 56 g/ha + PIW-111 wetter registered higher WCE. Post-emergence application of herbicide combination bispyribac sodium 4% SE + metamifop 10% SE at 140 g/ha + PIW-111 wetter recorded significantly higher grain yield of 5.89 and 6.49 t/ha and which was comparable with application of herbicide combination bispyribac sodium 4% SE + metamifop 10% SE at 70 g/ha + PIW-111 wetter of 5.68 and 6.39 t/ha and bispyribac sodium 4% SE + metamifop 10% SE at 70 g/ha without wetter of 5.49 and 6.23 t/ha significantly superior to the rest of the treatments (Table 1). Veeraputhiran and Balasubramanian (2010) reported that application of bispyribac sodium at 50 g/ha recorded the higher grain yield. This favoured the rice to produce more LAI and plant dry matter production, increased productive tillers and grain yield over unweeded check. The economic analysis of weed management practices in direct seeded rice revealed that the higher net return of' Rs 45,126 and 51,406 /ha was obtained with the post-emergence application of bispyribac sodium 4% SE + metamifop 10% SE at 140 g/ha + PIW-111 wetter than the rest of the weed control methods adopted.

Table 1. Effect of weed management practices on grain yield, weed index and economics in direct seeded rice

Treatment	*Kharif* 2012				*Rabi* 2012			
	Grain yield (t/ha)	WCE at 40 DAHS (%)	Net return (10^3 Rs/ha)	BC ratio	Grain yield (t/ha)	WCEat 40 DAHS (%)	Net return (10^3 Rs/ha)	BC ratio
T_1 - Bispyribac sodium 4% SE + metamifop 10% SE at 42 g/ha + PIW-111 wetter	4.29	60.22	27.32	2.13	4.66	63.1	31.09	2.25
T_2 - Bispyribac sodium 4% SE + metamifop 10% SE at 56 g/ha + PIW-111 wetter	4.98	69.73	35.41	2.46	5.72	72.1	43.63	2.74
T_3 - Bispyribac sodium 4% SE + metamifop 10% SE at 70 g/ha + PIW-111 wetter	5.68	80.07	43.56	2.77	6.39	81.7	51.41	3.03
T_4 - Bispyribac sodium 4% SE + metamifop 10% SE at 140 g/ha + PIW-111 wetter	5.89	86.01	45.13	2.76	6.49	86.9	51.55	2.95
T_5 - Almix (Chlorimuron + Metsufuron 20% WP) at 4 g/ha	4.95	62.63	35.60	2.50	5.79	65.1	45.03	2.84
T_6 - Clincher (Cyhalofop Buthyl 10% EC) at 80 g a.i./ha	4.40	58.36	28.04	2.13	5.25	66.5	37,466	2.46
T_7 - Bispyribac sodium 10% SC at 20 g/ha + PIW-111 wetter	5.44	66.06	40.05	2.59	6.08	65.6	46.96	2.81
T_8 - Metamifop 10% SE at 50 g/ha + PIW-111 wetter	5.00	50.22	35.39	2.44	5.75	61.5	43.62	2.72
T_9 - Bispyribac sodium 4% SE + metamifop 10% SE at 70 g /ha	5.49	73.10	41.11	2.66	6.23	80.1	49.33	2.93
T_{10} - Bispyribac sodium 10% SC at 20 g/ha	5.17	59.00	36.95	2.48	5.91	61.8	45.18	2.75
T_{11}- Metamifop 10% SE at 50 g/ha	4.28	47.89	26.86	2.10	4.97	55.7	34.47	2.37
T_{12} - PIW-111 wetter	2.97	15.32	11.97	1.51	3.68	5.4	19.86	1.81
T_{13} - Unsprayed control	2.73		9.96	1.44	3.01		12.59	1.535
LSD (P=0.05)	6.88	-	-	-	6.23	-	-	-

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Pesticide regulation in India with reference to herbicides

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Herbicides, insecticides & fungicides broadly known as 'pesticides', are one of the essential inputs in sustaining agricultural production of the country to feed its burgeoning population. As pesticides are meant to kill, they are toxic and, thus, inherently hazardous. Accidental contamination of food stuff with pesticides in late 50s and early 60s, led to their regulation under a comprehensive legislation, namely, The Insecticides Act, 1968 (the Act). The rules, namely The Insecticides Rules, 1971 (the Rules), were subsequently framed to give effect to the provisions of the Act.

So far 870 such molecules have been included in the schedule to the Act. Such inclusion is done by the Central Government on the recommendation of the Central Insecticides Board, which too is constituted by the Central Government through a Gazette Notification under Section 4 of the Act. The Board advises the Central and State Governments on technical matters arising out of administration of this Act on matters such as risk to human beings or animals involved in the use of insecticides and safety measures necessary to prevent such risk and on the matters, relating to manufacture, sale, storage, transport and distribution of insecticides with a view to ensure safety to human beings or animals.

Any person desiring to import or manufacture any herbicide/insecticide/fungicide has to make an application to the Registration Committee (RC), constituted by the Central Government under Section 5 of the Act and obtain a registration under Section 9. Main function of the Registration Committee is to scrutinize the formulae of pesticides and verify claims regarding efficacy and safety to human beings and animals and environment. The Registration Committee has the powers to decide its own procedure to conduct its business. The Registration Committee frames guidelines for different categories of registration so as to avoid arbitrariness in scrutinizing applications and achieving satisfaction with regard to efficacy and safety of pesticides before granting registration, *i.e.* before permitting their use. As per the recommendation of the Joint Parliamentary Committee on Pesticide Residues in and Safety Standards for Soft Drinks, Fruit Juice and other beverages, no registration for use of pesticides in agriculture is granted without fixing of Maximum Residue Limits (MRLs) except for certain exemptions. Registration Committee grants three types of registrations under Section 9 of the Act, *viz.* (i) provisional registration on the basis of minimum data for two years for first time introduction of pesticides under Section 9 (3B) to facilitate complete data generation; (ii) a regular or "original" registration under section 9 (3) based complete scientific data as per the guidelines of the Registration Committee; and (iii) a repeat or "me too" registration for the same pesticide on same conditions under Section 9 (4) as already granted under section 9 (3).

Registration for import or manufacture for the purpose of export only purpose are also granted under Section 9 (3) on fast track to facilitate exports, wherein no scientific data is sought. Registrations for bio-pesticides are also granted under Section 9 (3B) and 9(3) with commercialization to encourage their use and promote environment-friendly Integrated Pest Management approach of plant protection. As on date 260 technical along with their 585 formulations have been registered for use in the country. Out of which 57 are herbicides technical with 75 formulations and 19 are Plant Growth Regulators (PGRs). There is no repeat or "me too" registration for bio-pesticides as chemical equivalence cannot be established being culture-based products. Registration of pesticides is on such conditions as may be laid down by the Registration Committee and can be modified from time-to-time. A pesticide can be refused registration, if the claims on its efficacy or safety are not proved by the scientific data, and a registration, if already issued can also be cancelled in the interest of public safety. No person can import or manufacture a pesticide in contravention to the provisions of the Act or the Rules.

Once the registration has been obtained by a person, he also has to obtain a license to manufacture, stock, distribute and sell the product from the State in which he proposes to conduct the business. However, for issuance of license for stocking, distribution, retail sale or commercial pest control operations, registration is not a pre-requisite. No person can manufacture, stock, distribute, sell or undertake commercial pest control operations using a pesticide in contravention to the provisions of the Act or the Rules.

The Act provides for joint responsibility of the central and State Governments for monitoring the quality of pesticides. Both can appoint Insecticide Inspectors to inspect manufacturing, stocking or sale premises at any reasonable time to ensure the compliance of conditions of registration and licensing, and also take copies of records besides samples of products manufactured, stocked, distributed or sold by them and have them tested/analyzed as per the specifications approved by the Registration Committee. Interfering with the duties of an Insecticide Inspector is a punishable offence under the Act. The first analysis of a sample is carried out by an Insecticide Analyst, who can be appointed by the Central or State Government, and in case of its non-conformation to the relevant specification and challenge, there is a provision for appellate testing/analysis at the Central Insecticides Laboratory, whose results are conclusive evidence of the facts stated therein.

Any person, who contravenes any provision of the Act or the Rules is liable to administrative action, *viz.* suspension or cancellation of license, *etc* and punishable as per the penal provisions laid down under section 29 of the Act, which envisage fine as well as imprisonment varying with the category of offence, including publication of name and address of offenders in the news papers in case of frequent commitment of offences by the same person.

The Act has been in operation for the last over four decades, after publication of the Rules in 1971. The administrators, the regulators, the registrants, the licensees and the users, all have been feeling that there is a need to bring improvement for better regulation. A bill, namely The Pesticides Management Bill, 2008/2014 is under consideration of Government. In addition to this Act, relevant provisions in EPA Act, Factories Act, FSSAI are enforced for pesticides regulation. India is also signatory for international conventions on pesticides like Stockholm, Basel, Montrial, OECD *etc.*

Efficacy of Some Herbicides on control of Purple nutsedge (*Cyperus rotundus* L.)

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Weeds compete with sugarcane to a much greater extent than with other short season row crops, because the wide row spacing and slow growth of its seedling allow for the invasion of weeds. Purple nutsedge (*Cyperus rotundus* L.) causes severe losses in sugarcane yields and sugar content in many sugarcane growing countries in the world (Durigan et al. 2005). The outstanding characteristic of the purple nutsedge plant is its prolific production of underground tubers that can remain dormant and carry the plant through the most extreme conditions of heat, drought, flooding or lack of aeration (Holm et al., 1977).

Maurer (2001) reported that three successive annual applications of Krismat significantly reduced purple nutsedge tuber production and germination. Durigan *et al.* (2005) in Brazil reported that, Trifloxysulfuron–sodium + ametryn (1.000 and 1.500 g ha^{-1}) reduced the percentage of viable tubers by 50%. Griffin (2004) indicated that Envoke can suppress the growth of purple nutsedge. Therefore, the present investigation was undertaken to evaluate the efficacy of new herbicides on control of purple nutsedge and to assess the effect of the treatments used on number and viability of nut-sedge tubers.

METHODOLOGY

A field experiment was conducted in September and January of seasons (2004/05 and 2005/06) at the Sugarcane Research Center, Guneid, Sudan to study the efficacy of new foliar herbicides on control of purple nut sedge (*Cyperus rotundus* L.) in sugarcane. The experiment was laid in randomized complete block design with three replications. Three eyed cane setts of variety Co 6806 were planted in 10 m long, 4 furrows spaced at 1.55 m (62 m^2). Tubers of purple nutsedge were planted in the furrows around the cane setts at a rate of 10 tubers m^{-1} (i.e. 400 tubers $plot^{-1}$). The treatments consisted of Krismat 75 WG (Trifloxysulfuron-sodium+ametryn) at three dosage levels of 1.79, 2.38 and 2.98 kg product ha^{-1} + Agral 90, 0.25% v/v, Envoke 75 WG (Trifloxysulfuron-sodium) at three doses of 0.025 kg, 0.030 kg and 0.035 kg product ha^{-1} + Agral 90, 0.25% v/v; Ametryne (Gesapax 50 FW) and Atrazine (Gesaprim 50 FW) used at its recommended dosage rate of 3.81 L + 3.81 L product/ha from each was used as a standard , hand weeding and unweeded control. All herbicide treatments were applied 5 weeks after the first irrigation when sugarcane seedlings and weeds were 60-70 cm and 15-20 cm, respectively. Herbicides were applied using knap sack sprayer fitted with flat fan nozzle.

RESULTS

Results showed that good control of purple nutsedge was attained by all chemical treatments compared to the untreated check. Envoke 75 WG at 0.035 kg product/ha and Gesapax +Gesaprim at its recommended rate significantly reduced the number of purple nutsedge (P=0.05) compared to the untreated check. Krismat at the higher rate and Gesapax +Gesaprim gave the lowest number of green leaves per weed. Envoke 75 WG and Krismat 75 WG showed a consistent reduction in tuber production and sprouting ability of *Cyperus rotundus* L.

CONCLUSION

Herbicides Krismat 75 WG and Envoke 75 WG at their different dosage rates can be used for purple nutsedge control in sugarcane and their successive application may lead to persistence and a continuous reduction in the population density of purple nutsedge.

Table 1. Effects of herbicide mixture on weed control, number of millable stalks (x 1000)/ ha, sugarcane yield (tons cane/ha) and sugar yield (tons sugar/ha) in sugarcane.

Treatment	Dose (product /ha)	Plant height (cm)	No. of plants/ m^2	No. of gree leaves/plan
Un weeded control	-	22.45 a	34.00 a	7.00 a
Hand weeding	-	0.00 c	0.00 c	0.00 c
Gesapax + Gesaprim (std)	3.81L+3.81L	17.22 ab	18.08 b	5.11 b
Krismat	1.79 kg	16.89 ab	24.17 ab	6.78 a
Krismat	2.38 kg	15.56 b	21.00 b	6.78 a
Krismat	2.98 kg	14.00 b	18.17 b	4.89 b
Envoke	0.025 kg	19.22 ab	28.42 ab	6.78 a
Envoke	0.030 kg	17.11 ab	18.58 b	7.22 a
Envoke	0.035 kg	22.33 a	17.50 b	7.11 a

At each column, treatments means followed by the same letter(s) are not significantly different according to DMRT at p d" 0.05.

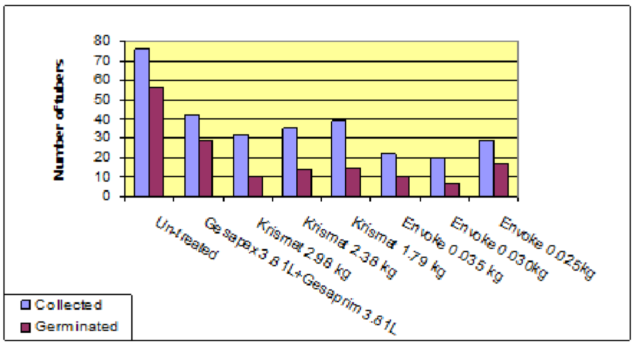

Fig. Tuber production and viability

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Evaluation of different spray volumes used for weed control in field crops

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Hydraulic spray nozzles are commonly used for herbicide application utilizing high volume spraying technique. This spraying technique requires large amount of water and poses problem where there is scarcity of water. Field evaluation was conducted to evaluate the different spray volumes for herbicide application in field crops to access the suitability of low volume sprays. Different spray volumes varying from 400 to 40 l/ha were applied using four different hydraulic fan spray nozzles of different discharge rate / spray throughput and one spinning disc atomizer.

METHODOLOGY

The field experiment with seven treatments and three replications was conducted in RBD laid out plots in soybean and wheat crops. The spray volume of 400, 300, 200, 100 and 40 l/ha were achieved using four different fan spray nozzles at specified spraying pressure and one rotary disc spray automiser. The fan spray nozzles used were flat- fan (brass, WFN 78), fan (brass, 60675), fan (HDP, blue tip) and fan (HDP, orange tip).The herbicide imazethapyr was applied in soybean for weed control at application rate of 1.0 l/ha in different spray volume treatments. In wheat, herbicide mesosulfuron + iodosulfuron @ 1.0 kg/ha was applied using the same spray nozzles/automiser.

RESULTS

In soybean crop, herbicide imazethapyr was found effective and highly significant in all spray volumes applied in different treatments as compared to no weed control treatment.

The weed control efficiency attained by imazethpyr was found varying between 44.5 to 56.4 % (based on weed count) and 43.7 to 49.9 % (on dry wt. basis).

The very low volume application of 40 l/ha was found equally effective as compared to that with others spraying by fan and flat-fan nozzles.

The higher grain yield of soybean was found varying between 2.78-3.14 t/ha in herbicide treatments as compared to 2.35 t/ha in no weed control treatment.

In wheat crop, weeding efficiencies based on dry weight were found non-significant among different spray volume treatments but were significantly different when compared with weed free and weedy plots.

The weeding efficiencies based on weed count were non-significant in spray volume applications of 300, 200, 100 and 40 l/ha and 400, 300 and 40 l/ha.

Table 1. Weed control efficiencies and grain yield of soybean (*Kharif* 2012) and wheat (*Rabi* 2012-13)

Spray Volume (l/ha)	Soybean (*Kharif 2012*) Weed control efficiency (%)		Grain yield (t/ha)	Wheat (*Rabi 2012-13*) Weed control efficiency (%)		Grain yield (t/ha)
	Weed count, no/m^2	Dry wt. g/m^2		Weed count, no/m^2	Dry wt. g/m^2	
400	53.4	45.5	3.07	68.8	59.6	3.76
300	49.1	43.7	3.14	60.1	57.2	3.30
200	56.4	49.9	2.96	53.5	54.2	2.69
100	46.5	45.9	2.96	50.1	51.1	3.44
40	44.5	49.1	2.78	55.0	51.2	3.02
No weed control	0.0	0.0	2.35	0.0	0.0	2.22
Weed free	74.3	76.3	3.01	87.5	84.9	4.38
LSD(P=0.05)	24.2	6.04	0.42	0.86	0.99	0.35

· The weeding efficiencies on weed count attained in different spray volume treatments were significantly different when compared with weed free and weedy plots in wheat.

· The grain yield of wheat crop in different spray volume treatments were non-significant but were significantly different when compared with weed free and weedy plots.

CONCLUSION

It was concluded that imazethapyr for soybean and mesosulfuron + iodosulfuron for wheat crops were found effective in all spray volumes applied from 400-40 l/ha representing different spray application techniques

Design, development and evaluation of DWR herbicide wick applicator for weed management in field crops

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The DWR herbicide wick applicator is suitable in those crop situations when recommendations and selective herbicides are not available. The herbicide wick applicator is a better option for application of non-selective and contact nature of herbicides.

METHODOLOGY

A DWR herbicide wick applicator has been designed and developed for applying non-selective herbicides in between crop rows. It consists of cylindrical roller pad, frame, ground wheels, solution tank, cut-off valve and handle. The concentrated herbicide solution is stored in chemical tank and flows over to cylindrical roller pad through cut-off valve. The cylindrical roller is covered with fibrous clothed pad which gets wet by herbicide solution. When the unit is operated in wide spaced crop rows, the wet roller pad come in contact with the grown up weed plants and herbicide solution stickled and gets in contact with weeds. The DWR herbicide wick applicator was evaluated and compared with high volume Knapsack sprayer for application of the herbicides in soybean and mustard crops.

RESULTS

The weed control efficiency (WCE) achieved were 58.0% and 70.9% by DWR herbicide wick applicator and knapsack sprayer (HV spraying) respectively for imazethapyr application in soybean crop (dry wt. basis).

The weed control efficiencies were 62.3% and 73.1% by wick applicator and knapsack sprayer, respectively for application of chlorimuron - ethyl + quizalofop-ethyl in soybean (*Kharif* 2011).

The weed control efficiency achieved were 67.7 % and 72.1 % for imazethapyr in mustard by DWR herbicide wick applicator and HV Knapsack sprayer respectively (dry wt basis).

The weed control efficiencies attained were at par in glyphosate application in mustard crop by DWR herbicide wick applicator and HV Knapsack sprayer (*Rabi* 2011-12).

Table 1: Weed control efficiency (%) achieved by wick applicator and H.V. knapsack sprayer in Soybean crop.

Treatment	Weed control efficiency (%)		Yield (t/ha)
	Weed count nos./sq m	Dry wt	
Imazethapyr by wick applicator	62.3	58.0	1.52
Chlorimuron + quizalofop by wick applicator	60.1	62.3	1.55
Imazethapyr by H.V. Knapsack sprayer	60.6	70.9	1.56
Chlorimuron + quizalofop by H.V. Knapsack sprayer	64.1	73.1	1.55
Weed free by mechanical twin wheel hoe weeder	71.07	60.5	1.56
No Control measures	0.00	0.0	1.57

Table 2: Weed control efficiency (%) achieved by wick applicator and H.V. knapsack sprayer with nozzle hood in mustard crop in Rabi 2011-12.

Treatment	Weed control efficiency (%)		Yield (t/ha)
	Weed count	Dry wt	
Imazethapyr by wick applicator	57.6	67.8	1.13
Glyphosate by wick applicator	57.0	74.0	1.17
Imazethapyr by H.V. Knapsack sprayer with nozzle hood.	54.6	72.1	1.17
Glyphosate by H.V. Knapsack sprayer with nozzle hood.	53.9	75.2	1.17
Weed free by mechanical twin wheel hoe weeder	57.7	90.7	1.24
No Control measures	0.00	0.00	1.00

CONCLUSIONS

The DWR herbicide wick applicator controlled weeds grown in between crop rows and its weeding efficiency was found at par with HV knapsack spraying using nozzle hood

Efficacy and Crop Tolerance of Rinskor™ Active, a New Rice Herbicide, in ASEAN Countries

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Rice is a major staple food with a planted area of approximately 30 million ha in ASEAN countries (Thailand, Malaysia, Indonesia, Vietnam, and Philippines) in 2014. With an increasing population in these countries, there is a need to increase rice production. One of the most important methods to increase rice production is to minimize losses caused by weed competition in rice fields. Weeds not only reduce rice production, but also affect rice seed quality. Since the beginning of agriculture, growers have tried to control rice weeds by many techniques. One of them is the use of synthetic herbicides. Various types of herbicides have been commercialized; however, farmers still prefer a one-shot treatment that provides broad-spectrum weed control **[Reference ?]**. Rinskor™ active, a new rice herbicide from Dow AgroSciences LLC, belongs to a new arylpicolinate class of herbicides and exhibits broad-spectrum herbicidal activity on select grass, sedge, and broadleaf weed species. Field studies with Rinskor™ active in ASEAN countries were initiated in 2011. This report summarizes the results of more than 100 trials conducted in this region from 2011 through 2014.

METHODOLOGY

Field studies were conducted at field stations of agricultural research institutes or centers and in farmer fields in Indonesia, Malaysia, Philippines, Thailand and Vietnam. Trials were designed as randomized complete blocks with 3 or 4 replications per treatment with a plot size of 16 to 25 m^2. The target crop was *Oryza sativa* (Indica rice) cultivated by direct-seeding or transplanting. In wet-seeded rice, water was partially drained from the field, post-emergence foliar application made to exposed weeds, and the field was reflooded within 48 hours after application. Rice trials were conducted utilizing local farming practices.

Rinskor™ active was formulated as an emulsifiable concentrate (NeoEC™ formulation) containing 25 g aiL^{-1}, with the tested rates ranging from 10-35 g/ha. Each rate was diluted in a spray volume of 160-400 l of water/ha and applied by knapsack sprayer with fan nozzle tip. Individual weed control evaluations were made 14, 28, 42, and 56 days after application (DAA) by visual observation of biomass reduction of each weed species compared to the untreated plot and are reported as percent control.

Collected data were analyzed with ARM8 and StatMart, proprietary Dow AgroSciences software.

RESULTS

When applied at 25 g/ha, Rinskor provided >90% control of *Echinochloa crus-galli* and *Cyperus iria*; at 30 g/ha, Rinskor provided 88% control of *Fimbristylis miliacea* and *Leptochloa chinensis* (Table 1). A 20 g/ha use rate of Rinskor was sufficient for >90% control of all other weeds in these studies including *Ludwigia octovalvis*, *Monochoria vaginalis*, *Sphenoclea zeylanica*, *Echinochloa colona* and *Cyperus difformis* at all application leaf stages.

Table 1. Efficacy of Rinskor on common weeds in rice when applied to 1-5 leaf ECHCG

Weed species		Rinskor tested rate (g/ha)			
Scientific name	Code	20	25	30	35
Echinochloa crus-galli	ECHCG	89	92	94	95
Echinochloa colona	ECHCO	92	95	96	97
Leptochloa chinensis	LEFCH	82	86	88	91
Fimbristylis miliacea	FIMMI	81	86	89	92
Cyperus iria	CYPIR	84	91	91	94
Cyperus difformis	CYPDI	92	94	95	97
Ludwigia octovalvis	LUDOC	95	96	97	97
Monochoria vaginalis	MOOVA	95	96	98	99
Sphenoclea zeylanica	SPDZE	97	95	98	97

Table 2. Rice injury after application of Rinskor or fenoxaprop at three different application stages

Rinskor rate (g/ha)	Rice Type	Rice Injury (% biomass reduction) applied at rice leaf stage		
		2-3 leaf	4-5 leaf	>5-8 leaf
20				
25	Transplanted	0	0	0
30				
20		0	0	0
25	Direct Seeded	<5	0	0
30		<10	<5	0
Fenoxaprop at 35	Direct Seeded	20-30	10-20	-

Rinskor at 30 g/ha applied at the 2-3 leaf stage of rice caused less than 10% injury which was significantly less than the injury caused by the commercial standard Fenoxaprop (20-30% injury) (Table 2).

CONCLUSION

Rinskor™ active provided good to excellent control of mostcommon weeds in ASEAN rice fields that include the following weeds: *Echinochloa crus-galli*, *Echinochloa colona*, *Cyperus difformis*, *Cyperus iria*, *Ludwigia octovalvis*, *Monochoria vaginalis*, and *Sphenoclea zeylanica.* A very low use rate of 20-30 g/ha provided 90% controls of these weeds. Rinskor will provide farmers a very flexible timing of application to control *Echinochloa crus-galli*, from early post-emergence application (1 to 2 leaf stage) to late post application (4 to 5 leaf stage). Rinskorat 30 g $aiha^{-1}$ was safe to indica rice when applied at the 2-8 leaf stage of rice. Finally, Rinskor provides an alternative mode of action in herbicide resistance management programs.

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Triafamone (Council®) A new herbicide for Asia's diverse rice cropping systems

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Rice is the major crop and staple food in Asia where more than 90% of rice globally is produced and consumed. FAO reported that population in Asia is growing by 1.8% per year and it is estimated that by year 2025, demand for rice will soar faster than the population growth. Rice pests pose one of the key challenges in meeting the demand and specifically, weeds have become the major constraints in rice farming. Rice is grown in different agro-ecological conditions, hence diversity in weed problem vary with geography, rice cultures, fertility, water and weed management. In addition, improvement in rice production technology and economic factors are leading to shortage of farm labor and shift of rice culture practices which give rise to new or more difficult weed problems. There is an urgent need for innovation in rice weed management to address these trends.

Triafamone is a new sulfonanilide rice herbicide discovered and developed by Bayer CropScience AG and sold as Council®. It is selective on various transplanted and direct seeded rice cultivars and effective via different application methods and timings. Target weeds of Triafamone include the most important grass in rice, *Echninocloa crus-galli*, including ACCase resistance strains and other major grasses such as *E.colonum*, *E.oryzicola*, and *Paspalum distichum.* It also controls key sedges including ALS resistant strain and the weed spectrum is further extended with combination of other herbicides. Triafamone is absorbed through the foliage and roots and transported throughout the plant to the target site offering pre-emergence and post-emergence control of weeds. Its mode of action is inhibition of the enzyme Acetolactate synthase (ALS) causing stunting, necrosis and eventual death to the weeds.

METHODOLOGY

Weed control and crop compatibility of Triafamone have been evaluated globally in numerous field trials both solo and in mixture with other herbicides under different rice cultivation and weed management practices.

RESULTS

A large number of field trials across Asia have shown crop safety in direct seeded and transplanted rice after application of triafamone at a use rate of 5-50 g/ha from pre-emergence to mid post-emergence of weeds without negative impact on yield.

Table 1. Susceptibility of Triafamone solo and mixtures to typical weeds in rice

Weed Species	Percentage control levels at various application timings		
	Council® Triafamone	Council activ® Triafamone & Ethoxysulfuron	Council Complete® Trifamone & Tefuryltrione
Echinochloa crus-galli	>95%	>95%	>95%
Echinochloa oryzicola	>95%	>95%	>95%
Echinochloa colonum	>95%	>95%	>95%
Leptochloa chinensis	80-90%	80-90%	90-95%
Paspalum distichum	90-95%	90-95%	>95%
Lindernia spp	- -	>95%	>95%
Monochoria vaginalis	- -	>95%	>95%
Monochoria korsakowii	- -	>95%	90-95%
Ludwigia octovalvis	90-95%	>95%	>95%
Sphenoceia zeylanica	90-95%	>95%	>95%
Sagittaria pygmaea	90-95%	>95%	>95%
Sagittaria trifolia	90-95%	90-95%	90-95%
Alisma spp.	80-90%	>95%	>95%
Cyperus difformis	>95%	>95%	>95%
Cyperus serotinus	>95%	>95%	>95%
Fimbrystylis miliacea	90-95%	>95%	>95%
Eleocharis kuroguwai	90-95%	90-95%	90-95%
Scirpus planiculmis	90-95%	90-95%	90-95%
Scirpus juncoides	80-90%	90-95%	>95%

Triafamone provides excellent control of *Echinocloa* weed species and other key grasses and sedges at dose rates from 5-50 g/ha depending on field conditions at the time of the treatment such as weed species, weed growth stage, rice growth stage, water management practices, and environmental conditions. It can be applied via spraying, shaker bottles or as granules. It is also adaptable to new technologies such as the 0 DAT applications *via* transplanting machine in northeast Asia.

Several co-formulations products are being developed to suit country specific rice cropping conditions. This is possible due to the chemical and physical properties of Triafamone which allows flexibility in formulations needed for different application techniques. Examples are mixture with Ethoxysulfuron (Council activ®) which is a WG formulation developed for season long weed control in south Asia with excellent crop safety (substanciate with results ????) and Council Complete® SC formulation containing Tefruyltrione for anti-resistance broad spectrum control of weeds in northeast and southeast Asia.

CONCLUSION

Triafamone is a new herbicide being developed for Asia's diverse rice cultivation and weed management systems. The features (eg wide window of weed control, broad rice selectivity, application and formulation flexibility, compatibility with other herbicides) exhibited by Triafamone in different rice cropping systems provides farmers across Asia a new flexible weed management tool to enhance their productivity. The first registration and sales of Triafamone was obtained in Korea in 2014 and 2015, respectively.

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Theme 17

New tools and technologies for better weed management

Detection of jungle rice (*Echinochloa colona*) using remote sensing technique

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Spectral approaches involving the use of plant reflectance spectra based on the light reflected from the plant surfaces offer great potential for weed detection (Noble *et al*. 2002). In India, very little information is available on the spectral signatures of crops and weeds. Jungle rice (*Echinochloa colona*) and Barnyard grass (*Echinochloa crus-galli*) are the two main weeds growing in association with other annual grasses, sedges and broad leaf weeds. Reduction in rice grain yield ranged from 48% with a density of 50 plants *of E. colona*/m^2 to 86% with 400 plants/m^2 (Prasad Babu 2013).

METHODOLOGY

To explore the possibility of detection of *Echinochloa colona* in rice based on spectral response patterns, field experiment was conducted in *Kharif* 2006 at Directorate of Weed Research, Jabalpur, Madhya Pradesh. Seven treatments consisting of crop alone, weed alone, and increasing densities of *Echinochloa colona* were studied in RCBD with three replications. Spectral observations in four bands ranging from visible to near infrared region (*i.e.* from 400 nm to 900 nm) were recorded between 12 and 2 PM with the help of ground truth radiometer of Optomech Make, Model: 041. The spectral indices, *viz*. radiance ratio (RR) and normalized difference vegetation index (NDVI) were calculated as per the standard procedures.

RESULTS

Red reflectance of rice decreased as growth period progressed up to 60 DAS and it increased with increasing density of *E. colona*. Infrared reflectance increased as growth period progressed up to 60 DAS which decreased thereafter up to 90 DAS in all the treatments. With increasing density of *E. colona*, infrared reflectance decreased at all the growth stages. Infrared reflectance of rice crop was much higher than that of *E. colona* at all the growth stages. Radiance ratio (Table 1) and NDVI (Table 2) of all treatments were found to be higher at 80 DAS. Radiance ratio and NDVI for pure rice were higher than that of pure *E. colona* at all growth stages. Both RR and NDVI were found to be well correlated with the grain yield of rice.

Table 1. Radiance ratio of rice under different densities of *Echinochloa colona* in rice

DAS	Rice	T_{50}	T_{100}	T_{200}	T_{300}	T_{400}	*E. colona*
20	2.996	2.635	2.483	2.058	1.967	1.848	1.521
40	3.552	2.872	2.760	2.435	2.293	2.057	1.809
60	5.569	4.162	3.695	3.100	3.036	2.766	2.383
80	8.022	4.451	3.762	2.840	2.588	2.508	1.689
90	3.776	2.886	2.782	2.336	2.254	2.189	1.396
100	2.401	2.218	2.092	1.863	1.806	1.721	1.193

Table 2. NDVI under different densities of *Echinochloa colona* during the rice growth period

DAS	Rice	T_{50}	T_{100}	T_{200}	T_{300}	T_{400}	*E. colona*
20	0.500	0.450	0.426	0.346	0.326	0.298	0.207
40	0.561	0.483	0.468	0.418	0.393	0.346	0.288
60	0.696	0.613	0.574	0.512	0.504	0.469	0.409
80	0.778	0.633	0.580	0.479	0.443	0.430	0.256
90	0.581	0.485	0.471	0.400	0.385	0.373	0.165
100	0.412	0.378	0.353	0.301	0.287	0.265	0.088

CONCLUSION

Spectral reflectance data, rice and jungle rice (*E. colona*) can be identified. Both RR and NDVI were found to be well correlated with the grain yield of rice.

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Fabrication of nano-encapsulated pendimethalin herbicide using solvent evaporation method for season-long weed control under irrigated ecosystem

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Nanotechnology is a technology having the potential ability to study, design, create, synthesis, manipulation of functional materials, devices and systems to fabricate structures with atomic precision by controlling the size of the matter at the scale 1-100 nm. Hence development of a new slow release nanoencapsulated herbicide formulation will help the agronomist by season long control of weeds.

METHODOLOGY

Pendimethalin 1 mg was dispersed in 4 ml of acetone solvent and sonicated with energy output 25 W under continuous mode for 90 seconds. Poly ethylene glycol polymer of 20 mg was dissolved in 8 ml of dichloromethane solvent and sonicated with energy output 25 W under continuous mode for 90 seconds. Both of them were mixed well to form organic phase.Took 4 ml of starch polymer with 6 % concentration and stir it with magnetic stir for one hour for the preparation of aqueous phase.Took the organic phase containing the polymer with herbicide and added drop wise to aqueous phase containing the different per cent of starch to form oil in water phase.The nanoparticles produced were collected and stored in vial.10 ml of water was added to the Petridish containing nano-encapsulated particles and the suspension was allowed to leach for overnight. The samples were transferred to a seperatory funnel by adding another 10 ml of water along with 40 ml of Methanol and shake it for one hour. Separate the oil phase and water phase using the seperatory funnel. Then it was dried using rotary evaporator at 60^{o}C. Then the volume was made up to 10 ml by using 9 ml Hexane of HPLC grade. Garden soil and FYM (mixed in the ratio (2:1)) were taken in the tubular plastic tubs

(12×4 cm) and treated with different treatments along with control. Twenty earthworms washed cleanly with water were placed on the top of the substrate. After every 120 hrs, 50 g of FYM was mixed inside the container and the water lost by evaporation was replaced daily.

RESULTS

Encapsulated pendimethalin particles prepared by solvent evaporation technique viewed under SEM shows perfect spherical shape. The surface characteristics of the sphere formation embedded with polymer into nanoencapsules. The nano-encapsulated herbicide by solvent evaporation method X-ray diffractogram shows peaks at an angle of (2è) 28°, 36° and 56° with d spacing values of 3.18, 2.49 and 1.64. The same angle was observed in JCPDS card no. 33-0664, 43-0679 and 05-0664. The particle size distribution of solvent evaporation methods were 265.8 nm diameters with 100 per cent intensity. Fabrication of uniform particles is very much important with respect to slow release. Application of nanoencapsulated pendimethalin of solvent evaporation methods had no significant effect on the survival rate of earthworm (Edwards and Bohlen, 1992). The solvent evaporation method the releasing efficiency was higher upto40 days of the experiment. Six per cent starch encapsulated pendimethalinreleasing efficiency was persistently increasing in nature with the evidence of surface area (1026.20, 879.00, 1681.95, 2064.65 and 2455.30 mVs) and quantity (1.52, 1.30, 2.50, 3.06 and 3.64 ppm) at 3, 10, 20, 30 and 40 days, respectively.

CONCLUSION

The nano structures fabricated using solvent evaporation was found to be longer in releasing the encapsulated herbicide molecules consistently up to the study period of 40 days under controlled environmental condition. This confirms that the herbicide released in slow manner based on the moisture availability and also nano-encapsulated pendimethalin were non-toxic to earthworms.

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Phytoremediation potential of *Solanum nigrum* grown in lead contaminated soil

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Weeds are suitable for phytoremedial purpose because of their inherent resistant capability, less cost input and their non-suitability for other purposes like fodder (Lum *et al.* 2014; Girdhar *et al.* 2014). The present experiment identified a hardy weed plant that could tolerate concentrations of Pb in soil. *Solanum nigrum* (Solanaceae)commonly known as black nightshade is a herbaceous weedy plant with rapid growth, proliferation, strong tolerance to adverse conditions and good biomass production. Thus, the aim of the present investigation is (i) to evaluate the phytoremedial potential of *Solanum nigrum* with respect to Pb and, (ii) to study the effect of Pb on its growth and physiology.

METHODOLOGY

Seeds of *S. nigrum* were sterilized and then allowed to germinate in a germination tray. After germination, seedlings were transplanted to pots having 5 kg garden soil. Single plant per pot was maintained. The seedlings were first allowed to grow for 4 weeks after which Pb was added to pots at varying concentrations (0, 25, 50, 100, 200, 250 mg/kg soil) as aqueous solution using Lead nitrate ($PbNO_3$) salt. Sampling was done at 25, 50 and 75 days after treatment (DAT). Plant growth parameters like root length, shoot length, biomass and physiological parameters like total chlorophyll and proline content were also determined. To assess the phytoaccumulation potential of plants some factors like Bioabsorption coefficient (BAC), Bioconcentration factor (BCF), and Translocation factor (TF) were also calculated.

RESULTS

A linear increase in Pb accumulation with increasing metal concentration and exposure period was observed for all treatments. Accumulation of Pb in roots was found to be higher than that of shoots. Roots showed a progressive accumulation of Pb as a function of the external medium. Significantly, a maximum Pb uptake of 32.6 mg/kg (in root) and 6.1 mg/kg (in shoot) was observed at highest Pb treatment (250 mg/kg) at 75 DAT. At all the sampling, maximum uptake of Pb was observed in highest dose. Effect of Pb on growth and physiology was also evaluated. At higher Pb levels, root and shoot length, and biomass of test plant were reduced significantly. Although, growth was delayed initially, it was comparable to control at the end of the study. Chlorophyll and proline content declined with the increase in Pb concentration at 25 and 50 DAT. However at 75 DAT, values were more or less comparable to the control values showing the adaptability of *S. nigrum* in Pb contaminated soil. Considering the accumulation ability, BCF > 1 (Bioconcentration factor) and TF < 1 (Translocation factor) established *S. nigrum* as a potential weed for phytoremediation. Hence, phytoremediation employing indigenous weed species like *S. nigrum* can be an ecologically viable option for sustainable and cost-effective management of heavy metal contaminated soils.

Table 1. Pb uptake and accumulation (mg/kg) in *S. nigrum* (root/shoot) at successive days of study

Treatment (mg/kg)	25 DAT		50 DAT		75 DAT	
	Root	Shoot	Root	Shoot	Root	Shoot
Pb-25	3.7±0.6	0.51±0.2	5.6±1.3	0.72±0.2	6.8±1.1	0.87±0.1
Pb-50	6.6±1.1	0.62±0.1	9.1±1.7	0.95±0.1	10.9±1.3	1.2±0.3
Pb-100	8.5±0.8	1.2±0.2	11.6±2.2	1.6±0.4	14.7±2.6	2.6±0.6
Pb-200	11.8±1.7	1.6±0.3	18.4±3.4	2.5±0.8	23.3±3.1	3.7±1.1
Pb-250	17.9±2.3	2.8±0.6	26.4±2.8	4.2±1.3	32.6±2.8	6.1±1.4

CONCLUSION

Solanum nigrum showed potential for Pb bioaccumulation, and also maintained its growth and physiology. Given the good tolerance, fast growth, high accumulation, and global distribution, we propose that *S. nigrum* is a potential weed to remediate moderately Pb contaminated soil.

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Practical implications in real time implementation of smart weed sensors: Future of precision farming

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Based on the morphological properties of plants, the crop species and weed species can be sensed with smart sensors which can detect the weed and help selectively processing of weed. In this paper the sensors proposed in the literature have been presented. The sensing mechanisms are classified as non-commercialized and commercialized sensors. The study has been presented on the challenges posed by the sensors in its implementation to the real fieldconditions. The common problems listed for sensing mechanisms are sensing time, sensors in weed/crop jumbled up conditions, resolution of the sensors and the cost of the sensors *etc*. The existing sensors are identified for common weeds in maize crop and presented in the paper. The study will help automatic weed detection and controlling to a great extent in maize crop.

METHODOLOGY

Existing sensors available in the market for differentiation of weed and crop are facing real field challenges in their applications. The sensors common in maize, wheat, rice and tomato crops have been discussed. It is inferred that most of the sensors are based on morphological and chemical differences between crop and weed. The challenges in the each discussed sensors are studied. The applicability of sensors to the particular crop in specific terrain profile has been proving the bottleneck in the implementation of precision farming. The area has been specified for applicability of sensing mechanism and the country most suited for the application. The reason for the failures of non-commercial sensors has been inferred.

Table 1. Existing commercialized sensors

Sensor name	Principle
Crop meter	Determines the height of the plant
Crop circle	Optical sensors
Optical Chlorophyll	Fluorescence sensors
YARA N sensors	Optical sensors
Weed seeker	Green seeker (Optical sensor)
Laser scanning	Morphological (Leaf area)
Image processing	Crop/weed pattern detection
Hyperspectral imaging (UHD 185)	Real time spectral markers
Thermography	Stomatal Stress
Acoustic sensor	Mutli-reflection ultra-sonic sensors

Table 2. Problems with existing sensors in crop and weeds

Property	Problem occurring with sensors/system
Each Marker for differentiation of crop and weed is applied to specific conditions.	Hyperspectral sensors, Ultrasonic system, crop meter (Escola *et al.* 2011, Moshou *et al.* 2013)
Sensing time (different components) for each specified sensor has been plotted.	Real Time 3D Computer vision (Escola *et al*. 2011)
Limited morphological difference between specific species of weed and crop	Laser Scanning
Farm machinery to house sensing assembly	Mechanical sensors Bulky and less intelligent sensing mechanism, manual monitoring
The farm conditions making the electronic sensors non-viable.	Stress sensors, optical sensors, H sensors (Moshou *et al*. 2013)
The interference from surrounding noise.	Acoustic sensors, Crop meters & Measurement sensors like humidity, temperature,
Failure in specific condition of Jumbled up crop and weed	Camera based sensors, Hyper-spectral video camera,3D Imaging (Escola *et al.* 2011, Moshou *et al*. 2013)

RESULTS

A literature survey has been carried out in the area of plant classifying sensors. The list of few sensors is given in Table 1. The study of failure for specified sensors isattributed for reasons given in Table 2.

CONCLUSION

The future of automatic weed sensing lies in involvement of information technology in the area. Machine vision has proved to be promising in other aspect of agriculture but failed in weed detection at most of the fronts for above mentioned reasons. The algorithmic development is needed at IT level for further improvement in the existing sensing mechanisms.

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Management of weedy rice – Indian experience

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In India, shift in the rice crop establishment method from transplanting to direct sowing of pre germinated seeds, dependence on pesticides especially herbicides, reduced tillage practices, acute shortage and high cost of labour etc., have led to several biotic and abiotic stresses in rice cultivation (Wang and Chang, 2009). A perennial constraint in rice cultivation is weed infestation and of late weedy rice infestation has become a serious threat in the rice belts of India. Morphological similarity of weedy rice to cultivated rice, variable seed dormancy, early seed shattering nature, staggered germination and high competitiveness of weedy rice make hand weeding/rouging incomplete and ineffective (Chauhan 2013). Lack of biochemical differences make selective herbicidal control of weedy rice in cropped field difficult. Surveys conducted in India, have indicated the severe incidence of weedy rice in the traditional rice belts of South and North East India compared to the new rice belts of Punjab and Haryana. Wild and weedy forms are problematic in Eastern U.P., Bihar, Orissa, Manipur, Assam and West Bengal and in southern states of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. During the recent years, heavy infestation of weedy rice resulting in huge reduction in yield (50-70%) has forced the farmers to abandon the crop even without harvesting and leave the land fallow in the subsequent years. Therefore, detailed studies were taken on the infestation, biology and control of weedy rice.

METHODOLOGY

Stratified survey was done in all panchayaths (covering representative polders in a panchayath) in the major rice belts of Kerala (Kuttanad, Palakkad and Kole) during 2011-13, to study the extent of incidence of weedy rice in different agro ecological conditions of Kerala. The role of hull induced seed dormancy was studied by Scanning Electron Microscope and by testing the germination of intact seeds as well as seeds with scraped hull (both fully matured and half matured grains). Management of weedy rice was attempted in three ways *viz*., stale seed bed technique, modified application of pre-emergence herbicides and direct contact application of herbicides for post emergence control of weedy rice. Reduction in the incidence of weedy rice or drying of weedy rice plants was recorded to assess the efficiency of the treatments.

RESULTS

More than 65% of the major rice belts of Kerala had low to severe (1-13 plants/m^2) weedy rice infestation. Seeds shatter within 15 days after flowering and by the time of harvest of the crop most of the seeds had shed and enriched the soil seed bank. Electron microscope studies have shown that weedy rice seeds possess hull induced dormancy due to tight packing and increased overlapping of lemma and palea, making the seeds impermeable to water. The mature dried seeds do not germinate immediately after shattering and majority of them took 45-60 days, while the seeds at physiological maturity germinated rapidly within 6-12 days and some seeds remained viable for long periods under deep burial and submergence. Stale seed bed technique proved effective for depletion of soil seed bank. There was 91% decrease in the weedy rice population in double staling. It was observed that destruction of the first flush of weeds germinated from the soil seed bank by wet tillage followed by second staling with herbicide application decreased the weedy rice population by more than 70% in the succeeding crop compared to dry tillage. There was 25% increase in yield in double stale with wet tillage in between stales over dry tillage. Oxyfluorfen 2-3 kg/ha applied to a thin film of standing water three days before sowing gave 50-60% control of weedy rice. After herbicide application, the water was allowed to evaporate/infiltrate leaving the field free of standing water and pre germinated rice seeds were broadcast. The yield increase obtained was 20-25% over the control by this management strategy. In addition to weedy rice, other weeds were also got controlled by pre sowing surface application of oxyfluorfen. Utilising the earliness in flowering of weedy rice plants compared to rice plants (10-15 days) and consequent difference in height of weedy rice panicles and rice plant at 60-65 DAS, it is possible to dry 75-85% earheads of weedy rice by direct contact application of broad-spectrum non selective herbicides at 10-15% concentration of the formulated product using wick applicator. In Kerala Agricultural University, a wiper applicator has been developed and found effective on field testing. Use of paraquat and glufosinate ammonium could dry only the earheads of weedy rice whereas glyphosate could dry the plant also.

CONCLUSION

Effective and economical management of weedy rice is possible by the integrated use of different options for management, *viz*. stale seed bed technique, modified application of pre emergence herbicides and direct contact application of herbicides for post emergence control of weedy rice depending on the intensity of infestation. The promising technologies standardised for managing weedy rice were demonstrated in the farmers' field in a participatory mode, with appropriate modifications to suit the local conditions. In areas of severe infestation, integration of more than one method is recommended.

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Cover crops as tool for control of weeds in coffee plantations

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Weed menace is a severe problem especially in young coffee plantations and open patches occurred due to removal of white stem borer affected plants. To overcome the above situations the cover crops are can grown in coffee plantation to suppress weeds, prevents soil erosion and to enrich the soils by way of biomass addition. Cover crops that are grown temporarily along with main crop mainly for suppression of weed growth. At Central Coffee Research Institute and other research stations of Coffee Board, the experiments were conducted on cover crops as tool for control of weeds in coffee plantations. The experiments were included both perennial and annual cover crops for their suitability.

METHODOLOGY

In coffee plantations, cover/green manure crops was sown two times in a year during the onset of monsoon showers (May-June) and during post monsoon (Sept-Oct). Cover/green manure crops seeds 15-20 kg/acre was broadcasted after mixing with sand in the proportion of 1:5 (*i.e.* 1 kg cover crop seeds mixed with 5 kg sand) for appropriate germination and good plant stand. Harvesting was done at 55-60 days after sowing.

RESULTS

Results in coffee plantations showed that cover crops - cowpea followed by horsegram was found most efficient in both Robusta and Arabica estates with respect to biomass production, weed suppression and nutrient contribution. These cover crops had broader leaves, better ground coverage, good nodulation, fast growing nature and contributed good amount of nitrogen to the soils by way of biomass. Higher fresh biomass of 5.51 t/ha was produced in cowpea followed by 3.19 t/ha in horsegram. Significantly highest nutrients were contributed by cowpea (20.8, 5.4 and 21.2 kg/ha N, P and K) followed by Horse gram (11.2, 3.2 and 11.4 kg/acre N, P and K). The nutrients added to soil account to 20.8, 5.4 and 21.2 kg/ha N, P and K in cowpea this saved the mean addition 75, 20, 75 kg N, P and K per ha for coffee growth and the cost of fertilizers to supply 75:20:75 kg NPK, savings were worked out to be Rs. 989/ha approximately (Table 1). The weed control efficiency was to the extent of 92% in cowpea and 90% in horse gram. Cowpea followed by horsegram is most ideal cover crop in coffee.

Table 1. Fresh, dry biomass of cover crops, weed dry weight, weed suppression and nutrient contribution from different cover crops in coffee plantations

Treatment	Dry biomass (kg/ha)	Weed dry weight (g/m^2)	Weed suppression (%)	Nutrient contribution (kg/ha)		
				N	P	K
Greengram	753	13.6	89	7.0	1.8	7.0
Cowpea	2158	9.9	92	20.8	5.4	21.2
Sunnhemp	450	17.5	86	3.4	1.0	3.0
Dhiancha	298	22.9	82	2.0	0.4	1.8
Horsegram	1260	11.6	90	11.2	3.2	11.4
Control	-	128.3	0	0.0	0.0	0.0
LSD (P=0.05)	172.5	24.0	-			

CONCLUSION

Cowpea and horse gram are most efficient cover crops in coffee plantations because of their adoptability in shaded area, biomass production, weed suppression and nutrient contribution ability.

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Efficacy of Rinskor™ active against weed flora in different rice cultures of India

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Weed infestations during the crop growing season can reduce rice yields 57-61% in transplanted rice and 64-66% in wet seeded rice as compared to season- long weed free situations (Mukherjee *et al.* 2008). Considering the current herbicides of choice are either ALS or ACCase mode of action, there is a need for effective herbicides with an alternative mode of action. Rinskor™ active is a new arylpicolinate herbicide that has as a synthetic auxin mode of action that specifically addresses this need. Field studies were conducted to evaluate the bioefficacy of Rinskor for weed control in two different rice cultures in India.

METHODOLOGY

Field experiments were conducted to evaluate the efficacy of Rinskor (formulated as a NeoEC™ formulation) on weeds in transplanted and puddled direct-seeded rice during *Kharif* 2013, 2014 and *Rabi* 2013-14 across various States in India. Varying doses of Rinskor were compared with Vivaya™ (penoxsulam + cyhalofop 60 OD) and bispyribac-sodium (10% SC). All treatments were applied at the 4-8 leaf stage of weeds and were arranged in a RCBD with three replications. Weed density (No./m^2) by species was observed at 25-30 days after application. Weed count was subjected to per cent Abbot Transformation to calculate per cent weed control from untreated plot.

RESULTS

Rinskor™ active at 25 g/ha provided 94% control of *E. crus-galli* in transplanted rice (Table 1). For sedges and broadleaf weeds, Rinskor at 25 g/ha provided control superior to bispyribac and comparable to Vivaya. In puddled direct-seeded rice, Rinskor at 31.25 g/ha provided 85% control of *E. crusgalli* and for the control of grass weed *E. colona* and the sedge weed *C. difformis*, it provided significantly greater control than the Vivaya and bispyribac at the recommended rates (Table 2), Rinskor at 25 g/ha exhibited 85-100% control of *Ludwigia* spp. and *Monochoria vaginalis* that was comparable with Vivaya and bispyribac when applied at the recommended field rates.

CONCLUSION

Rinskor™ active is a new herbicide from Dow AgroSciences suitable for various kinds of rice cultures in India. As a novel herbicide with an auxinic mode of action, Rinskor will provide an alternative to current ALS and ACCase herbicide solutions. With excellent herbicidal efficacy when applied at 25-31.25 g/ha, Rinskor will provide rice growers a novel choice for superior control of key weeds in rice.

Table 1. Percent control of major weeds in transplanted rice

Weed species	Rinskor (g/ha)			Vivaya (g/ha)	Bispyribac-Na (g/ha)
	25	31.25	37.5	135	25
Grass					
E. crus-galli	94	98	100	97	95
Sedges					
C. difformis	84	94	96	94	73
Scirpus pp.	81	93	98	92	71
BLWs					
Ammania spp.	67	75	77	73	69
Ludwigia spp.	87	93	96	93	60
Marsilea spp.	100	100	100	100	87
Monochoria vaginalis	89	93	99	79	82
Sphenoclea zeylanica	86	87	83	94	70

Table 2. Per cent control of major weeds in puddled direct seeded rice

Weed species	Rinskor (g/ha)			Vivaya (g/ha)	Bispyribac-Na (g/ha)
	25	31.25	37.5	135	25
Grasses					
E. crus-galli	78	85	NA	84	82
E. colona	81	87	97	74	75
Sedges					
C. difformis	93	86	86	76	59
BLWs					
Ludwigia spp.	85	89	99	76	83
Monochoria vaginalis	100	100	100	100	100

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Studies on weed management practices in machine transplanted rice

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Infestation of weeds causes a heavy investment on farm operation and ultimately on the cost of cultivation. Manually it is difficult to differentiate and remove the grassy weeds particularly *Echinochloa colona* and *Echinochloa crus-galli* due to phenotypical similarities between weeds and rice seedlings in early stages. In such a situation, the chemical and mechanical weed control becomes an alternative method for weed control.

METHODOLOGY

A field experiment was conducted at Agricultural Research Station, Gangavathi, University of Agricultural Sciences, Raichur, during *Kharif* 2012 and 2013. The experiment was laid in Randomized Block Design with twelve weed management practices comprising of hand weeding, weeders and both pre and post emergent herbicides were evaluated and replicated thrice. The data on weed count, dry weight, grain and straw yield and economics were recorded.

RESULTS

Application of bensulfuron methyl 0.6% + pretilachlor 6% at 12.50 kg/ha *fb* bispyribac-sodium at 250 ml/ha and bensulfuron methyl 0.6% + pretilachlor 6% *fb* 2,4-D sodium salt at 2.50 kg/ha recorded significantly lower total weed count and dry weight next only to weed free check at 20 DAT. However from 40 DAT onwards, application of butachlor 50 EC fb passing of power operated low land rice weeder twice at 20 and 30 DAT with hand weeding in intra row space recorded lower total weed count and dry weight next only to weed free check compared to unweeded check and rest of the treatments. At 20 DAT, significantly higher weed control efficiency (86.66%) was recorded with the application of bensulfuron methyl 0.6% + pretilachlor 6% *fb* bispyribac sodium 10 SC whereas at 40 DAT and onwards, application of butachlor 50 EC *fb* passing of power operated low land rice weeder twice at 20 and 30 DAT with hand weeding in intra row space recorded significantly higher (87.53%) weed control efficiency and significantly lower weed index compared to rest of the treatments. These results are in conformity with Yadav *et al.* (2009) and Pasha *et al.* (2012). Growth, yield parameters and yield were significantly higher with the application of butachlor 50 EC fb passing of power operated low land rice weeder with hand weeding in intra row space compared to all other treatments except weed free check. Higher B:C (2.22) was noticed with application of butachlor 50 EC fb passing of power operated low land rice weeder with hand weeding in intra row spaces as compared to weed free check. However, in weed free check, the B:C (2.12) was lesser even though the grain yield and gross returns were higher. This was due to higher cost of cultivation as a result of high cost incurred towards labour for weeding.

CONCLUSION

Application of pre-emergent herbicide butachlor at 2.5 l/ha fb passing of power operated low land rice weeder twice at 20 and 30 DAT with hand weeding in intra row space was found to be most effective and economical method of weed control in machine transplanted rice.

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Effect of time of nitrogen application and weed management practices on weeds, yield attributes and yield of wheat

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Wheat (*Triticum aestivum* L.) is one of the most important staple food crop cultivated in almost all the countries in the world. It provides about 20% of total food calories for the human race. Weed is one of the major factors affecting the yield of wheat and with reduction of yield to the extent of 18-73% (Naik *et al*. 1997). In wheat crop, weed control is the basic necessity during its early growth stage, if potential production of the crop is to be realized. As weeds have naturally good competitive ability, use more water and nutrients as compared to the crop plants and hence, weed management plays a vital role in boosting up wheat production.

METHODOLOGY

Treatments comprised combination of time of nitrogen application (T_1 – $^1/_2$ as basal + $^1/_2$ at CRI, T_2- $^1/_2$ as basal + $^1/_4$ at CRI + $^1/_4$ at FND and T_3 - $^1/_3$ as basal + $^1/_3$ at CRI + $^1/_3$ at FND) and weed management practices [W_1- pendimethalin at 1000 g/ha (PE) , W_2 – metsulfuron-methyl at 4g/ha (PoE at 25-30 DAS), W_3 - pendimethalin at 1000 g/ha(PE) *fb* metsulfuron-methyl at 4 g/ha (PoE at 25-30 DAS), W_4 - hand weddings at 20 and 40 DAS and W_5 - weedy check]. Application of pendimethalin 1 kg/ha as pre sowing and metsulfuron-methyl 4 g/ha at 25 days after sowing was done as per treatment. Two hand weedings were carried out at 20 and 40 days after sowing as per treatment.

RESULTS

Treatment T_3 significantly recorded the highest grain yield (4.01 t/ha) and straw yield (6.50 t/ha, respectively) as compared to treatment T_1. Treatment T_3 minimize the monocot as well as dicot weed population and recorded significantly the lowest weed dry matter as compared to rest treatments at 25 and 50 DAS as well as at harvest (Table 1). Split application of nitrogen supply may have decreased N uptake by the weeds, which might have resulted in lower weed density and dry matter accumulation of weed species (Panwar *et al*. 1992). Treatment W_3 recorded significantly higher grain yield than treatment W_5 but was at par with W_2, W_1 and W_4. Treatment was also significantly superior in straw yield than W_4 and W_5 but was at par with treatments W_1 and W_2, respectively (Table 1). The minimum yield was found with weedy check than rest of the treatments. Significantly lower weed count (monocot and dicot), the lowest weed dry matter, maximum WCE and maximum weed index at 20 and 40 DAS as well as at harvest were noted under W_5 treatment *i.e*. hand weeding at 25 and 50 DAS. Significantly minimum weed dry matter was found with treatment combination T_3 and W_4 at 25 and 50 DAS as well as at harvest of the crop

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Effect of skip row planting and different cultivars on weed population and yield of happy seeder sown wheat

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Happy seeder is a machine recommended for sowing of wheat in standing stubbles of paddy for *in-situ* management of straw in rice growing areas of India. Skip row planting, with one row unsown after two or three row of continuous sowing, affects the density and spatial uniformity of wheat, significantly influenced the crop yield and weed growth. Different cultivars in standing stubbles may also show different performance than the normal sowing.

METHODOLOGY

A replicated field experiment to investigate the effects of skip row planting method and varieties on weed growth, growth of crop and yield of happy seeder sown wheat was conducted for two seasons (2011–12 and 2012–13) at the Punjab Agricultural University farm at Ludhiana (30%56'N, 75% 52'E, 247 m ASL), Punjab, India. The experimental site had been under R-W system for more than 5 years. The experiment was laid out in a split plot design with 3 planting pattern (M1 - 3 rows at 20 cm inter-row spacing and 40 cm space between two sets of rows, M2 - 2 rows at 20 cm inter-row spacing and 40 cm space between two sets of rows, M3- normal sowing at 20 cm row spacing) as the main plots and 4 four cultivars *i.e.* 'PBW 621' (V1), 'DBW 17' (V2), 'HD 2967' (V3) and 'PBW 550' (V4) in the sub-plots.

RESULTS

Higher grain yield was observed in M1 which was at par with M3 and significantly higher from M2 in both years of study. In M2 method, the unsown area was 33% and crop was not able to compensate this gap (Das and Yaduraju 2011). But in M1 there is only 25% area was unsown, which was compensated with higher dry matter accumulation and more number of effective tillers, and other yield attributing characters. Sowing of wheat with this technique can save 25% seed, and get 5% higher grain yield than normal sowing. All the varieties showed better growth, yield and yield contributing characters of happy seeder sown wheat under 25% skip row technique as compared to other planting methods. Long statured variety of 'HD 2967' gave significantly higher grain yield with this technique (M1) as compared to other treatment combinations. However, among the short statured varieties, 'PBW 550' and 'DBW 17' also gave significantly higher grain yield in 25% skip row technique as compared to the normal planting with happy seeder in combined harvested field of rice.

Table 1. Effect of skip row planting and cultivars

Treatment	Weed count at 40 DAS (no./m^2)		Weed dry matter at 40 DAS (g/m^2)		Grain yield (t/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Skip row planting						
M1	5.2b	5.3b	26.74b	29.80b	5.66a	5.46a
M2	5.5 a	5.7 a	32.33a	36.19a	5.04b	4.86b
M3	4.9 c	5.1 c	27.66b	30.64b	5.36ab	5.16ab
Cultivars						
V1	4.8 b	5.1b	26.20b	31.43b	4.92c	4.89b
V2	4.9ab	4.9 b	28.12b	31.62b	5.41b	5.29a
V3	5.3a	5.2 b	25.89b	30.05b	5.74a	5.46a
V4	5.9 a	6.1 a	35.43a	35.73a	5.35b	4.87b

CONCLUSION

The results of the investigation revealed that by using a technique of 25% rows (M1) unsown better to obtain the higher grain yield than 33% missing row sowing (M2) and normal sowing (M3). Sowing of wheat with this technique can save 25% seed, and gets an average of 5% higher grain yield than normal sowing. However, the differences were significantly higher under M1 over the M2.

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2,4-D induced senescence enhanced glyphosate efficacy in control of *Cyperus rotundus*

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Leaf senescence degrades macromolecules and mobilizes the degraded essential products to growing apex. 2,4-D induced senescence by stimulating ACC-synthase activity, led to uncontrolled apex grows by 48 h after its application. Senescence enhanced high and low affinity phosphate transporters present on plasma membrane and mobilized phosphate having glyphosate. Four parametric logistic model predicted the dose-response, and predicted additive dose model ED_{50} accurately thus comparable with observed ED_{50} (Devendra *et al.* 1997). With this in background attempt was made to assess 2,4-D sodium salt induced senescence on glyphosate isopropyl amine salt efficacy in control of *Cyperus rotundus*.

METHODOLOGY

Single *Cyperus rotundus* tuber having same size was planted in pots (size 30×10×10 cm^3) filled with Kandic Paleustalf soil and irrigated daily. Twenty-five days after establishment, the various proportions of 1:3, 1:1 and 3:1 of 2, 4-D pretreatment (48h) followed by glyphosate *viz*, 25:75, 50:50 and 75:25of recommended dose of herbicides with dilution factor of two, *viz*. (Recommended- R, R/2, R/4, R/8 and R/16) were sprayed. Further, herbicides alone sprayed only once. Thus treatments were 2,4-D Na salt 2, 1, 0.5, 0.25 and 0.125**;** glyphosate 1.3, 0.65, 0.32, 0.16 and 0.08**;** 1:3 proportion of 2, 4-D: glyphoste were 0.50:0.97, 0.25:0.48, 0.12:0.24, 0.06:0.12 and 0.03:0.06**;** 1:1 proportion were 1.00:0.65, 0.50:0.33, 0.25:0.17, 0.13:0.08 and 0.07:0.04**;** 3:1 proportion were 1.50:0.32, 0.75:0.16, 0.38:0.08, 0.19:0.04 and 0.09:0.02 kg/ha respectively. These 25 treatments compared with 2,4-D (1 kg/ha) and glyphosate (0.65 kg/ha) twice application at 48 h interval and no herbicide control. Thus, total 27 treatments with three replications where tried. Treatments killed the foliage 45 DAS and subsequently tubers sprouted thus biomass (g/pot) produced was assessed at 85 DAS. Percent biomass produced under various treatments over unsprayed control was worked out and regressed against corresponding doses. The dose-response of various treatments was explained by four parametric logistic functions.

RESULTS

The entire dose-response line of glyphosate separated away towards more efficient Y-axis from dose-response line of 2,4-D. The other dose-response lines of 1:1 and 3:1 lays between glyphosate and 2, 4-D lines whereas 1:3 lays close to glyphosate with still lower ED_{50} (0.064) than glyphosate (0.068) and 2,4-D (0.44) (Table 1). Relative potency being the ratio between ED_{50} of various treatments to ED_{50} of 2,4-D indicates how many folds more effective treatments than 2, 4-D. Thus, relative potency were 3.33, 3.25, 2.19 & 1.7 for 1:3, glyphosate, 1:1 and 3:1 respectively compared 2, 4-D. The observed ED_{50} for herbicide mixture were found to be lower than respective ADM predicted ED_{50}. Thus at lower dose of 2,4-D present (1:3), led to lower the reactive oxygen species production, which facilitated intact membrane and phosphate transporter thus increased phloem loading of glyphosate (Chinalia *et al.* 2007) and its efficacy.

Table 1. Regression and statistical parameters of logistic function fitted to doses of herbicides alone and combinations with biomass (g/pot) of *Cyperus rotundus*

Parameter	2,4-D Na salt	Glyphosate	2, 4-D Na. Salt: glyphosate		
			1:3	1:1	3:1
Regression					
C	0	0	0	0	0
D	100	100	100	100	100
A	1.13	2.87	2.79	2.07	1.96
B	1.27	1.07	1.02	1.14	1.37
log (ED_{50})	-0.825	-2.688	-2.748	-1.807	-1.427
RP	1	3.25	3.33	2.19	1.73
Statistical					
Goodness of fit R^2	0.987	0.998	0.961	0.931	0.933
RSS	33.2	2.6	26.8	201.4	181.8
RMSD	2.58	0.72	2.32	6.35	6.03
Observed ED_{50}	0.438[a]	0.068[c]	0.064[c]	0.164[c]	0.240[b]
ADM predicted ED_{50}			0.154	0.209	0.324
Student 't' test			**	*	NS

T test indicated NS – Non significant between ADM predicted and observed ED_{50}; Treatments with same alphabets indicates non-significant with Duncan Multiple Range Test

CONCLUSION

2,4-D followed by glyphosate (1:3) has more potential had 97% reduction in biomass over control than herbicides alone, compared to glyphosate (95%) and 2,4-D (90%) at maximum dose. Similar results obtained in micro-plot condition the percent reduction over control were 82, 77 and 51% respectively (Devendra 2014). Under field condition 2, 4-D fb glyphosate 1:3 proportion had greater expression than potted condition and work on increased dosage needed.

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Synergistic effect of different rice-based cropping systems on weed management

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In rice-wheat zone of Madhya Pradesh, rice and wheat occupy an area of 16.75 lakh and 43.0 lakh ha, respectively. The average productivity of these crops is 1.19 t/ha and 2.0 t/ha, respectively, which is low. Rice-wheat cropping system is widely adopted by the farmers due to stable production and less labour requirement (Kumar *et al.* 2001) but continuous adoption of this cropping system has led to the problems of specific weeds, reduced soil fertility in specific root zone, development of soil sickness and infestation of similar kind of pests which ultimately resulted in decline the efficiency and productivity of system (Katyal 2003; Kumar and Yadav 2005). The weed population in different crops can be minimized up to economical level by diversified cropping systems.

METHODOLOGY

The present field investigation was under taken at Kuthulia Farm of JNKVV, Rewa (M.P.). The experiment was conducted under All India Coordinated Research Project on Farming Systems during *Kharif* and *Rabi* seasons of two consecutive years during 2010-11 and 2011-12. The average annual rainfall of the tract is 1140 mm. The site selected was representative of the major rice growing area of the region in which transplanted rice was grown in *Kharif* followed by wheat, gram, berseem, potato, garlic, linseed, lentil, mustard, pea and gram + linseed. The topography of experimental field was uniform. The soil of experimental field was silty-clay-loam in texture, neutral in reaction (pH 7.25), medium in organic carbon (0.56%) and low in available nitrogen and phosphorus and high in potash (315 kg/ha).The field experiment was laid out in a RCBD with four replications. The ten cropping systems: rice-wheat, rice-gram, rice-berseem fodder +seed, rice-potato-wheat, rice-garlic, rice-toria-onion, rice-lentil, rice-pea-wheat, rice-linseed + gram in 1:3 and rice-mustard were tried.

RESULTS

The most dominating weed in rice field was *Monochoria vaginalis*, *Jussia easuffruticosa*, *Cyperus iria* and *Echinochloa colona* with higher relative density. The *Medicago hispida* was found most dominating weed under all the rice based cropping systems except rice-wheat and rice-berseem cropping systems. The relative weed density of *Phalaris minor* and *Heliotropium indicum* was reduced effectively by rice-pea-wheat cropping system followed by rice-chickpea for *Phalaris minor* and rice-wheat for *Heliotropium indicum*, whereas, *Anagallis arvensis* and *Medicago hispida* were found lower under rice-berseem cropping system. The rice-mustard cropping system was found most suitable for reducing the relative density of *Chenopodium album* among all the rice based cropping systems (Table 1). The reduction of specific weed flora may be due to synergistic effect of different cropping systems. Anderson (2011) reported that due to crop weed synergism among crops increases tolerance of weed interference because of improved resource-use efficiency. Weed management can also benefit from synergistic sequences. Because of crop diversity, producers can manage weeds with an ecological approach that integrates cultural tactics disruptive of weed population dynamics with herbicide use (Anderson 2005).

Table 1. Relative weed density under different rice based *Rabi* cropping systems

Cropping system	*Phalaris minor*	*Heliotropium indicum*	*Anagallis arvensis*	*Medicago hispida*	*Chenopodium album*	*Sonchus arvensis*
Rice-wheat	33.50	12.93	11.42	33.49	8.65	0.00
Rice-chickpea	18.65	16.07	15.01	43.10	7.13	0.00
Rice-berseem	27.22	23.47	8.15	13.57	4.37	23.20
Rice-potato-wheat	27.96	17.63	15.23	30.97	5.03	0.00
Rice-garlic	26.70	16.39	15.29	36.52	5.10	0.00
Rice-toria-onion	28.48	14.95	13.42	36.84	4.03	0.00
Rice-lentil	36.14	17.02	11.46	31.54	3.80	0.00
Rice-pea-wheat	12.26	11.61	27.55	31.72	3.99	1.97
Rice-chickpea-linseed	25.10	14.62	17.07	34.70	5.68	0.00
Rice-mustard	22.11	17.87	14.33	40.32	1.41	0.00

CONCLUSION

It was concluded that the different cropping systems can be utilized for controlling the weeds by changing the resource use capacity of crops due to synergism. No definite trend was observed in reduction of mass weed population but some specific associated weeds can be reduced by the adoption of diversified cropping system.

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Estimation of losses due to pests in rapeseed (*Brassica campestris*)

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In West Bengal, only 25% of required oil is produced, of which, rapeseed shares more than 30%. The pest causes 33% production losses (weed 12.5, insect 9.5, pathogens 6.5 and other pests 4.5%). Among the different pests, weed causes the maximum losses followed by insect-pest and pathogens. Thus, for oil security minimizing these pest losses is needed which would thereby help to increase the productivity of rapeseed as well as the oil production.

METHODOLOGY

Field experiment was conducted at Bidhan Chandra Krishi Viswavidyalaya Farm during *Rabi* 2014-15 on rapeseed (*Brassica campestris* var. yellow sarson cv. B-9) to study the percent losses in yield caused by the three major pests i.e., weed, insect and pathogens and also to find out the contribution of rapeseed plant branches (main stem, primary, secondary and tertiary branches) to the grain and empty siliqua yield. Untreated control and full treated were the two treatments used in six replications following pair plot technique design for each pest (weed, insect and pathogens) in a plot size of 3 m×5 m. The yield and yield parameters were recorded along with the oil yield.

RESULTS

The dominant weeds in the experimental fields were *Cyperus rotundus*, *Echinochloa colona*, *Digitaria sanguinalis*, *Eleusine indica*, *Brachiaria mutica* (monocots) and *Anagallis arvensis*, *Corchorus acutangulus*, *Cleome viscosa*, *Chenopodium album*, *Melilotusalba*, *Digeraarvensis*, *Physalis minima*, *Viciahirsuta* (dicots). The dominant insect & pathogens were *Lipaphis erysimi*, *Plutella xylostella* and *Alternaria brassicae*, respectively. The results of the experiment revealed that weed causes maximum losses (32%) followed by insect (19.9%) and pathogens (11.7%). The average oil yield is 41.5%. There was no nematode infestation found in the experimental plot. Similar result was observed by Karmakar *et al.* (2014) while working on green gram at BCKV farm, Nadia, West Bengal. The contribution to grain and siliqua yield was maximum from primary branches followed by main stem and secondary branches. Tertiary branches contribution to yield was negligible (below 1%). Similar result was observed by Ghosh and Chatterjee (1988).

CONCLUSION

From this experiment conducted at the new alluvial zone of India it could be concluded that weed is the major pest for rapeseed and its management should be given more weightage along with the other two pests to get higher grain and oil yield. Further, primary branches followed by main stem contributed more in grain and oil yield of *Brassica campestris* var. yellow sarson.

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Effect of lethal soil temperature on growth suppression of *Cyperus rotundus* L

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Lethal soil temperatures impede tuber formation, enhance respiration and deplete the tuber's reserve and reduce size and viabilityof *Cyperus rotundus*. Lethal air temperature led to 1) thermal death point (50^{0}C), 2) reduced uptake and assimilate (Ca uptake- 28^{0}C in maize), 3) decreased nitrate reductaseactivity, 4) reduced shoot and root growth and 5) scorching of leaves and stem (TNAU Portal Agriculture Agrometeorology: temp. and plant growth www.agritech.tnau.ac.in). Solarization with plastic mulch (PM) over weed canopy creates green house effectleading to increased RH, air temperature and CO_2 level between soil surface and PM (Shekh and Patel, 2006). Mere solarization does not raise the soil temperature to 60^{0}C, the temperature at which *Cyperus rotundus* tubers exposed for half an hour in hot air oven reduced tuber production and viability by 50% over control. Further, 95% of tubers are distributed in top 15cm depth (Webster 2003). Hencean attempt was made to maximize soil temperature (to around 60^{0}C) by different treatments during different seasons, to assess—soil temperature at different depths, as well as to assess its affect on suppression of *C. rotundus*.

Under field condition, *C. rotundus* infested 2 x 2 m^{2}were demarked; with solar water heater (200 l) irrigating facility to let out surface irrigation at centere of the plot.Spade width of soil was removed from 15cm depth, 175 micron PM was spread over weed canopy and its periphery wasmade air tight by tucking the edges with removed soil. Below PM, soil surface was irrigated with hot water (160 l/4 m^2). Four treatments (Control, HW, PM + HW, PM + HW + WBC) with five replications were maintained in split plot design with hot or normal water as main plot treatments. Surface irrigation of hot water between PM and soil carried out during 2PM-3PM during April, whereas for other seasons between 10-11AM. Irrigating 40 l/pot to attain 100% FC from 60%, led to maximize soil temperature to depth 5, 10 and 15 cm was standardized by using gravimetric method with load cell digital weighing device (Udaya Kumar *et al*. 1998, Anonymous 2011). Soil temperature was recorded at 10min interval till 90 min, using digital thermometer having -50 to 300^{0}C after hot water surface irrigation. Mean soil temperature was computed over different depths and replications.The standard error denotes variation

Table 1 Effect of plastic mulch, hot water irrigation and their combination on different seasonssoil temperature (Mean of 3 or 4 irrigations & different depths) and biomass (g/0.025 m^2) of *Cyperus rotundus* after 30 days of treatments

Treated plot	May 2011	Sept 2011	March 2012	April 2012**
Control	29.9^c	29.9^b	29.8^c	38.9^b
Hot water (HW)	39.1^b	31.7^a	41.2^b	48.0^b
Plastic mulch(PM) + HW	44.1^a	36.4^a	46.5^a	52.9^a
PM + HW + WBC	NA	NA	NA	54.6^a
LSD (P = 0.05)	2.21	2.87	4.12	6.14
Biomass (g/0.025 m^2)				
Control	363.1^a	115(10.7^c)	73^a	141^a
HW	196^b	196(14.0^b)	61^b	84.0^b
PM+ HW	127^b	331(18.2^a)	25^c	68^c
PM+HW+WBC	NA	NA	NA	18.2^d
LSD (P=0.05)	94.8	(3.5)	10.1	10.7

** indicates soil temperature measured during 2.00PM during April 2012, rest of soil temperature was measured during 10.00AM; plot with PM+HW+WBC treatment was introduced laterthus data was not available (NA) for other seasons; WBC denotes woolen blanket cover during night only which retainsnext day initial high soil temperature.

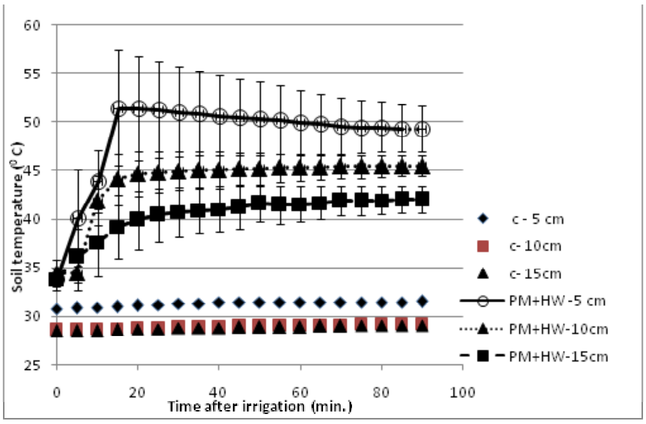

Fig.1 Effect of PM+HW on pattern of soil temperature reaching maximum and retention time of periodic mean and SE (due to replications, different irrigation days, different samples) during June 2010 under field condition

in hot water temperature (65-85^{0}C) from solar heater, which limits irrigation between replications.**B**iomass (fresh weight g/ 0.025 m^2) from 15cm depth was recorded by harvesting after 30days of treatments and their viability was assessed by slicing the tuber and exposing the cut end to the tetrazolium chloride in petri-dish with filter paper. Less pink colourintensity denotes low tuber viability.

Plastic mulch with hot water irrigation (PM + HW) had higher soil temperature than control and maximum soil temperature reached 57^{0}C at 5 cm depth by 20 min, whereas for 10 and 15 cm depth had 48 and 43^{0}C by 30 and 40 min. respectively. Maximum temperature was maintained for 90 min for all depths (Fig.1). Highest Soil temperature of 54.6 was recorded during April 2012 with PM + HW + WBC. During May2011, September2011, March and April 2012 temperature increase overcontrol was 10.8, 4.8, 11.4 & 9.1^{0}C in HW plot respectively (Table 1). Whereas, in PM + HW soil temperature was 5^{0}C more than HW irrigationduring all seasons.This results suggests thatrise in soil temperature depends on season and hot water temperature from solar heater. Thus during September soil temperature was optimum for weed growth with PM + HW. Soil temperature was 9.1^{0}C, 14^{0}C and 15.7^{0}C higher than control due to HW, PM + HW and PM + HW + WBC respectively during April.

Highest biomass (331 g/0.025 m^2) was recorded during September 2011.Travlos *et al.* (2009) showed that higher night and day temperature fluctuation of 0, 4, 8 and 12^{0}C with same mean 32^{0}C, *viz.* 32/32, 30/34, 28/36 and 26/38 led to enhanced sprouting of *C. rotundus* tuber by 72, 75, 87 and 97% respectively, which happens due to prevailing low temperature during night in Bangalore during September.Least biomass (18 g/0.025 m^2) was recorded during April with PM + HW + WBC compared to control (Table 2). The percent decrease in total biomass was 40, 52 and 87 in HW, PM + HW and PM + HW + WBC respectively inApril Compared to control. PM + HW effectivelyreduced tuber size and viability (Plate 1) of small, medium and large *C. rotundus* till 15 cm depth.

CONCLUSION

Plastic mulch cover over infested weed foliage and hot water surface irrigation during April provides lethal soil temperature 58^{0}C which led to drastic reduction of biomass (87%) and loss of size and viability of *Cyperus rotundus* tubers.

ACKNOWLEDGEMENT

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Herbicides for enhancing weed control efficiency in Indian mustard

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Weed management in mustard is done by both cultural and herbicidal approaches. Different herbicides are commonly used to eliminate weed species and most of these are effective against only narrow range of weed species. Hence, there is need to focus our attention on herbicide mixtures to enhance the weeding efficiency, broadening the spectrum of weed control and saving the herbicide and labour requirement. Also integration of herbicide with one or two hand weeding at proper time for improving the weed suppressing effect of crop gives significant improvement in crop yield.

METHODOLOGY

Experiment was carried out at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat) during *Rabi* 2013-14. The experiment comprised 10 treatments, and was evaluated in randomized block design with three replications. After uprooting of weeds, the weeds were sun-dried completely till reached to constant weight and finally the dry weight was recorded for each treatment. Weed control efficiency (WCE), net returns and B:C ratio were calculated for drawing conclusion.

RESULTS

Higher seed yield (2.35 t/ha) and stover yield (4.92 t/ha) were recorded under the weed free, which mostly remained statistically equivalent to oxyfluorfen 0.12 kg/ha + pendimethalin 0.45 kg/ha tank mix as pre-emergence *fb* HW and IC at 40 DAS. Next to the weed free, oxyfluorfen 0.12 kg/ha + pendimethalin 0.45 kg/ha tank mix as pre-emergence *fb* HW and IC at 40 DAS, oxyfluorfen 0.18 kg/ha as pre-emergence *fb* HW and IC at 40 DAS, pendimethalin 0.6 kg/ha as pre-emergence *fb* HW and IC at 40 DAS and HW & IC at 20 & 40 DAS recorded significantly weed control efficiency. Higher net returns of Rs. 55611/ha were realized with weed free, followed by oxyfluorfen 0.12 kg/ha + pendimethalin 0.45 kg/ha tank mix as pre-emergence *fb* HW and IC at 40 DAS, oxyfluorfen 0.18 kg/ha as pre-emergence *fb* HW and IC at 40 DAS and pendimethalin 0.6 kg/ha as pre-emergence *fb* HW & IC at 40 DAS. Higher B:C of 3.08 was realized with oxyfluorfen 0.12 kg/ha + pendimethalin 0.45 kg/ha tank mix as pre-emergence *fb* HW and IC at 40 DAS, as earlier reported by Kumar *et al.* (2012) and Patel *et al.* (2013).

Table 1. Effect of different treatments on weed control efficiency, yield and economics

Treatment	WCE (%)	Seed yield (t/ha)	Net returns (/ha)	B:C
Oxyfluorfen	75.1	1.77	38,251	2.72
Oxyfluorfen + HW and IC	91.0	2.03	46,932	2.97
Pendimethalin	72.3	1.75	39,364	2.83
Pendimethalin + HW and IC	89.1	2.01	46,727	3.01
Oxadiargyl	70.1	1.56	30,104	2.39
Oxadiargyl + HW and IC	81.0	1.86	39,461	2.55
Oxyfluorfen + pendimethalin + HW and IC	91.4	2.10	48,570	3.08
HW and IC	87.0	1.98	43,643	2.74
Weed-free	100	2.35	55,611	2.14
Unweeded control	0.0	1.32	26,561	2.34
LSD (P=0.05)		0.25		

CONCLUSION

Pre-emergence tank mix application of oxyfluorfen 0.12 kg/ha + pendimethalin 0.45 kg/ha *fb* HW and IC at 40 DAS or oxyfluorfen 0.18 kg/ha as pre-emergence *fb* HW and IC at 40 DAS or pendimethalin 0.6 kg/ha as pre-emergence *fb* HW and IC at 40 DAS could result in efficient management of weeds with higher seed yield of mustard.

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On-farm evaluation of pendimethalin in rainfed castor

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Weed infestation is one of the constraints limiting the production of castor (Yadav and Singh 2007). Castor being a wider spaced crop with slow initial growth makes it vulnerable to weed competition and first 40 days appeared to be critical. The conventional method of weed control is very effective, expensive, labour intensive and time consuming and most often protracted rains do not allow or delay the weeding during the critical period (Singh *et al.* 2013). Labour scarcity is another big hurdle and necessitate for an alternative cost effective economically viable weed management practice. Hence, an attempt has been made to work out an effective weed management strategy using herbicides alone or in combination with inter culture/ hand weeding.

METHODOLOGY

A field experiment was conducted during 2012, 2013 and 2014 to find out most suitable and cost effective weed management practice for rain fed castor on the medium black soils of central dry zone of Karnataka (Hiriyur). The experiment consisted of ten treatments involving two pre-emergence herbicides (trifluralin and pendimethalin) alone and in combination with hand weeding / inter cultivation, inter-cropping of castor + groundnut (1:3 ratio), three weedings (20, 40 and 60 DAS), farmers' practice (one weeding at 20 DAS followed by two intercultures at 45 and 60 DAS),two post–emergence herbicides (quizalofop-ethyl 5% EC and fenoxaprop-p-ethyl 75 EW, both at 50 g ai/ha at 25 DAS) and weedy check.

RESULTS

Three seasons' pooled results revealed that pre-emergence application of pendimethalin at 1.0 kg/ha followed by one inter-cultivation at 40 DAS resulted in better weed control efficiency and seed yield (1.61 t/ha) and B:C ratio (4.3) comparable to farmers' practice (1.33 t/ha). Graminicides controlled grasses and gave moderate yield comparable to farmers' fields. Weedy check lowered the yield by 76% due to severe competition offered by grasses and broad leaf weeds. The research results were further validated through large scale on farm demonstration on best treatment of pre-emergence pendimethalin at 1.0 kg/ha followed by interculture at 40 DAS was compared with farmers' practice (one hand weeding at 20 DAS followed by two intercultures at 40 and 60 DAS) on five farmers fields of village Gannayakanahalli (plot size of 1000 m) in Chitradurga district during 2014-15 as farm trials through farmers' participatory approach. The findings revealed that pendimethalin at 1.0 kg/ha followed by one inter-cultivation at 40 DAS (1.47 t/ha and Rs. 3.90/Re) gave seed yield and B:C ratio (Table 1) comparable to farmers' practice of weed control (1.49 t/ha and Rs. 3.70/Re).

Table 1. Seed yield and B:C ratio of castor as influenced by integrated weed management practices

Treatment	Seed yield (t/ha)	Benefit : cost ratio
Pendimethalin 50 EC (1.0 kg/ha) + inter-cultivation at 40 DAS	1.47	3.90
Farmer's practice (HW on 25 DAS + two IC at 45 and 60 DAS)	1.49	3.70

CONCLUSION

It was concluded from the study that pre-emergence application of pendimethalin at 1.0 kg/ha followed by interculture at 40 DAS for realizing higher weed control efficiency, seed yield and economic returns under rainfed conditions of Karnataka.

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Crop-weed dynamics and weed management under the regime of climate change

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Predictive models suggest unprecedented increase in atmospheric CO_2, temperature and changes in precipitation through time. Changes in temperature and CO_2 are likely to have significant direct and indirect effects on biology of crops and weeds including growth, reproduction, competitive ability, responses to environmental stresses, and efficacy of herbicides (Ziska 2000, Ziska *et al.* 2010).Weeds have better adaptability to the changing environment by virtue of greater genetic diversity and evolutionary potential than crops. Evidences, however limited, indicate that weeds may show a strong response to changes in climate. Overall, the data that are available on the response of weeds and changes in weed ecology are limited and situation becomes worse as not much clue is available at mechanistic level to solve the puzzle of weed-crop interactions in changing climate regime. Hence, efforts have been made to study effect of elevated $CO_2$and temperature individually and in combination on rice-wheat-greengram sequence along with their associated weeds.

METHODOLOGY

The present study was conducted in open top chambers (OTCs) in rice-wheat-summer greengram cropping sequence along with dominated weeds in each crop. Mix population of crops and important weeds (rice + weedy rice + *Echinochloa crus-galli*; wheat + *Phalaris minor* + *Avenaludoviciana*; greengram + *Euphorbia geniculata* + *Amaranthus viridis*) were grown in OTCs in their respective seasons. Plants of each species were subjected to long-term exposure to ambient conditions, elevated CO_2 (550 ± 50 ppm), elevated temperature (ambient + 3 °C) and combination of these two (elevated CO_2 and elevated temperature). For comparison, control treatment was maintained at ambient CO_2 (390 ± 5 ppm) and ambient temperature. Morpho-physiological, phenological, biochemical, activity of soil enzymes and molecular observations were recorded in each species periodically. Efficacy of herbicides like sulfosulfuron against *P. minor*, and bispyribac-Na against *E. colona* was also examined under same set of treatments.

RESULTS

In general, enrichment of atmospheric CO_2 had a positive effect on overall growth of crops as well as weeds, however, elevated temperature alone or in combination of elevated CO_2 had adverse effect on phenology, growth and development of the crops (more so in rice and wheat). Gas exchange, antioxidant defence mechanism and expression analysis of gene involved in photosynthesis and antioxidant defence have been studied in detail in crops and weed species. Differential regulation as well as induction of new iso-forms in response to elevated CO_2 and elevated temperature and combination of these two was evident. Overall, weeds exhibited stronger antioxidant defence as compared to crop counterparts. Expression of genes involved in photosynthesis and defence pathways was found to be altered in species-specific and treatment-specific manner. Differential regulation of genes involved in antioxidants defence pathway point towards possible involvement of these genes in adaptation to high temperature and high CO_2 environment. Elevated temperature and elevated CO_2 individually and in combination delayed onset of reproductive stage and panicle maturity in rice, wild rice and weedy rice; however, reverse was true in case of wheat. Elevated CO_2 and temperature influenced the activity of soil enzymes (FDA hydrolysis, dehydrogenase and urease) in rhizosphere of crops and weeds. *E. crus-galli* responded positively with respect to the soil enzymes at elevated CO_2 alone or in combination of temperature. Efficacy of sulfosulfuron against *P. minor*, and bispyribac against *E. colona* reduced at elevated CO_2 and elevated temperature indicating adverse effects on weed management.

CONCLUSION

Rise in atmospheric CO_2 concentration and temperature affects plants' performance in species-specific manner. At elevated CO_2 and temperature, crop-weeds interaction altered in favour of weeds and weed management will be more difficult due to reduction in efficacy of herbicides.

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Distribution patterns of weedy rice populations in different climatic zones in Sri Lanka

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Weedy rice (*Oryzasativa* f. *spontanea*) (WR) or 'red rice' is one of the most nuisance weeds possess higher morphological plasticity and mimic the wild and cultivated rice. The close morphological similarity makes it difficult to distinguish between WR bio-types and cultivated rice varieties in the field. WR was first reported in 1990 from Ampara District in Eastern Province of Sri Lanka and by the year 1997, it had become a serious problem in the area. Presently WR distributed in almost all agro ecological zones of the country with varying population densities (Abeysekara *et al.* 2010). The studies related to the genetic diversity of WR populations and eco-climatic trend in distribution of weedy rice are limited. Further, lack of such studies precludes the WR control and management in the country. In general, the distribution of weeds is facilitated by the changing climate (Hulme 2014). The objective of the present study was to outline the distribution patterns of WR population in different eco-climatic zones of Sri Lanka.

METHODOLOGY

Seeds of presumed different WR eco-types were collected from five different locations in each zone (Wet, Dry and Intermediate). Collected seeds and two wild rice varieties (*O.nivara* and *O.rufipogan*) were subjected to dormancy breaking treatments and sown in plastic trays in a plant house at the Open University of Sri Lanka. A total of five replicates of each eco-type were planted in plastic pots with representative paddy soils from each location. Replicates were arranged in Complete Randomized Design (CRD). Agro-morphological characterization (using thirty six characters) of WR eco-types and cultivated rice varieties were measured using the Standard Characterization Catalogue of PGRC, 1999**.** Total genomic DNA was extracted from 7-day old seedlings of the respective WR eco-types and cultivated types using Ceygen Plant total DNA purification kit. A total of ten SSR primer pairs were used for the molecular study. The SSR markers were obtained from Gramene.A four-primer system was used, which included a universal M13 oligonucleotide (TGTAAAACGACGGCCAGT), labeled with one of four fluorescent dyes (6-FAM, NED, PET or VIC). All amplification reactions were carried out in a total volume 30 µl of which consist 1 × PCR buffer, 1mM dNTPs, 2µM SSR primers, 2mM $MgCl_2$, 50 ng of genomic DNA and 0.5 U of Taq polymerase. The SSR alleles were resolved on an ABI Prism 3100 DNA sequencer using Gene Scan 4.1 software, and sized precisely using Gene Scan 600 LIZ ladder. Fragment analysis using capillary electrophoresis was performed using GENE MAPPER software and identified different peaks among WR eco-types and wild rice varieties. The data collected from the WR eco-types and wild rice was subjected to PCA with 'varimax rotation' in SPSS/PC Ver. 20.

RESULTS

The pattern reflected from the PCA on the variation of agro-morphological characters of WR eco-types and wild rice varieties revealed that agro-morphological characters were broadly vary between the different rice eco-types in climatic zones with certain degrees of overlapping of the groups of Wet zone and Dry zone WR eco-types. The WR eco-types that occur in Intermediate zone were clustered into a group. The distribution of agro-morphological characters of the WR, wild and cultivated rice showed a weak trend with climatic zones indicating the plasticity of the morphological features of WR that enable them to grow in any agro-ecological zone. The molecular data on PCA yield a distribution pattern revealed that WR eco-types and wild rice were fallen into groups reflecting their eco-climatic provenance. The distribution pattern of wild rice *O. nivara* which is restricted to the dry zone is associated with dry zone WR and cultivated rice varieties suggest that they possibly originated from the *O. nivara*. Further, the WR type associated with *O.rufipogon* which is common in wet zone could be assumes as a contributive wild rice of the WR eco-types in wet zone. The WR populations in Intermediate zone shows closer affinities to *O. nivara* and suggest that they possibly hybridization with *in situ* cultivated rice.

CONCLUSION

WR populations in different climatic zones of country are sporadically originated in the respective ecological zones associated *O. nivara* for dry zone and Intermediate zone; *O.rufipogon* for the wet zone WR type.

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Germination of weedy rice under anaerobic conditions and varying seed burial depths

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Weedy rice, a menace in direct seeded rice fields and largely accepted as a natural hybrid between cultivated and wild rice, has the ability to backcross with the parents and other such hybrids. The developed hybrid swarm, thus, varies immensely in its phenotypic as well as genetic properties. Where this attribute is a problem while developing efficient technologies for managing weedy rice, it is also a boon in context of available natural germplasm. This naturally introgressed material, yet unexplored, may have potential use in future breeding programmes. Of the many areas in rice breeding, screening germplasm for potential to germinate under anaerobic conditions and establishment of seedling is of importance (Reddy *et al.* 2009). In this context, a study was conducted at Directorate of Weed Research, Jabalpur to screen available weedy rice morphotypes for their ability to germinate under stringent anaerobic conditions.

METHODOLOGY

In a preliminary screening ninety nine morphotypes of weedy rice, collected across different states of India, were tested for germination along with 13 varieties of cultivated rice. Seeds of all the accessions showed good germination in the range of 96-100% under normal conditions. Thirty seeds were uniformly placed 0.5cm beneath the soil and covered with 15 cm standing water and observed for percent germination. The screened in morphotypes were then tested for germination by placing 25 seeds 1cm and 2.5 cm beneath the soil and covered with 15 cm of standing water. This screening was done with four replications. Observations were recorded for determining percentage seed germination, germination index, vigor index, and dry matter production at 15 DAS and/or at 25 DAS.

RESULTS

Among the ninety nine weedy rice morphotypes studied, only four weedy rice morphotypes and one cultivar of cultivated rice germinated in range of 57-69%. The selected four weedy rice morphotypes and one cultivar of cultivated rice screened for germination with increase in seeding depth and constant water height revealed drasticallydelayed and reduced germination. At a depth of 2.5cm, cultivated rice had 4% germination while maximum germination (14 and 12%) were observedin weedyrices from Madhya Pradesh and Kerela states of India(Table 1).The weedy rice WR1 had significantly higher vigour index over other weedy rices as well as rice cultivar 'Sahbhagi'.

Table 1. Performance of selected weedy rice under anaerobic conditions

Weedy rice morpho-type	Details	Germination percentage Standing water height 15 cm with seed burial depth at			Standing water height 15 cm seed burial depth at 2.5 cm
		0.5 cm (15 DAS)	1cm (15 DAS)*	2.5 cm (25 DAS)*	Vigor index
CR 1	Sahbhagi	56.7	52.00	4.00	104.00
WR1	Madhya Prasesh	56.7	53.00	12.00	681.00
WR2	Madhya Prasesh	66.7	40.00	4.00	168.00
WR3	Kerela	66.7	60.00	14.00	435.50
WR4	Madhya Prasesh	68.9	60.00	10.50	393.50
LSD (P=0.05)			NS	NS	119.00

*Percent germination calculated based on number of plants above water surface

CONCLUSION

Variation in germination/seedling establishment under stringent anaerobic conditions is present among weedy rice accessions collected across geographical regions. Though germination ratesreduced with increasing seed depths, weedy rice performed relatively better over cultivated rice studied. This clearly indicates towards potential amongst weedy rices to be very well utilized as potential germplasm.

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Climate change studies in India with various approaches, simulation and modeling

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The increasing CO_2 concentration of atmosphere and associated predictions of global warming have stimulated research programs to determine the likely effects of future elevated CO_2 levels on agricultural productivity and on the functioning of natural ecosystems. Researcher reported the results on plant responses on elevated level of CO_2 by conducting experiments with different types of structure and simulation modelling which include growth chamber, controlled environmental chambers, open top chamber and free air CO_2 enrichment facilities etc,. The effects of atmospheric CO_2 enrichment have been studied for many years in green house, controlled environmental chambers, OTCs and other elevated structures to confine the CO_2 gas around the experimental plants. The accuracy on maintenance of CO_2 inside chamber installed around the crops did not succeed in many other studies because of technical constrains. In the enclosed structure, the experiment will not be the same as that in the open top chamber and FACE facilities.

METHODOLOGY

Genesis Technologies is one of the leading organizations in India working on different models of climate change studies like Temp. Gradient Tunnel (TGT), Open Top Chamber (OTC), Free Air CO_2 Enrichment System (FACE), Free Air Temp. Enrichment System (FATE), Free Air O_3Enrichment System (FAOE) and Elongated Tunnel (ET) with instrumentation, control and automation system.

RESULTS

We have successfully established systems for IIT-Kharagpur, ICRISAT-Hyderabad, OUAT-Bhubaneswar, ICAR-Patna, JNU-New Delhi, IHBT-Palampur, IARI (ICAR)-New Delhi, National Bureau Agriculturally Important Insects (NBAII), Bangalore,, Assam Agricultural University (AAU), Jorhat, and Central Rice Research Institute, Cuttack, NBRI (CSIR), Lucknow and IIVR (ICAR), Varanasi , Indian Forest Research Institute (FRI)-Dehradun, Central Potato Research Institute (CPRI), Jalandhar, Bharatidasan University , Trichy on various projects like OTC, TGT, FACE, FATE , CO_2 Gradient Tunnel and elongated tunnel and CO_2 elevated/controlled bioreactor for Azolla Cultivation. Various research work and experiments are being conducted on different crops and tree species on effect of elevated CO_2, temp, and ozone The present article highlights different executed projects in India on different model and simulation with respective crops for last seven years.

CONCLUSION

A number of technologies have been developed to study the impact of rising atmospheric CO_2 on a plant system and also monitor the carbon exchange processes under changing climate. Here, we tried to focus on effects of elevated CO_2 and temperature on forest tree species using OTC and other approaches which are strongly required for developing adaptation and mitigation strategies to address the potential impacts of future climate change. There are so many areas in forestry science such as breeding new varieties against abiotic stress and improved water and nutrient use efficiency, effects of elevated CO_2 on host parasite interaction and on insect-pests and diseases and species and ecosystem levels and phyto-remediation potential of tree species under elevated CO_2 which might be taken as priority basis with respect to effects of elevated CO_2 on growth dynamics, structure and function of plants species using Open Top Chambers (OTCs), FACE and FATE facilities.

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Theme 18

Weed biology and management under changing climate

Weed dynamics in direct-seeded rice varieties sown at different dates in Vertisols

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Due to changing environmental conditions with variations in the onset of south-west monsoon, sowing dates are affected, causing losses in crop yield as well as changes in cropping systems in this region. Weed infestation in direct-seeded rice is causing severely reduction of grain yield up to 74% (Ramzan 2003). Furthermore, weed population dynamics also varies with changes in the sowing dates and cropping patterns. Keeping this in mind, an experiment was initiated with an objective to evaluate weed dynamics in different varieties planted at different dates. Additionally, weed analysis of major weed species, *Echinochloa crus-galli* and *Cyperus* spp. were also evaluated. The hypothesis is that changes in sowing dates among varieties affect weed population and biomass.

METHODOLOGY

A direct-seeded rice experiment was established in *Kharif* 2014 in a split plot design with three replications at Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur, India. The main treatment consisted of three sowing dates (June 10, June 25, and July 10, 2014) and sub-treatments were five rice varieties ('Sahbhagi', 'Danteshwari', 'IR 36', 'Kranti' and 'Swarna'). The maturity period of 'Sahbhagi' and 'Danteshwari' is 90-100 days after sowing (DAS), 'IR 36' is 100-120 DAS, 'Kranti' is 120-130 DAS and 'Swarna' is 140-150 DAS. Field remained irrigated at 30 and 70 DAS. Weed population and biomass were observed at 30 and 60 DAS, and at harvest. Biomass was collected and oven dried before its weight. Hand weeding was performed two times at 30 and 60 DAS after recording weed data. Data were analyzed using GLM, SASstatistical software and means were separated using least significant difference at the 5% level of significance. Interaction between date of sowing, varieties, and timings of collected data were compared using least square means.

RESULTS

Weed population of *Echinochloa crus-galli* and *Cyperus* spp. and weed biomass were significantly higher in the June 10 sown date than the other dates except weed biomass at June 25, which was at par with the June 10 sown date (Table 1). There was no significant difference among varieties for total weed population and biomass, and *E. crus-galli* and *Cyperus* spp. population. Similarly, no interaction was observed between date of sowing and varieties among variables studied except total weed biomass (Table 1). There was no significant interaction in variables between varieties and different timings, except in total weed biomass. Among weed biomass, no significant differences were observed between varieties at different timings.Mubeen et al. (2014) reported similar results when crop was sown in the 1st week of June. There was an increase in *E. crus-galli* population from 30 to 60 DAS but decreases at harvest among all the sowing dates. On the other hand, *Cyperus* population increases from 30 to 60 DAS but decreases at harvest except at the third sown date. After hand weeding and less water availability, weed population decreased at harvest.

Table 1. Influence of date of sowing and varieties on total weed population, weed biomass and weeds in direct-seeded rice

Treatment	Total weed population (no./m^2)*	*Echinochloa crus-galli* (no./m^2)*	*Cyperus* spp. (no./m^2)*	Total weed biom (g/m^2)
Date of sowing (DOS)				
June10	118.5 a	15.4 a	13.7 a	84.3 a
June 25	80.1 b	8.3 b	8.5 b	86.4 a
July 10	65.9 c	5.7 b	7.3 b	75.7 b
Varieties				
Sahbhagi	87.5 a	8.7 a	9.3 a	82.7 a
Danteshwari	84.2 a	10 a	10.3 a	82.7 a
IR 36	88.2 a	10.5 a	7.8 a	81.7 a
Kranti	89.7 a	8.5 a	11.4 a	82.3 a
Swarna	91.3 a	11.1 a	10.4 a	81.3 a

*Square root (X+1) transformed. Means within columns are original values.

[a] Letters represents comparing means within columns using LSD test at 5 % probability level. Means with same letters within column are not significantly different

CONCLUSION

Weed and selected species population and biomass were more in plots sown early than plots sown late. There was no significant difference of weed species population and biomass between varieties.

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Effect of sowing date on weed infestation in wheat varieties under different irrigation schedules

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With the introduction of high yielding dwarf varieties coupled with increased use of fertilizer and irrigation, the weed problems in wheat have increased tremendously. Uncontrolled weed growth may reduce wheat yield ranging from 15-40% depending upon magnitude, nature and duration of weed infestation (Jat *et al.* 2003). Among various factors that affect the yield of wheat, sowing date, irrigation and weed management are of supreme importance. In the current scenario of changing climate, sowing time became crucial adaptation to decide the success of the crop. Hence, accurate knowledge of the sowing window of any particular variety at a particular location is critical to achieve an optimum yield. Weeds compete with crops for water and conditions became severe under its scarcity. The yield increases significantly with an increase in the level of irrigation. The present study was therefore conducted to study the effect of sowing dates on weed incidence in wheat varieties under different irrigation schedules.

METHODOLOGY

A field experiment was conducted at Jawaharlal Nehru Krishi VishwaVidyalaya, Jabalpur, Madhya Pradesh, during the *Rabi* season of 2014-15 with eighteen treatment combinations, consisting of three sowing dates (27 Nov., 12 Dec., 27 Dec.) and two varieties ('GW 366' and 'MP 1202') in main plots and three irrigation schedules (Crown root initiation + Flowering, Crown root initiation + Flowering + Milk, Crown root initiation + Late jointing + Flowering + Milk) in subplots were laid out in a split plot design with three replications. Fertilizers were applied uniformly to all the plots through urea, single superphosphate and muriate of potash (120-60-40 kg N-P_2O_5-K_2O/ha). A half of the nitrogen and full dose of phosphorus and potash were given basal and remaining nitrogen was given in two splits. Irrigation schedule was followed as per the treatments keeping 60 mm depth of irrigation. However, a shallow come-up irrigation was given immediately after sowing of the wheat crop to all the treatments. During the period of investigation, total rainfall received (175.1 mm) in the months of December, January, February and March was 4.8 mm, 58.7 mm, 20.6 mm and 91.0 mm, respectively. Hence, the total water applied in the treatments was, two irrigations (295.1 mm), three irrigations (355.1 mm) and four irrigations (415.1 mm), respectively. Weed data was recorded at 30 days interval and statistically analysed.

RESULTS

The wheat crop was infested mainly with *Chenopodium album*, *Melilotusindica*, *Anagallis arvensis*, *Physalis minima*, *Cichoriumintybus*L.*Alternanthera sessilis* L., *Medicago denticulata* L.and *Vicias ativa* L. among the broad leaf weeds and *Cyperus rotundus* of sedges group while, *Phalaris minor* and *Echinochloa colona* among the grassy weeds. Broad-leaved weeds were predominant, followed by grassy weeds and sedges. The highest total weed density and biomass was observed when crop was sown on 12th Dec. which was closely followed by 27th Nov. sowing while, lowest in 27th December sowing. Among the varieties, 'GW 366' recorded the highest weed density (44.11) and biomass (9.69) as compared to 'MP 1202', but with no significant differences among them. Irrigation schedules does not show significant differences in case of weed density but higher irrigation frequency recorded higher weed biomass (10.13 g/m^2) as compared to reduced number of irrigation frequencies. The increase in weed density and biomass in higher irrigation frequencies might be due to sufficient moisture present in the upper soil layers. Choubey*et al.* (1998) also reported significant increase in weed population with the increase in irrigation frequency from IW:CPE ratio 0.6 to 1.0. Weed density and biomass was highest up to 60 DAS when crop was sown on 27th Nov. while, after 60 DAS, it was observed in 12th Dec. sowing. There was no significant difference among these treatments while lowest weed density and biomass was observed in 27th Dec. sowing. GW 366 recorded highest weed density and biomass throughout growing period as compared to the MP 1202. The irrigation schedules have highest weed density and biomass at later growth stages of the crop i.e. 60 DAS up to the harvest of the crop. Irrigation applied at 3 and 4 frequencies had highest weed density and biomass but there were no significant differences among the treatments throughout the growth period of crop. Nadeem *et al.* (2007) reported non-significant differences between low and high frequencies of irrigation for weed density and biomass in wheat. This might be due to the intermittent rains received during the crop growing season which resulted in better supply of moisture for even growth of the weeds in all the treatments.

CONCLUSION

Sowing dates has profound effect on weed density and biomass of wheat crop while varieties and irrigation schedules does not differ significantly throughout the growth period of the crop indicating less impacting factors on density and biomass of weeds.

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Effect of sowing time on weed infestation in wheat cultivars under different fertilizer levels

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Weeds account for 37% of the total annual loss of agricultural produce in India (Yaduraju *et al.* 2006). If not controlled they can lead to a reduction of 20-40% in wheat yield and critical period for crop-weed competition is 30-45 days after sowing (Mishra 1997). With the introduction of high yielding dwarf varieties coupled with increased use of fertilizer and irrigation, the weed problems have increased tremendously. Among various factors,the most important that affect the yield of wheat are sowing time, irrigation, nutrients and weed management.Hence, accurate knowledge of the sowing time of any particular variety at a particular location is critical to achieve an optimum yield. Fertilizers constitute an integral part of improved crop-production technology. Proper amount of fertilizer is considered a key to the bumper crop production. Studies showed a direct relationship between increased balanced fertilizer uses for higher crop yields. The present study was conducted to find the effect of sowing dates on weed infestationin wheat cultivars under different fertilizer levels.

METHODOLOGY

A field experiment was conducted at Jawaharlal Nehru Krishi VishwaVidyalaya, Jabalpur, Madhya Pradesh, during the *Rabi* seaon of 2014-15 to study the effect of sowing timeson weed infestation in wheat cultivars under different fertilizer levels.The experiment was laid out in split plot design comprising 3 sowing times (Timely, Late and very late.) and three varieties (MP 1203, MP 3336 and GW 173) in main plot and 3 fertilizer levels (RDF, 20% higher than RDF, 20% less than RDF,) in subplots with three replications. Fertilizers were applied through urea, single superphosphate and muriate of potash with RDF as 120:60:40 kg $N-P_2O_5-K_2O$ kg/ha. All the recommended package of practices was followed for this region. Data on weed growth and yield was recorded using suitable techniques.

RESULTS

The wheat crop was infested mainly with *Chenopodium album, Melilotusindica, Anagallis arvensis, Cichoriu-m intybus* L., *Medicago denticulata* L., *Cyperus rotundus* and *Phalaris minor*. Among the broad-leaved weeds, *Cichorium intybus* L.,*Chenopodium album, Melilotus indica* and *Anagallis arvensis* were the predominant weed species while *Cyperus rotundus* as narrow leaved weed.Data in Table 1 indicated that, the highest total weed density was observed when crop was sown on 20th Dec while total biomass was observed in 30th Nov sowing. Cv.MP 1203 recorded highest weed density and biomass as compared to MP 3336 and GW 173. Higher dose of fertilizer, 20% more than RDF exhibited highest weed density and biomass at critical period of weed competition.The highest grain yield was recorded under timely sown crop over that of late and very late sown crop. The increase in grain yield was to the tune of 11.09 and 27.55 percent, respectively. Wheat cv. 'MP 3336' gained maximum grain yield than rest of the cultivars. The 20% higher dose of RDF recorded highest grain yield versus rest levels. All the weed species showed reduced number and dry weight under delayed sowing. The timely sown crop was highly infested with *Chicorium intybus* and *Chenopodium album* while *Melilotus indica*, *Cyperus rotundus* and *Anagallis arvensis* exhibited highest weed density under late sowing. Cv. MP 3336 had lowest weed density and biomass which was followed by GW 173, while it was highest in MP 1203. This might be due to the fast growth and maximum canopy cover in earlier phases of growth of both the cultivars. The 20% reduced level of RDF showed lesser weed density and dry weight as compared to rest of the levels. This might be due to the higher competition for uptake of nutrients by both the crop and weeds.

CONCLUSION

It was concluded from the experimentation thatsowing time, cultivars and fertilizer levels havegreater role on weed density and biomass.Hence to achieve higher yield of wheat crop, weed population can be controlled by managing sowing time, selection of suitable cultivars and proper nutrient supply.

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Density and nitrogen effects on the interference of *Phalaris minor* in wheat

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Weed infestation is one of the major biotic constraints in wheat production. Growing high-yielding dwarf varieties of wheat has led to a shift in weed flora from broad-leaved weed dominance in 1960s to grass weed menace in early 1970s and *Phalaris minor* Retz. dominance in late 1970s. *P. minor* has developed resistananceto isoproturon (Malik and Singh 1993) and cross-resistance biotypes to clodinafop-propargyl (Das *et al*. 2014). The yield losses due to weeds vary depending on the weed species, their density and environment. *P. minor* is single most dominant grassy weed in northern Indian plains causing significant yield lossess (Chhokar *et al*. 2012). The growth factors, particularly, N may intensify the interference effect but less studied in the context of climate change. The effect of *P. minor* densities on wheat in response to nitrogen (N) application may alter the crop-weed balance but hardly documented.

METHODOLOGY

The field experiment was conducted at Indian Agricultural Research Institute, New Delhi, India, during winter of 2014. The experiment was laid out in a split plot design with 3 replications consisting of 21 treatment combinations: 3 N doses (100 kg N/ha, 150 kg N/ha and 180 kg N/ha) in main plot and 4 *Phalaris minor* densities (10, 20, 40 and 80 plants/m^2) and 3 controls (unweeded control without *Phalaris*, unweeded control having mixed population and weed free check) in sub plots. The wheat variety HD 2967 was sown with seed-cum fertilizer drill by using 100 kg seed/ha at row spacing of 22.5 cm. The seed of *Phalaris minor* was broadcasted at the time of sowing to maintain the desired densities. The herbicide metsulfuron at 5 g /ha was used at 20 DAS of wheat in *Phalaris* plots to remove the broad-leaved weeds. All recommended package of practices were used to grow wheat crop including recommended dose of Pand K. The data on *Phalaris* tillers and dry weight of weeds, and yield and yield attributes of wheat were recorded and analysed statistically by using SAS version 9.3.

RESULTS

All yield attributing characteristics of wheat *viz*., effective tillers, number of grains/spike and grain yield were significantly improved asthe doses of N increased from 100 to 180 kg /ha (Table 1). Significantly higher grain yield of wheat was observed with the application of 180 kg N/ha followed by 150 kg and 100 kg N/ha. Similarly *P. minor* densities also influenced yield and yield attributing characters of wheat. Increase in the density of *P. minor* from 10 plants/m^2 to 80 plants/m^2, the yield of wheat was reduced considerably. The yield reduction was 9.16 to 31.42 % respectively over weed-free check. Tillers and dry weight of *P. minor* were also influenced by N doses and *P. minor* density. Higher number of tillers and dry weight of *P. minor* were observed under lower doses of nitrogen during 60 DAS over higher dose of 150 and 180 kg N/ha. Significantly higher tillers and dry weight were observed under *Phalaris* density of 80 plants/m^{2}at 60 DAS.

Table 1. Yield and yield attributes of wheat and dry weight and tillers of *Phalaris minor*as influenced by N doses and densities

Treatment	Effective tillers (no./m row length)	Grains/ Spike	Grain yield (t/ha)	*Phalaris minor* tillers (no./m^2) at 60 DAS	Dry weight of weeds (g/m^2) at 60 DAS
Nitrogen dose					
100 kg N /ha	78.48	40.27	3.57	7.89*	168.29
150 kg N/ha	98.86	47.98	4.77	6.60	123.19
180 kg N/ha	108.95	51.11	5.41	5.43	76.14
LSD (P=0.05)	4.33	1.31	0.54	1.36	19.32
Phalaris minor density					
10 plants/m^2	107.89	50.59	5.06	7.02	59.89
20 plants/m^2	102.78	48.97	4.78	8.24	94.11
40 plants/m^2	89.33	45.53	4.39	10.03	147.89
80 plants/m^2	84.67	43.31	3.82	13.05	296.11
Unweeded control without *Phalaris*	87.56	44.00	4.41	1.00	79.78
Unweeded control having mixed population	81.44	41.28	4.07	6.13	180.00
Weed free check	114.33	51.50	5.57	1.00	0.00
LSD (P=0.05)	3.39	1.57	0.26	0.77	11.39

*Data transformed to square root transformation

CONCLUSION

Higher dose of 180 and 150 kg N/ha proved beneficial towards reduction of *P. minor* interference, however, higher density of *P. minor* reduce the effect of N. The effect of higher dose of N was more prominent at the lower density of 10-20 *Phalaris* plants/m^2.

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Field host range and host specificity of *Dereodus denticollis:* a potential biological control agent for prickly acacia (*Vachellia nilotica*) in Australia

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Prickly acacia (*Vachellia nilotica* sub sp. *indica*), a native of the Indian subcontinent, is a serious weed of the grazing areas of northern Australia and is a target for classical biological control. Three years systematic surveys on prickly acacia at its natural habitats in Southern India revealed 94 different species of insects belonging to five families (Dhileepan *et al.* 2013). The defoliating weevil *Dereodus denticollis* Boheman is one of the promising agents prioritized as a potential biological control agent for further studies.*D. denticollis* is distributed widely and occurs throughout the year and cause severe defoliation in young and mature trees. Except for a little information on its pest status on *V. nilotica*s sp. *indica* in India (Pillai *et al.* 1995), no other details existing on its biology, field host range and host specificity. The present paper describes the host range and host specificity studies of the weevil, *D. denticolis* that were carried out in India.

METHODOLOGY

Systematic surveys were carried out in 2008-2011 at 72 sites in the states of Tamil Nadu and Karnataka. During the surveys, other acacia species nearby and related species were also sampled to monitor the natural host range of *D. denticollis*. No-choice host testing of *D. denticollis* was carried out by exposing 48 hours starved adults on the test plant species raised in poly bags (20 cm × 30 cm). Ten adults of the unfed weevil selected from the same batch were placed on a potted plant of each plant species.The adult weevils were confined on each plant species by a transparent net cloth (30 cm diameter, 60 cm height). Five replications were maintained for each plant species. The plants were monitored daily and observations on the feeding damage, number of adults colonized the plant, duration of adult survival was recorded.

Table 1.Percent survival of the weevil *D. denticollis* on various non-target plants in no-choice host specificity tests

Test plant species	No of weevil survival (%)					Mortality (%)
	Day 1	Day 2	Day 3	Day 8	Day 90	At Day 90
V. niloticassp. indica (control)	50	50	50	50	80.46±1.15	19.54±2.06
V. niloticassp.tomentosa	50	50	50	50	100±0.00	0.0±0.00
V. auriculiformis	50	42±2.15	6±4.03	6±4.03	0.00±0.00	100±1.06
V. planiferons	50	52±3.61	0±0.00	0±0.00	0±0.00	100±1.02
V. leucophloea	50	24±2.00	0±0.00	0±0.00	0±0.00	100±1.02
V. tortilis	50	30±1.85	0±0.00	0±0.00	0±0.00	100±1.04
S. ferruginea	50	10±4.11	0±0.00	0±0.00	0±0.00	100±1.03
S. catechu	50	4±3.84	0±0.00	0±0.00	0±0.00	100±1.02
S. mellifera	50	24±3.01	0±0.00	0±0.00	0±0.00	100±1.05
V. farnesiana	50	32±2.95	0±0.00	0±0.00	0±0.00	100±1.05

Values mean of five replication±SE

RESULTS

In Tamil Nadu, 60 sites had the *D. denticollis* incidence **o**ut of 64 regular survey sites and it was recorded commonly on *V. nilotica* sub species, *V. nilotica* ssp. *indica*, *V. nilotica* ssp. *tomentosa*. In Karnataka, 6 out of 8 plantations had *V. nilotica* ssp. *Cupressiformis*, in which low level of incidence of *D. denticollis* was recorded. During the field surveys, theweevil was not recorded on any other acacia species including the other subspecies of *V. nilotica* namely *V. nilotica* ssp. *subalata* and *V. nilotica* ssp. *leiocarpa*. Though nibbling of the insect was observed on all the 10 species of acacia used in the experimentfor the first 2 days, beyond that the feeding was observed only on 3 species, *V. nilotica* ssp. *indica*, *V. nilotica* ssp. *tomentosa* and *V. auriculiformis*. No adult survived beyond 8 days on any of the test plant species, except on *V. nilotica* ssp. *Indica* and *V. nilotica* ssp. *tomentosa*. The host specificity test was continuedbeyond 90 days as the individuals fed actively and survived on the subspecies, *V. nilotica* ssp. *indica* and *V. nilotica* ssp. *tomentosa*. These results indicated that the weevil, *D. denticollis* abundantly fed and survived longer on *A. nilotica* ssp. *tomentosa* and *on V. nilotica* ssp. *indica.*

CONCLUSION

*D. denticollis*hasnarrow field host range and highly host specifictothe sub species *V. nilotica ssp. indica* and *V. nilotica* ssp. *tomentosa*. The weevil could also cause significant feeding damage and live long on these subspecies without any hindrance.

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Theme 19

Education, research methodology and communication in weed science

Effect of Acetolactate synthase (ALS) inhibiting herbicides on Nitrate reductase (NRase) and Indole actic acid (IAA) activity in rice

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The selective herbicides belonging to the chemical class sulfonyl ureas, imidazolinones, triazolopyrimidines and pyrimidinyl benzoate are the major ALS inhibitors used in weed control. These herbicides will bind with ALS and make the enzyme inactive there by affecting the protein synthetic pathway of plants leading to their death. Resistant plants are able to detoxify these herbicides. Application of these herbicides does not show any visible symptoms of toxicity to the rice plant. However, morphological changes such as reduction in height have been observed in the field. Garg (2013) reported that nitrate reductase is one of the most important enzymes in the assimilation of exogenous nitrate, the most available nitrogen to green plants growing in soil. Activity of the enzyme in plants gives an estimate of the nitrogen status of the plant and is correlated with growth and yield. Indole-3-acetic acid (IAA) is a major plant hormone which serves as signaling molecule necessary for development of plant organs and coordination of growth (Taiz and Zeiger 1991). IAA induced cell division and cell elongation subsequently affects plant growth and development (Sugawara *et al.* 2009). A study was undertaken to find the effect of ALS inhibiting herbicides on the Nitrate reductase enzyme activity and IAA content of rice and its effect on rice productivity.

METHODOLOGY

The study was conducted in the college of Horticulture during 2013-14 in a farmer field in the *kole* lands of thrissur. The variety chosen was Jyothi and experiment was laid out in RBD with 4 replications. The treatments were bispyribac-sodium at 30 g/ha, azimsulfuron at 35 g/ha, Metsulfuron methyl and chlorimuron ethyl at 6.7% w/w 4 g/ha, and hand weeded control. Herbicides were applied on the 15th day after sowing and plant samples were taken at 7 days after application and at flowering stage.

RESULTS

The ALS inhibing herbicides showed a significant effect on the NRAase activity of the rice plants, NRAase is a key enzyme in nitrogen metabolism. Among the herbicide treated plots NRAase activity was highest in the Bispyribac treatment and lowest in Azimsulfuron treated plot. However by the time of flowering the plants recovered and the recovery was higher in the Bispyribac treatment as compared to the other two herbicides. The IAA content in the plants also showed a similar trend. Application of herbicide resulted in a 5-17% reduction in yield as compared to hand weeded control. This might be attributed to the reduction in the NRAase and IAA content in the plant by the application of ALS inhibiting herbicides.

CONCLUSION

ALS inhibiting herbicides are effective for weed control in rice, however application these groups of herbicides slightly inhibited the growth of the rice plant by inhibiting the NRAase enzyme activity and IAA content of the rice plants

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Technique for investigating the impact of parthenium weeds on fishes

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Worst allergenic weed, *Parthenium hysterophorus* L. is usually found to grow on the river bank, bank of fish pond and flowering plants of parthenium weed are found to hangover the irrigation canals from where the washed out allelochemicals (either from leaves or seeds) may enter the pond or water catchment (Karim *et al*. 2015). Very little is known about the impacts of parthenium weed on the growth of fishes. Prasad and Haider (1986) stated that parthenium seed extract possessed the potential to alter fish metabolism. It caused neuro-toxic effects causing paralysis of respiratory muscles and finally decreased the rate of O_2 uptake. The technique of studying the effects of parthenium on fishes is less developed. Therefore, an easy and quick method, "Parthenium extract in fish tank technique" of studying allelopathic effects of parthenium weed on fishes has been developed.

METHODOLOGY

In this technique, aqueous extract of fresh leaves and seeds are prepared by dipping the samples (100 gm in 100 ml distilled water) in water for 7 days, which is regarded as stock extract. The extract is filtered by Whatman No. 1 filter paper and is diluted to different concentrations. Test fish (e.g. tilapia) is reared in plastic aquaria at the rate of 3 fishes per 50 gallon of water. The extracts (leaf, seed and leaf + seed) are added to the aquaria after 10 days of releasing fish fry of two weeks age. For first 10 days the fishes are provided with normal diet after which the extracts are added as per treatment specification. The extracts are added once per fortnight and the experiment is continued for 60 days. Regular monitoring of fish growth is done to detect discoloration, gulping of air, erratic swimming, slow movement etc., if any. Abnormality assessment scores are developed to rank the abnormality in fish growth (Table 1). The scale gives zero for absolutely normal growth, while increasingly larger totals results in fish abnormality.

After two months the fishes are harvested and the body weights are measured to compare the final impacts. The data are analyzed using One-way Anova and the means are submitted to Duncun Multiple Range Test for significant differences at $P<0.05$.

Table 1. Fish abnormality assessment scores

Skin	Eye	Swimming	Gills
Bright and shiny	Normal shape and clear eye	Normal swimming	Characteristic color
Bright	Normal shape and clear eye	Normal swimming	Fading in normal color
Faded (dull)	Plane shape and faded eye	Sudden erratic swimming	Fading in normal color
Spotted with colors	Plane shape and faded eye	Continuous erratic swimming	Faded and cloudiness in mucus
Small lesion occurred	Cloudy eye	Continuous erratic swimming	Faded and cloudiness in mucus
Many lesions produced	Cloudy eye	Abnormal swimming with upside down	Slight bleaching and discolored

(Modified QIM from Archer 2010)

CONCLUSION

"Parthenium extract in fish-tank technique" can easily be used to study the impacts of parthenium weed on fishes.

ACKNOWLEDGEMENT

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Standardization of glyphosate lethal dose in rice seedlings

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The herbicide glyphosate (*N*-(phosphonomethyl) glycine) is a 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor in plants. The enzyme participates in biosynthesis of aromatic amino acids phenylalanine, tyrosine and tryptophan (Cao *et al.* 2012). Glyphosate acts as a competitive inhibitor for phosphoenolpyruvate and is used as a broad-spectrum systemic herbicide. Development of glyphosate-tolerant crops allows preferential and more effective use of glyphosate resulting in fewer or more environmentally benign chemical inputs. Glyphosate-resistant crop varieties were developed by inserting glyphosate resistant clone *CP4-EPSPS* into plants. This transgene allows the shikimate pathway to function in presence of glyphosate, thus allowing plants to survive after glyphosate application. It is hypothized that standardizing the lethal dose of glyphosate in wild types will help to use standard dosage to screen putative transgenic rice genotypes to develop tolerant lines.

METHODOLOGY

Wild type paddy seedling of 21 days old was sprayed with 0, 500, 1000, 1500, and 2000 ppm concentration of Round up 41% SL iso propyl amine (I.P.A) salt of glyphosate. Seven days after glyphosate treatment leaf samples were collected. Chlorophyll was estimated following the standard procedure. Fresh weight of leaf sample were taken and kept immersed in 10 ml solution of acetone and dimethyl sulphoxide (DMSO) in 1:1 proportion for 24 hours. After 24 hours, the solutions were filtered through Whatmann No. 1 filter paper in a suction filter. Optical density of the extract was measured at 652 nm for total chlorophyll by using UV-VIS spectrophotometer (TECON from Sunrise). Total chlorophyll, contents was arrived by using the Equation (1) and percent reduction in chlorophyll content over control was calculated

$$\text{Total Chlorophyll (mg/g FW)} = \frac{\text{OD@652 X}}{\text{K X FW}} \quad \text{.........(1)}$$

Where, V= Volume Made up (ml).

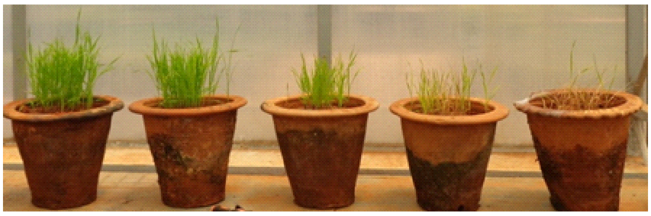
F= Fresh weight (g).

RESULT

To standardize the lethal dose of glyphosate to wild type seedlings, 21 day old seedlings was applied with different concentrations of glyphosate viz 0, 500, 1000, 1500, 2000 p pm. After 7 days from spraying leaf sample were collected and total chlorophyll was quantified (Fig. 1). Wild type rice seedlings showed more than 50 percent reduction in total chlorophyll at 1500 ppm of glyphosate compared to the untreated control (Table 1 and Fig. 2).

Table 1. Effect of different concentration of glyphosate on the total chlorophyll content (mg/g FW of tissue) in wild type rice 7 days after spraying

Concentration (ppm)	Total chlorophyll (mg/g FW of tissue)
0 ppm	1.12
500 ppm	0.94
1000 ppm	0.51
1500 ppm	0.40
2000 ppm	0.21
LSD (P=0.05)	0.04
CV%	6.2%



0 ppm 500 ppm 1000 ppm 1500 ppm 2000 ppm

Fig. 1. Rice plants, 7 days after spraying with different concentration of glyphosate

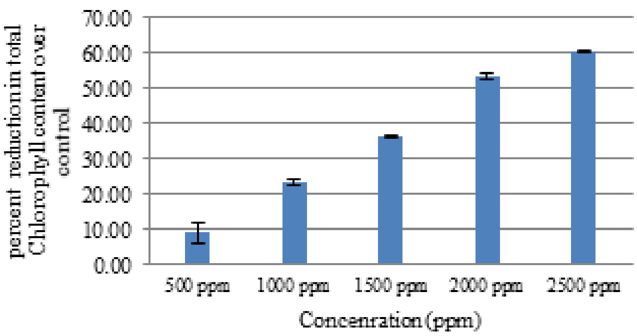


Fig. 2. Per cent reduction in total chlorophyll content in wild type rice plant sprayed with varying concentration of glyphosate

CONCLUSION

Wild type rice seedlings showed more than 50% reduction in total chlorophyll at 1500 ppm of glyphosate compared to the untreated control. So, concentration of 1500 ppm of glyphosate can be used to screen the putative rice transgenics lines.

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All India Coordinated Research Project on Weed Management : A profile

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Weed research in India started soon after independence in early 1950 when a project was launched to survey weed flora and asses economic losses due to weeds in major crops like rice, wheat, sugarcane etc. All India Coordinated Research Project on Weed Control (AICRP-WC) was launched in 1978 to undertake the systematic research on weed management in the country. Initially, there were 6 centres in different parts of the country, which grew to 23 centers in 2015, almost in all the Agricultural Universities of the country. Over the last 36 years, information relating to weeds in different cropped and non-cropped situations, management practices, herbicides residues and utilization aspects of weeds has been generated. Location-specific improved technologies on weed management have been developed and adopted in large areas throughout the country.

METHODOLOGY

Research and coordinated programme of the AICRP on Weed Management are discussed in the Annual Review meetings. Research findings of the previous year are presented and based on the results, the programmes for the next year are decided.

Since 2014, several initiatives were taken to improve and strengthen the research programmes on weed management under this project. The recommendations made by the Quinquennial Review Team were effectively implemented. Nodal Officers were identified for providing technical guidance, monitoring and evaluation of the work done at different centres. Collaborations were initiated with other AICRPs at the same University. On-Farm Research was given greater emphasis and impact assessment of weed management technologies was undertaken.

The following research programmes were undertaken:

- Weed surveillance and monitoring
- Weed biology and physiology
- Weed management in crops and cropping systems
- Management of problematic/invasive/parasitic/ aquatic weeds
- Herbicide residues and environmental
- Transfer of technology

RESULTS

- Major weeds of crops and cropping systems have been identified. District-wise distribution of weeds in India has been surveyed. *Coronopus didymus*, *Polypogon monspliensis* and *Poa annua* have become major weeds of berseem crop. Weed survey conducted in the high ranges of Kerala showed that new invasive weeds *Tithonia diversifolia*, *Ludwigia peruviana* and *Sphagneticola* are spreading in the region and replacing *Lantana camara*, *Mimosa invisa* and *Pennisetum species*. *Celosia argentea* was found a severe problem in upland rice and *rabi* pulses in the districts of Keonjhar. The weed is invading mostly the upland areas nearer to the foothills with the soil types belonging to light textured red soils. *Kharif* crops grown under light textured soils in south Haryana was heavily infested with broadleaf weed *Leucas aspera* which was not controlled by pendimethalin and atrazine. Weedy rice infestation was highest in direct-seeded rice and least in transplanted rice in Khorda district of Odisha and part of Bihar.

- In turmeric, fenoxaprop provided effective control of grassy weeds as post-emergence herbicide. Glyphosate provided effective control of most of the weeds at the time of its application.

- Metribuzin or pendimethalin or atrazine *fb* mulching+ hand weeding at 45 DAS provided complete control of weeds (100%) in turmeric with improved crop growth.

- Application of pendimethalin 0.50 kg/ha (sand mix) as PE showed phytotoxic effect on lucerne crop and only 10% plants were survived after germination in pendimethalin application.

- Oxadiargyl along with bispyribac persisted in soil up to harvest stage. Residual effect of fenoxaprop-p-ethyl, chlorimuron-ethyl and metsulfuron-methyl (applied in *kharif* rice) was observed during *rabi* experimentation up to showing time of chickpea. Clodinafop residues were detected in one out of 9 sites of Haryana and only two sites out of 50 were detected with pretilachlor residues in the range of 0.092 and 0.066 µg/mL at village Nabipur of Karnal. No oxadiagryl, butachlor and anilofos residues were detected at any site out of 50 sites from were samples were taken.

- Under on-farm research in tarai regions of Uttarakhand, application of ready mix of clodinafop-propargyl and metsulfuron-methyl in wheat crop was found more effective to control the weeds as compared to application of clodinafop-propargyl and metsulfuron-methyl alone, whereas in hilly areas, ready- mix combination of sulfosulfuron + metsulfuron-methyl 30 + 2 g/ha was found effective.

CONCLUSION

AICRP-WM has played an important role in developing and spreading weed management technologies in the country, which helped in reducing costs and drudgery involved in weed control, and increased crop productivity.

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Web based Information system for AICRP on Weed Management

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Advances in computer-based information technology in recent years have led to a wide variety of systems that are used to make and implement decisions. Similarly, an information system helps to organize and analyse the data. Subsequently, the purpose of an information system is to turn raw data into useful information that can be used for decision making in an organization. All India Coordinated Research Project on Weed Management (AICRP -WM) also generates voluminous data on many network experiments and other aspects of weed research. Therefore, keeping this in view, aweb based online database and information retrieval system for AICRP-WM is developed for data entry, information retrieval and analysis of the data. Such an effort has already been made in Project Directorate of Farming Systems Research and AICRP on Long Term Fertilizer Experiments.

METHODOLOGY

Information systemfor AICRP-WM is developed using C# language and .NET framework as the front-end coding and SQL server 2008 as back end. It has three basic functional modules: Information module, Data analysis module and Report generation module. There are four levels of authentications, i.e. End user, Sub-administrator, Administrator and Super administrator.Scientists from different AICRP-WM centres are the end users of this system. They have access to this system through their unique user-Id and password which they can obtain after registering themselves as end user. They are provided facility to enter the experimental data in a given format and to analyze the data based on the requirement. For analysis purpose, they can make use of statistical module in which provision has been made to analyse data under different experimental designs. After analysis, they need to submit experimental details along with data and analysis report for the approval of Sub-Administrator. He/she does not have the right to make any changes in the data, once data has been submitted.

Next level is for Principal Investigator of the coordinating centres which are sub-administrator of this system. They also have access to this system through user-Id and password. They have access to the information and reports submitted by the end user. After his/her approval, data can go to next upper levels which are 'Administrator' and' Super Administrator', respectively situated at headquarter of AICRP-WM. Super administrator and administrator both have access to information and data provided by different centres and Super Administrator has all rights to edit, delete, and modify any information provided by the different centres. Administrator has the privilege to add or delete any centre, create programme, sub-programme and experiments. Information flow in the information system is given by the following flow chart:

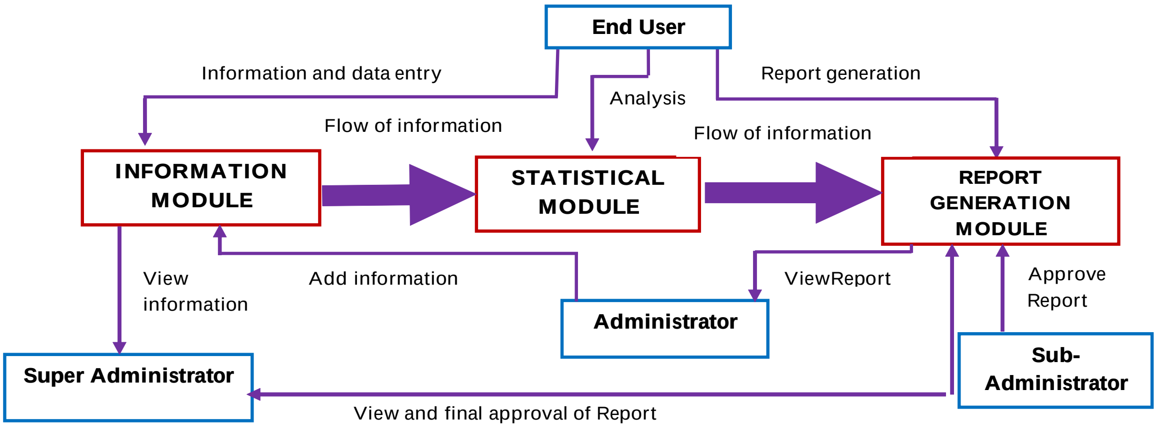

Fig. 1. Flow chart depicting the information flow in the information system

RESULTS

This information system provides one place where data generated from all the coordinating centres is available and act as data repository. Information module is made user friendly and very easy to enter the data obtained from all the experiments. Similar format is generated for data entry alongwith the report which can give a better understanding and similarity in the data and format of the report. It ensures the timely submission of data and report to the head quarter so that delay in reporting can be avoided which is very common in manual task. This automatically reduces the manual work and time to perform analysis from different software, andavoids the presentation of report in different format. It is easy to monitor the coordinating centres progress in compiling the data and report submission with the help of Information system. Further, the purpose of this information systemis to make data available at the headquarter level for further analysis and interpretation.

CONCLUSION

Information system for AICRP-WM provides one platform to store, analyse the data and report generation of result along with compilation of data and interpretation of results.

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Assessment of community awareness and perception on spread of invasive plant species along roads in Northern Tanzania

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Human beings are potential vector of introduction and spread of Invasive Alien Species (IAS). Invasive species are one of the main threats to local livelihoods and biodiversity conservation worldwide. Though local communities can play a major role in helping to control and/or prevent their introduction, majority of the population is not yet aware of this problem. Introduction and spread of invasive plant species is driven by several factors such as climate change, human socio-cultural and political attitudes, as well as biological and ecological characteristics of invasive plants. In Tanzania, more than 80% of the population lives in rural areas and depends on subsistence farming for their economy. Thus the socio-economic activity of the rural communities mostly depends on agriculture. Lack of public awareness is recognized as contributing to the ineffective control and fast spread of weed seeds and their establishment in rural areas poses high risk to crop production, livestock grazing lands and biodiversity conservation in protected areas. Kilimanjaro and Arusha regions in Tanzania, on the eastern boundary (Tanzania-Kenya boundary) there is a great surge of invading plant species such as *Prosopis juliflora*, *Parthenium hysterophorus*, *Calatropis*, *Datura spp's*, *Argemone Mexicana, Prickly acacia, Mauritius thorn (Caesalpinia decapitalla*, *Ricinus communis*, *Lantana camara*, *Lantana montevidensis Tithonia*, *Opuntia stricta* and some other unusual plant species, whose phylotaxy could not be readily determined.

The present study surveyed a strip of 305 km of roadside from Ngorongoro Conservation Area in northern Tanzania, through the Dodoma-Arusha road in the Arusha Municipality and Arusha-Moshi road to Holili (North eastern border of Tanzania-Kenya). The study was carried between April and June ; 2015 which the period of long rains and the setting of dry season when most plants flowers). The specific aims were to; (i) identify invasive plant species and their relative importance, (ii) to assess the community perceptions and awareness on the invasive species on their livelihoods and, (iii) map the invasion spread along the Ngorongoro-Dodoma-Arusha-Moshi and Himo road. The primary data were collected by driving slowly in a vehicle at an average speed of 20 Km/hr, using Geographical Positioning System (GPS). After every 10 km of driving, we stopped and searched for occurrence of invasive species in either side of the road, whenever encountered, a GPS location were taken alongside recording the species name, the coinciding habitat (composition) and people residing nearby the occurrence point6+

03s were asked if they know the alien plants, and if they are aware of the effects of such plants in pasture, crop land or protected areas. Results indicated that 70% of the communities do not know the alien plants and their likely impacts on the landscape they reside, 21% were partially aware of the invasive species, while 9% do not know about the effects of alien plants invasions. A total of 11 (insert number of invasive species) invasive plant species were identified in the study area, and Mexican poppy (*Argemone Mexicana)* was highly spread, followed by Thorn apple (*Datura stramonium*) and low spread was observed for species Mexican marigold (*Targetes minuta*). However, these weeds have been observed in farm lands, pastures, and protected areas whilst some of them had been classified as noxious; e.g. Datura and Argemone.

Of the recent, 2009 *Pathernium hysterphorus* was observed close to Kilimanjaro International airport and later near Arusha airport. From these points this Parthenium has profusely spread along Arusha streets with the aid of road and buildings construction materials like morum, quarry and sand. Worse still local flower sellers used Parthenium flower heads as fillers of rose's bouquets.

Public awareness is therefore recommended to draw public attention to the problem of invasive species and identification of the species involved, with assumptions that an educated public can help prevent introduction of invasive control in their areas, which in turn will contribute to mitigate the problems caused by these species to community landscapes. The findings from the present study will foster higher level of public awareness about invasive species and their likely impacts as well as provide an overview to correctly identify species that are harmful to their livelihoods and the consequences of the same to the wildlife conservation in northern Tanzania.

Web based system for information retrieval on weed scientists and research work in India

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Internet is widely used and is a preferred tool for retrieving information and making communication among researchers and extension workers. To facilitate this communication, it is necessary to have scientists personal information organized at one place, so that their profiles and contact details are easily accessible to contact them in shorter time. Development of database of scientist in different field of their specialization under National Agricultural Research System (NARS) has already been taken place and being strengthened National Centre for Agricultural Economics and Policy Research (NCAP) has already developed a web-based network of Social Scientists to strengthen Agricultural Economics Research in National Agricultural Research System (NARS) comprising ICAR organizations and state Agricultural Universities (SAU's). Indian Agricultural Statistical Research Institute (IASRI) under ICAR has also developed an Agricultural statisticians' Network under NATP project "Institutionalization of Research Priority Setting, Monitoring and Evaluation and Networking of Social Scientists". Agricultural Statistician Network, a web application provides profiles of statisticians working in NARS and enhance dynamic working linkages among the statisticians with emphasis on research information exchange, resource sharing and optimizing response time. Information base has been categorized discipline-wise to provide information for different disciplines.

An expert system is a computer program that contains formally encoded knowledge of experts in a given problem area or domain, and is able to use this knowledge to provide help to a non-specialist in problem solving in that domain (Patterson 2004). In agriculture, expert systems were developed in various disciplines. So far, in the field of weed science, easy retrieval based data base is still lacking. The present database would be resource based information system at one platform at National level and would provide a solid base for exchange of information & communication among scientists and their clientele.

Indian Society of Weed Science is very old society of India founded in 1968. It is one of the best platforms for weed scientist of India to share knowledge and exchange the view. Since the inception of society, weed scientists used to join it by becoming annual or the life members. Earlier, only the members' postal address used to be collected on becoming members for sending the journal published by the society and to inform other society's activities. It was not easy to retrieve the information quickly from this database.

The database was developed for easy retrieval of profile of scientists, their contact details etc. The work plan involved collection of personal information of members of ISWS who are weed scientists in the country; compilation of the information; design and creation of database; feeding information into the database; development of front-end web application for information display and reporting; and testing and hosting of the system on web server.

The membership form was developed to submit information on postal address phone/mobile no. and email address along with the field of their specialization. The old address were filled up in the new setup of members' proforma. This new set of proforma was uploaded on the website with the provision of self updating of biodata by the members. A password was generated for each member ID and was members were informed by mails and emails. An appeal was made to update the information on the database online. A provision was also made to upload members' photographs in the database. Fields were separated in such a way that information of weed scientists collected from the members would be generated and display on the screen. A user-friendly web-interface including search facility was developed by .NET. The developed application could be accessed using Internet browser. Subsequently, the application was hosted on ISWS website.

Theme 20

Miscellaneous

Weed management in wheat

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Wheat (*Triticum aestivum* L.) is the second most important crop after rice in India. The application of new herbicides like sulfosulfuron, metribuzin, isoproturon and 2, 4-D alone and with combination effectively control both grassy as well as broad leaved weeds in wheat. However, conclusive information is not available on relative efficacy of such herbicides and economics of different weed control methods. Keeping these in view, the present investigation was undertaken.

METHODOLOGY

The field experiment was conducted at Agronomy Farm, College of Agriculture, Pune during *rabi* 2010. The experiment with nine treatments was laid out in randomized block design with three replications. The wheat variety *Trimbak* (NIAW-301) was sown 125 kg seed/ha at a spacing 22.5 cm. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. As per the treatments post-emergence herbicides were sprayed at 30 DAS through knapsack sprayer with flat fan nozzle using 500 litres of water/ha.

RESULTS

The spraying of sulfosulfuron 25 g/ha registered significantly lower weed population (8.3/m^2), whereas, weedy check recorded significantly highest weed population (42.6/m^2) than remaining treatments. The significant lower weed population in application of sulfosulfuron 25 g/ha might be due to effective control of both grassy and broad leaved weeds. The significantly lower dry matter of weeds was recorded with application of sulfosulfuron 25 g/ha (4.13 g/m^2) than rest of the treatments; however, it was at par with hand weeding at 30 DAS. Kumar *et al.* (2003) reported that reduced dry matter of weeds were due to application of sulfosulfuron might be due to reduced weed population, which resulted lower dry matter of weeds. The same treatment i.e. spraying of sulfosulfuron 25 g/ha registered statistically higher weed control efficiency (80.50%) than rest of the weed control treatments. The weed index was also lower with this treatment (8.0). Dawson *et al.* (2008) reported that minimum values of weed dry weight and maximum values of weed control efficiency were registered with sulfosulfuron 25 g/ha followed by isoproturon + 2, 4-D and isoproturon alone.

Table 1. Weed growth, yield and economics of wheat as influenced by different treatments

Treatment	Weed population /m^2	Weed dry matter (g/m^2)	WCE (%)	Weed index (%)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x10^3 ` /ha)	B:C ratio
Weedy check	6.56* (42.6**)	28.65	-	37.80	2.51	2.89	28.50	1.34
Weed free check	0.70 (0.0)	0.0	100* (90**)	0.00	4.04	5.36	36.24	1.70
Hand weeding at 30 DAS	3.28 (10.3)	5.42	75.80 (60.54)	11.46	3.61	4.49	31.12	1.76
Isoproturon 1000 g/ha at 30 DAS	4.05 (16.0)	15.03	62.51 (52.24)	21.60	3.16	3.72	29.37	1.64
Sulfosulfuron 25 g/ha at 30 DAS	2.96 (8.3)	4.13	80.50 (63.81)	8.00	3.71	4.79	29.60	1.91
2, 4-D 750 g/ha at 30 DAS	3.43 (11.3)	7.35	72.56 (58.43)	15.00	3.42	4.32	29.01	1.80
Metribuzin 175 g/ha at 30 DAS	3.18 (9.6)	6.23	77.33 (61.56)	11.18	3.59	4.44	29.34	1.86
Isoproturon 500 g + 2, 4-D 375 g/ha at 30 DAS	3.58 (12.3)	9.20	71.08 (58.55)	14.82	3.38	4.25	29.19	1.76
Sulfosulfuron 12.5 g + 2, 4-D 375 g/ha at 30 DAS	3.71 (13.3)	12.23	68.73 (56.00)	17.49	3.33	3.89	29.31	1.73
LSD (P=0.05)	0.16	1.29	1.75	3.53	0.13	0.18	-	-

* Transformed values (“x+0.5) ** original values

The significantly higher grain and straw yield were recorded with weed free check than rest of the treatments. Among the weed control treatments, the spraying of sulfosulfuron 25 g/ha recorded statistically higher grain and straw yield of 3.71 and 4.79 t/ha, respectively than remaining treatments, however, grain yield was found to be at par with hand weeding and metribuzin treatments. The higher values of grain yield with these treatments may be ascribed to marked decrease weed population and weed dry weight and thereby better growth and increased the productive tillers and yield attributes. The cost of cultivation was higher with weed free check. The higher value benefit cost ratio of 1.91 was obtained with application of sulfosulfuron 25 g/ha. Yadav *et al.* (2008) reported that among the weed control treatments, application of sulfosulfuron 25 g/ha gave significantly higher net monetary returns and benefit cost ratio.

CONCLUSION

Thus, it can concluded that the spraying of sulfosulfuron 25 g/ha as a post-emergence herbicide in wheat crop could be used for controlling weed and for obtaining higher yield and returns.

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Impact of mexican beetle for biological control of *Parthenium* under field demonstration

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Parthenium hysterophorus L. locally called congress grass or gajarghas, is a short-lived annual plant, which can germinate and grow at any time of the year. It is a weed of global significance occurring in about 34 countries of the world including south Asia (Adkins and Shabbir, 2014). It has been well established that *Parthenium* is responsible to cause severe health problems in men and animals besides loss to crop productivity, environment and biodiversity (Sushilkumar 2014). It has invaded about 35 million hectares land in India alone (Sushilkumar and Varshney 2010). There are several methods to control Parthenium but each method suffers from one or other limitations. Out of several methods, biological control by Mexican beetle, *Zygogramm bicolorata* has been emerged as one of the most successful methods so far in spite of some limitations. Therefore, to see the impact of bioagent, a large scale demonstration was carried out to show the impact of bioagent on *Parthenium*.

MATERIALS AND METHODS

The study was undertaken during 2015 at ICAR-DWR, Jabalpur, Madhya Pradesh, India. *Parthenium* seeds collected three months before from the infested fields, were sown by broadcasting method in 0.5 hectare field in the second fortnight of July 2015 on commencement of rains. About 1500 Mexican beetle were released at randomly covering whole plot area on 30 days old *Parthenium*. Apart of 500 meter from treated field, another field was selected known to having history of Parthenium germination with the commencement of rains to act as a control. In this field beetles were not released. Dentistry of Parthenium was taken at randomly from 20 places with the help of 1 m^2 quadrate from bioagent treated and control field at 30 and 60 days interval. From each quadrate, one plant was sampled for height, flowers and dry weight at 30 days before release of beetle and at 60 days after release of beetle. Each plant was treated as one replication. Such samples were also taken from control plots. Impact of beetle was calculated in terms of reduction in plant density, height, flower no. and dry weight. Weed control efficiency was calculated from dry weight as per standard formula. The data were analysed at 5% level of significance by ANOVA.

RESULTS

Beetles started to eat the leaves just after release on *Parthenium*. By evening, several eggs were noticed reflecting start of egg laying on *Parthenium*. After three days, first star larvae started to hatch from the eggs first lot of egg laying and thus population buildup of bioagent started. With the more egg laying and hatching and growing of grubs, defoliating symptoms gradually increased and became visible after 10 days of release.

Application of *Z. bicolorata* after 60 DAS showed maximum efficacy in minimizing all parameters like density, height, number of flowers and dry weight and proved significantly superior over to control. Sushilkumar and Varshney (2010) also reported that *Zygogramma* beetles are best for control of *Parthenium* weed in field.

Weed density in treated (352/m^2) and control (335.5/m^2) plots was not found significant at 30 DAS. Weed density (21.55/m^2) in bio agent treated plot was reduced significantly compared to control plot (93.85/m2) at 60 days. Plant height was significantly reduced in treated plot (40.18 cm) compared to control plot (102.45 cm) at 60 DAS. Flowers were also found significantly reduced in bioagent treated plot (4.67/plant) than control (2920/plant). In biological control treatments, application of *Z. bicolorata* 1500/ha recorded higher weed control efficiency of 95.26% after 60 DAS. This was also comparing with control treatments (Table 1).

Table 1. Effect of bioagent *Zygogramma bicolorata* on density, height, number of flowers and dry weight

Treatment	Density (no./m^2)		Height (cm/plant)		Flowers (no./plant)		Dry weight (g/plant)		Weed control efficiency (%)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Bioagent	352	21.55	31.81	40.18	19.92	4.67	7.02	1.18	18.75%	95.26%
Control	335.5	93.85	33.66	102.45	19.99	29.20	8.64	24.87	-	-
LSD (P=0.05)	7.053	1.84	NS	1.49	NS	18.57	NS	1.02		

CONCLUSION

Mexican beetle *Z. bicolorata* was found an effective biological control agent to reduce the height, weight and flower number of Parthenium. Effectiveness of Mexicana beetle was more severe at early stages of plant growth. The new germinated plants are nipped in the bud by the bioagent.

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Bio-efficacy of pre- and post-emergence herbicides for control of weeds in dry seeded rice

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Weeds are the main constraint for farmers practising direct seeding since the inherent weed control from standing water at crop establishment is lost (Rao *et al.*, 2007). A weed free period for the first 25-45 DAS is required to avoid any loss in yield in dry direct seeded rice (Singh *et al.*, 2012). In Punjab state, seven pre-emergence herbicides namely pendimethalin, butachlor, thiobencarb, anilofos, pretilachlor, oxadiargyl and pyrazosulfuron ethyl have been recommended in puddled transplanted rice. Identifying herbicides with wide-spectrum weed control ability for efficient and economical weed management is crucial for improving the potential of direct seeding of rice in the state. Keeping this in view, experiment was conducted to study the bio-efficacy of different pre- and post-emergence herbicides used in conventional puddled transplanted rice in direct seeded rice.

METHODOLOGY

Field experiment was conducted during *kharif* 2010 to study the bio-efficacy of different pre- and post-emergence herbicides in dry seeded rice. The experiment was laid out in RCBD with 3 replications. Weed control treatments comprised of pre-emergence application of pendimethalin 0.75 kg, butachlor 1.50 kg, thiobencarb 1.50 kg, anilofos 0.375 kg, pretilachlor 0.75 kg, oxadiargyl 0.09 kg and pyrazosulfuron ethyl 0.015 kg/ha and with sequential application of bispyribac 0.025 kg/ha at 30 DAS; two hand weedings and unweeded control. Pre- and post-emergence herbicides were applied with knapsack sprayer fitted with flat fan nozzle using 375 l/ha of water. All other recommended package of practices for crop cultivation was followed.

RESULTS

The predominant weed flora of the experimental field was *Echinochloa crus-galli*, *Echinochloa colona* and *Cyperus iria*, *Cyperus difformis* at 30 DAS prior to post-emergence application of bispyribac. Grass weeds like *Digitaria sanguinalis*, *Dactyloctenium aegyptium* appeared but *Cyperus* spp. was not observed at later stages of observation. Pendimethalin resulted in significantly lower number of *Echinochloa* spp. than other pre-emergence herbicides but have no effect on *Cyperus* spp. Follow-up application of bispyribac controlled *Echinochloa* spp. and *Cyperus iria* but has no control over *D sanguinalis* and *D aegyptium*. Sequential application of pendimethalin and bispyribac recorded lowest weed biomass at harvest and 100 % weed control efficiency (Table 1). Follow-up spray of bispyribac after butachlor, thiobencarb, anilofos, pretilachlor, oxadiargyl and pyrazosulfuron ethyl resulted in significantly lower weed dry matter than alone application of pre-emergence herbicides, resulting in 88.3 to 92.0 % weed control efficiency whereas single application of pre-emergence herbicide showed poor weed control efficiency of 6.0 to 17.1 % as weed dry matter in these was statistical similar to unweeded control. The maximum grain yield was recorded in two hand weedings treatment which was at par with follow-up application of bispyribac after pendimethalin, butachlor, thiobencarb and oxadiargyl. Negative returns were obtained with alone application of different pre-emergence herbicides except pendimethalin.

Table 1. Effect of weed control treatments on weeds and grain yield of dry seeded rice.

Weed control treatments	Weed dry matter (g/m^2)	Weed control efficiency (%)	Grain yield (t/ha)	Benefit:Cost ratio
Pendimethalin0.75 kg/ha	30.8 (954)	17.1	2.28	0.04
Pendimethalin 0.75 kg *fb*bispyribac 0.025 kg/ha	1.0 (0)	100.0	5.21	1.20
Butachlor1.50 kg/ha	31.2 (977)	15.1	1.34	-0.37
Butachlor 1.50 kg *fb* bispyribac 0.025 kg/ha	11.3 (127)	88.9	5.14	1.21
Thiobencarb 1.50 kg/ha	32.2 (1035)	10.1	1.37	-0.36
Thiobencarb 1.50 kg *fb* bispyribac 0.025 kg/ha	11.5 (134.2)	88.3	5.17	1.23
Anilofos 0.375 kg/ha	32.5 (1070)	7.0	1.36	-0.36
Anilofos 0.375 kg *fb* bispyribac 0.025 kg/ha	10.4 (110)	90.5	4.22	0.83
Pretilachlor 0.75 kg/ha	32.4 (1053)	8.5	1.43	-0.33
Pretilachlor 0.75 kg *fb* bispyribac 0.025 kg/ha	11.6 (133)	88.4	4.17	0.78
Oxadiargyl 0.09 kg/ha	32.2 (1041)	9.6	1.44	-0.33
Oxadiargyl 0.09 kg *fb* bispyribac 0.025 kg/ha	11.0 (121)	89.5	4.96	1.14
Pyrazosulfuron ethyl 0.015 kg/ha	32.9 (1081)	6.0	1.35	-0.37
Pyrazosulfuron ethyl 0.015 kg *fb* bispyribac 0.025 kg/ha	11.6 (133)	88.4	3.84	0.65
Two hand weedings	9.7 (93)	92.0	5.29	0.96
Unweeded	33.8 (1151)	-	1.33	-0.25
LSD (P=0.05)	3.4	-	0.59	-

CONCLUSION

Sequential application of pendimethalin 0.75 kg/ butachlor 1.50 kg/thiobencarb 1.50 kg/ oxadiargyl 0.09 kg/ha with post-emergence bispyribac 0.025 kg/ha provided effective and economical control of weeds in dry seeded rice.

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Yield response of transplanted aman rice as influenced by weed management practice under conservation agriculture system

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Losses in crop yield as a result of increased weed pressure are the major hurdles to the widespread adoption of conservation agriculture system (CA). However, the recent development of broad spectrum herbicides provides an opportunity to control weeds in CA (Sharma *et al.*, 2013). But options for weed control must reduce selection pressure for herbicide resistance interaction weeds (Hossain *et al.*, 2014). In CA systems the presence of residue on the soil surface may influence soil temperature and moisture regimes that affect weed seed germination and emergence patterns thus help in reducing weed. Crop yields can be similar for conventional and conservation tillage systems if weeds are controlled and crop stands are uniform (Mahajan *et al.*, 2002). Considering the above facts, an on-farm experiment was conducted, to examine the performance of tillage practices and residue levels on crop and weeds.

METHODOLOGY

The research on-farm was conducted at the Durbacahra village under Gouripur Upazila of Mymensingh district of Bangladesh during *Kharif II* season 2014. Hybrid rice cv. *Hybrid Krishan2*, was transplanted with six tillage and weed control practices *viz*., **(i)** Conventional tillage + farmer's weeding practice (Control); **(ii)** Roundup (RU) + Strip tillage (ST); **(iii)** RU + ST + Pre-emergence (PE) herbicide (Pendimethalin); **(iv)** RU + ST + Post-emergence (PO) herbicide (Ethoxysulfuron); **(v)** RU+ ST + PE + PO; **(vi)** RU+ ST + weed-free (WF), and two levels of crop residue *viz*., **(R_{20})** 20% residue and **(R_{50})** 50% residue. The treatments were laid out in randomized complete block design with four replications using unit plots of 9 m × 5 m. Weed species and plant densities were recorded randomly from 4 locations of 0.25 m^2 each. Weed dry matter assessed by harvesting biomass which was then oven dried at 70^0 C for 72 hours. The crop was harvested at maturity and data were recorded. Data were subjected to ANOVA using MSTAT-C and means separated by Duncan's Multiple Range Test.

RESULTS

Pre-emergence herbicide reduced the density by 41%, post-emergence reduced 43% and combination of both reduced 53% density compared to roundup alone while roundup alone reduced 11% compared to conventional practice. 50% residue reduced density by 35% compared to 20% residue. Pre-emergence or post-emergence herbicide reduced 28% biomass while the combination of both reduced 55% biomass compared to roundup alone. There was 16% on average biomass reduction in 50% residue compared to 20% residue (Table 1).

The highest grain (24% higher compared to control) yielded from strip tilled weed free treatment. Combination of pre-emergence and post-emergence herbicide yielded 13 % higher grain compared to conventional practice or roundup alone. Strip tillage with only pre-emergence and only post-emergence herbicide yielded the identical grain. The higher (50%) residue yielded 4% higher grains compared to 20% residue. The correlation between weed biomass and grain yield revealed that, the lower the biomass the higher the grain yield. The highest BCR was calculated from strip tillage sprayed both pre and post-emergence herbicide while the conventional practice earned the lowest. Retention of 50% residue yielded 11% higher grains.

Table 1. Treatments effect on weed and crop

Tillage and weed control practice	Residue level	Weed density (no./m^2)	Weed dry matter (g/m^2)	Grain yield (t/ha)	B. C. ratio
CT	R_{20}	40a	57.52a	5.17gh	1.63g
	R_{50}	25b	50.28b	5.20g	1.76g
RU+ST	R_{20}	28b	51.61b	5.18g	2.15f
	R_{50}	20c	42.09c	5.27f	2.42e
RU+ST+PE	R_{20}	16cd	40.02cd	5.41e	2.44e
	R_{50}	14d	37.34de	5.52d	2.56de
RU+ST+PO	R_{20}	13d	36.18de	5.43e	2.65d
	R_{50}	8e	31.89e	5.56d	2.95c
RU+ST+PE+PO	R_{20}	8e	27.69f	5.47c	3.49b
	R_{50}	2f	14.25g	6.27b	4.17a
RU+ST+WF	R_{20}	0f	0h	6.36b	3.10c
	R_{50}	0f	0h	6.56a	3.30b
LSD (P=0.05)		4.41	4.73	0.032	0.18

CONCLUSION

Application of pre-emergence herbicide followed by post-emergence herbicide with the retention of higher level of crop residue could manage weeds satisfactorily which attribute the maximum outcome under CA practice.

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Efficacy of post- emergence herbicides in soybean under various fertility levels

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Soybean growth and seed yield are seriously affected if weeds are not controlled at initial stages. Bhan (1974).Weed infestation in soybean results in a loss to the content of 79 % (Reddy et. al 1990), depending on the type of soil, season and intensity of weed infestation. Reliance on herbicides for weed control is expected to increase in India due to shortage of agriculture laborers especially in the rainy season. Weed free environment up to critical crop growth stages is essential to harvest a good crop. The prudent use of fertilizers with appropriate method & time of application are the prime importance in securing higher yields of soybean.

MATERIAL AND METHODS

A field experiment was conducted on soybean variety Gujarat soybean -2 in clayey soil at the Instructional farm, college of Agriculture, Junagadh, Agriculture University, Junagadh, during the rainy season 2006.The soil of the experimental field was low in available nitrogen (223.4 kg/ha), medium phosphorus (35.5 kg/ha) and high in potassium (229.9 kg/ha).Eighteen treatments comprising six treatment weed management. W_1 = Pendimethalin 0.5 kg ha^{-1}pre-emergence + HW + IC at 30 DAS) W_2 =Quizalofop-ehyl 40 g ha^{-1} post-emergence (25 DAS) +HW +IC (45 DAS) W_3 = (Imazethapyr 75 g ha^{-1} post-emergence (25DAS) +HW +IC (45 DAS) W_4 = 2 HW and 2 IC at 20 and 40 DAS W_5 = Weed free through hand weeding up to 60 daysW_6 = Unweeded control.Three treatment of fertilizer levels *i.e.* F_1 = 20:40:20 F_2 = 30:60:30 F_3 = 40:80:40 Were tested in split plot design with 3 replication the experiment was sown on 11/07/2006 with Gross Net plot size 6 x 3.60 and 5.1 x 2.7 m^2 with the spacing 45x15 cm between row to row x plant to plant. The seed rate 60 kg /ha was used and the crop was fertilized as basal dose as per treatment. The total weed population/m^2 was recorded at 20, 40 and 60 days after sowing (DAS) randomly under each treatment with the help of 0.25 m^2 quadrat. Species wise weed population was also recorded. The weed flora obtained in plots are as 1) Sedge – *Cyperus rotundus* 2)Monocot weed –*Cynodon dactylon* (L.) pers. *Brachiara spp*., *Echino.Colonum* (L) Beauv., 3) Dicot weeds- *Digera arvensis* fersk, *Phyllanthus niruri* L., *Commelina bengalensis* L., *Physalis minima*, *Portulaca oleracca* L., *Leucas aspera* sperny, *Tridex procumbens* L., *Indigofera glandulosa*, *Euphorbia hirta*, *Parthenium hysterophorus* are the weeds observed in experimental plot. The weed dry matter and grain yield. Stover yield were recorded at harvested from each plot.

RESULTS

Effect of weed management practices: Grain yield and Stover yield:- The grain yield and Stover yield of the soybean crop was significantly influenced by the various treatment of weed management practices among all the treatment W_5 (weed free) produced significantly higher grain (2336 kg /ha) and Stover (2772 kg /ha) yield respectively but in grain yield the treatment W_5 (weed free) was statistically at par with the treatment W_4 (2HW and 2 IC at 20 and 40 DAS). The lowest grain and Stover yield was produced by the treatment W_6 (Un weeded check) grain (1220 kg /ha) and Stover yield (1465 kg / ha) .These findings corroborates the Chavan et al. (2000).

Table 1. Grain and Stover yield (kg/ha) , Monocot, Dicot weeds and Sedges/m^2 at 20,40,and 60 Days and Dry weight of weeds (kg/ha) as influenced by different weed control treatments

Treatment	Grain yield kg/ha	Stover yield kg/ha	Monocot weeds /m^2		Dicot weeds/ m^2		Sedges/m^2		Dry weight of weeds kg/ha
			40DAS	60DAS	40DAS	60DAS	40DAS	60DAS	
Weed Management									
W_1	1663	1997	3.87 (14.46)	3.92 (14.87)	3.50 (11.59)	3.86 (14.41)	3.47 (11.52)	3.86 (14.41)	32.77 (1073.37
W_2	1852	2163	3.72 (13.35)	3.24 (10.03)	3.55 (12.20)	2.97 (8.33)	3.75 (13.69)	3.17 (9.56)	30.75 (945.06)
W_3	1950	2267	2.83 (7.52)	2.60 (6.24)	2.66 (6.62)	2.32 (4.90)	3.86 (7.67)	2.47 (5.62)	29.77 (885.75)
W_4	2129	2496	3.38 (10.92)	3.29 (10.32)	3.24 (10.09)	2.48 (5.66)	3.74 (13.52)	2.68 (6.69)	25.01 (625.00)
W_5	2336	2772	1.88 (3.03)	2.00 (3.50)	2.16 (4.17)	1.90 (3.11)	2.10 (3.91)	2.05 (3.70)	3.59 (12.39)
W_6	1220	1465	8.36 (69.41)	8.39 (69.95)	6.50 (41.88)	6.53 (42.14)	5.50 (29.71)	6.20 (37.88)	38.94 (1515.82
LSD (P=0.05)	235.85	232.53	0.48	0.52	0.30	0.38	0.30	0.38	0.94
Fertility levels									
F_1	1596	1911	3.78 (13.79)	3.70 (13.19)	3.45 (11.40)	3.18 (9.61)	3.43 (11.26)	3.24 (10.00)	25.92 (671.35)
F_2	1973	2288	4.03 (75.74)	3.98 (15.34)	3.67 (12.97)	3.40 (11.06)	3.64 (12.75)	3.47 (11.54)	26.86 (720.86)
F_3	2006	2381	4.21 (17.22)	4.04 (15.82)	3.69 (13.12)	3.45 (11.40)	3.64 (12.75)	3.51 (11.82)	27.63 (762.92)
LSD (P=0.05)	108.3	108.20	0.22	0.17	0.16	0.17	0.16	0.17	0.94

Note :- X + 0.5 transformation (figures in parenthesis are original values)

Effect of fertilizer levels <u>Grain yield and Stover yield:-</u> Among the three fertilizers levels the treat. F_3 40:80:40 N-P_2O_5-K_2O kg /ha**)** recorded the highest grain (2006 kg /ha) and Stover (2321 kg/ha) yield these treatment was at par with the treatment F_2 (30:60:30 N-P_2O_5-K_2O kg /ha **)** grain (1973 kg /ha) and Stover (2223 kg /ha) the lowest grain and Stover yield was recorded by the treatment F_1.

Interaction effect : The interaction between weed management treatments and fertility levels was found to be non –significant. Effect of weed management practices <u>Monocot, Dicot and Sedges weeds/m2</u> Data presented in table 1 revealed that different treatment exhibited their significant influence on monocot weed, dicot weed and sedges. At 20 DAS, the monocot weed, dicot weed and sedges was significantly affected by different treatment. Besides the treatment W_5 (weed free) is recorded the lowest no. of monocot (0.71),dicot(0.71)&sedge (0.71) weed/m2 due to complete elimination of weeds by hand weeding as and when required. The next best treatment was W_1 (Pendimethalin 0.5 kg /ha pre-emergence + HW + IC at 30

DAS) monocot (3.69), dicot (3.25) &sedge (3.25). At early growth stage the [1]pre-emergence herbicides was most responsible for effective control of monocot weed, dicot weed and sedges. At 40 DAS and 60 DAS the monocot weed, dicot weed and sedges was significantly influence by the different weed management treatments. Among all the treatment the treatment W_5 (weed free) is recorded the lowest no. of weed m^2 at 40 & 60 DAS. The next best treatment at 40 &60 DAS was W_3 ((Imazethapyr 75 g/ ha post-emergence (25DAS) +HW +IC (45 DAS), which recorded less no. of monocot weed / m^2 (2.23) (2.60), dicot weed/ m^2 (2.66) (2.32) & sedge / m^2 (2.86) (2.47) respectively. This is due to the combined effect of hand weeding, interculturing and post- emergence herbicides. These finding corroborate the result reported by Chavan et al (2000).

Effect of fertilizer levels

At 20 DAS, the significantly the lowest monocot weed, dicot weed and sedges weed / m^2 was recorded the treatment F_1 (20 :40:20 N-P_2 O_5-K_2O kg/ ha) monocot (5.67 m^2),dicot (4.74m^2),sedge (3.76 m^2) followed by F_2 (30:60:30 N-P_2 O_5-K_2O kg/ ha) which is statically at par with F_3 (40:80:40 N-P_2 O_5-K_2O kg/ ha[1])

At 40 DAS and 60 DAS the monocot, dicot and sedges weeds m^2 was significantly influenced due to different fertilizer levels. Significantly the lowest monocot (3.78) (3.70), dicot (3.45) (3.18), sedges (3.43)(3.24)weeds/ m^2 was found under the treatment F_1(20 :40:20 N-P_2 O_5-K_2O kg ha^{-1}) followed by the treatment F_2(30:60:30 N-P_2 O_5-K_2O kg/ ha) which is remain stastically at par with F_3(40:80:40 N-P_2 O_5-K_2O kg/ ha)by recording significantly the highest monocot, dicot and sedges weeds per m^2.

Interaction No significant interaction was found between weed management and fertility levels.

Effect of weed management practices: Total dry weight of weeds:-

The total dry weight of weeds was significantly differed by different weed management treatment. Among all the treatments the treatment W_5 (weed free) recorded significantly the lowest total dry weight of weeds (3.59 kg/ ha). The next best treatment was W_4 (2HW and 2 IC at 20 and 40 DAS) followed by the W_3 (Imazethapyr 75 g/ ha post-emergence (25DAS) +HW +IC(45 DAS). Significantly the highest dry weight of weeds (38.94 kg/ ha) was observed under unweeded control (W_6).

Effect of fertilizer levels: Fertility levels had significant influenced on total dry weight of weeds (kg/ ha) .The significantly lowest dry weight of weed were recorded by the treatment F_1 (20 :40:20 N-P_2 O_5-K_2O kg/ ha) (25.92 kg/ ha) which remained statistically at par with F_2 (30:60:30 N-P_2 O_5-K_2O kg/ ha) (26.26 kg/ ha)

Interaction The interaction effect between **weed** management treatment and fertility levels was found to be non -significant.

It was concluded that weed free treatments recorded significantly highest grain and Stover yield. Besides weed free situation W_1 (Pendimethalin 0.5 kg/ hapre-emergence + HW + IC at 30 DAS) was found effective weed control at early growth stages of soybean crop and W_3 (Imazethapyr 75 g/ ha post-emergence (25DAS) +HW +IC (45 DAS) was most beneficial to control weeds up to 60 DAS and resulted in to less total dry weight of weeds.

Highest grain and Stover yield was recorded with the application of 40:80:40 N-P_2 O_5-K_2O kg/ ha(F_3) and 30:60:30 N-P_2 O_5-K_2O kg/ ha (F_2) was found equally effective.

RESULTS

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Menace of quarantine, invasive weed *Ambrosia psilostachya* in Karnataka, India and efforts for its effective management – a first time approach

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Ambrosia psilostachya native to North America, Southern Canada, Continental United States and Northern half of Mexico has been reported for the first time in Muniyur, M. Bevinahally, Sriramanagara, Gottigere and Pura villages of Turuvekere Taluk, Tumkur District, Karnataka, India (Ramachandra Prasad *et al*. 2013). The weed is reported to have been seen first around Eucalyptus plantations in Muniyur area. This weed has also been reported from Africa, Australia, Europe, South America, Pacific Islands and temperate – Asia (Taiwan). This weed is a new occurrence in India and how the weed has entered these villages is not known. *Ambrosia psilostachya*, quarantine weed has already invaded 350 – 400 acres of agricultural and horticultural land in Muniyur, M. Bevinahally, Sriramanagara, Gottigere and Pura villages of Turuvekere Taluk, Tumkur District. *Ambrosia psilostachya* is a strong colonizer due to spreading root system, exudating chemicals which inhibit germination and development of other plants through allelopathy. Due to this, animals do not have fodder to graze and do not relish the weed. The weed is highly invasive and totally eliminates the native flora. Thus, biodiversity is affected severely. Farmers feel that the weed is troublesome, obnoxious and need to be contained immediately. Shallow rooted plants (about 15-20 cm) can be uprooted easily and cultivator can remove the weed from the infested areas but proves to be expensive (Rs. 5000 to 8000/ha).

METHODOLOGY

Several field experiments for effective management of *Ambrosia psilostachya* in farmers field of Muniyur and M. Bevinahally villages of Turuvekere Taluk, Karnataka were taken up during 2012-13 and 2013-14 in a RCBD design to evolve with a suitable recommendation. Based on the initial trials, post-emergence herbicides namely glyphosate 41 SL and 71 SG, 2,4-D sodium salt 80 WP, 2,4-D amine salt 58 EC, combination of glyphosate 41 SL and 71 SG with 2,4-D sodium salt were tested along with manual uprooting and unsprayed control to cause top kill of *Ambrosia*. The treatments were replicated thrice in a RCBD. The results of the bio-efficacy of herbicides are provided in Table 1 over a period of stages like 23 days, 37 days and 65 days after spraying.

RESULTS

On 23rd day after spraying, all herbicides namely glyphosate 41 SL at 7.5 to 12.5 ml/liter of water, glyphosate 71 SG 5.0 to 6.25 g/liter of water, 2,4-D sodium salt 80 WP 2.0 to 2.5 g/liter of water, 2,4-D amine salt 58 EC 2.75 to 3.45 ml/liter of water, glyphosate 41 SL at 10 ml/ liter of water or 71 WP at 5.0 g/liter of water along with 2,4-D sodium salt 80 WP at 2.0 g / liter of water caused 95 to 99 % top kill. In unsprayed control and manual uprooting, the number of shoots/m^2 increased to 161 from initial count of 52.0/m^2 and 36/m^2 (Table 1). However by 37 days after spraying, the number of shoots showed an increase in all treatments indicating increased emergence of shoots from the underground rhizomes. At this stage, only treatments with 2,4-D sodium salt 2.0 to 2.5 g/liter of water, 2,4-D amine salt 58 EC 2.75 to 3.45 ml/liter of water and 2,4- D sodium salt 80 WP 2.0 g/liter of water along with glyphosate 41 SL 10 ml or 71 SG 5.0 g/liter of water caused 62 to 82% top kill of the weed, indicating that mere 2,4-D sodium salt or amine salt are effective in lowering the emergence of new shoots of *Ambrosia*. At this stage, in manual uprooted plot and unsprayed control, the number of shoots/m^2 were 104 and 278/m^2 as against 36 and 161 shoots/m^{2}observed on 23 days after spraying. By 65 days after spraying of herbicides, treatments receiving glyphosate 12.5 ml/liter of water, 2,4-D amine salt 3.45 ml/liter of water, glyphosate 71 SG 6.25 g/liter of water, 2,4-D sodium 80 WP at 2.0 g along with glyphosate 71 SG 5 g/liter of water or 41 SL 10 ml/liter of water and 2,4-D sodium salt 80 WP 2.5 g/liter of water caused 72 to 97 % mortality of shoots of *Ambrosia*. In unsprayed control as well as manual uprooted plots, the number of shoots of *Ambrosia* increased.

Table 1. Effect of post-emergence herbicides on the top kill of *Ambrosia psilostachya* at different stages of spraying of herbicides in farmers field at M. Bevinahally, Karnataka.

Treatment	Days after spraying of herbicides					
	23 days		37 days		65 days	
	Total shoots/m^2	% Top kill of shoots	Total shoots/m^2	% Top kill of shoots	Total shoots/m^2	% Top kill of shoots
T_1 : Glyphosate 41 SL at 7.5 ml/lit of water + 20 g urea + 2 drops of lime juice	89(85)#	95.5	231(100)#	43.3	140(86)#	61.4
T_2 : Glyphosate 41 SL at 10 ml/lit of water + 20 g urea + 2 drops of lime juice	84(80)	95.2	172(80)	46.5	125(80)	64.0
T_3 : Glyphosate 41 SL at 12.5 ml/lit of water + 20 g urea + 2 drops of lime juice	97(92)	94.8	136(73)	53.7	136(98)	72.1
T_4 : Glyphosate 41 SL at 10 ml/lit of water + oxyfluorfen 23.5 EC at 0. 5 ml / lit of water	98(95)	96.9	232(70)	30.2	181(79)	43.6
T_5 : 2, 4 D Na salt 80 WP at 2 g/lit of water	119(115)	96.6	186(115)	61.8	107(67)	62.6
T_6 : 2, 4 D Na salt 80 WP at 2.5 g/lit of water	138(135)	97.8	132(92)	69.7	38(37)	97.4
T_7 : Glyphosate 71 SG at 5 g/lit of water	97(95)	97.9	160(44)	27.5	164(95)	57.9
T_8 : Glyphosate 71 SG at 6.25 g/lit of water	167(165)	98.8	146(69)	47.3	114(90)	78.9
T_9 : 2, 4 D amine salt 58 EC at 2 .75 ml/lit of water	139(135)	97.1	132(83)	62.9	105(59)	56.2
T_{10} : 2, 4 D amine salt 58 EC at 3.45 ml/lit of water	128(125)	97.7	71(58)	81.7	81(62)	76.5
T_{11} : Glyphosate 41 SL at 10 ml/lit + 2,4 D Na salt 80 WP at 2 g/ lit of water	142(139)	97.9	113(92)	81.4	116(108)	93.1
T_{12} : Glyphosate 71 SG at 5 g/lit of water + 2,4 D Na salt 80 WP at 2 g/ lit of water	177(175)	98.9	104(77)	74.0	112(99)	88.4
T_{13}: Manual uprooting of weed	36(0)	0.0	104(4)	3.8	184(2)	
T_{14} : Unsprayed control	161(22)	--(13.7)‡	278(15)	-- (5.4)‡	287(8)	--(2.8)‡

(Number of shoots /m^2 at the time of spraying is 52.0 in unsprayed control); # = Number of dried shoots/m^2;

With the financial Assistance from funding agencies like University of Agricultural Sciences, GKVK, Bangalore, Karnataka State Department of Agriculture, Government of Karnataka, Directorate of Weed Research, ICAR, Jabalpur, Madhya Pradesh and National Institute of Plant Health Management, Government of India, Hyderabad repeated spraying of glyphosate 41 SL three times at every two months interval - a mass herbicide spraying approach by engaging contact labour has resulted in significant reduction in the *Ambrosia* weed density and menace in non-cropped areas, road sides, social forestry and in all public places of twelve villages infested with *Ambrosia* in Turuvekere Taluk, Tumkur District. So, it has shown that systematic approach, regular monitoring and periodic herbicide spray can check the further spread of *Ambrosia* weed. In farmers' fields also spraying of herbicides engaging contact labour during non-cropped conditions, fallow situations has resulted in effective management of invasive, quarantine *Ambrosia* weed. Further, there is a need for continuous monitoring, systematic spraying of herbicides combined with good land management practices to successfully eradicate *Ambrosia* weed and success achieved in complete eradication of *Ambrosia* weed in Turuvekere Taluk, will set an example in the history of management of quarantine weed in the entire world.

CONCLUSION

Use of post-emergence herbicides namely glyphosate 41 SL 10.0 to 12.5 ml/liter of water, 2,4-D amine salt 3.45 ml/liter of water, glyphosate 71 SG 6.25 g/liter of water, 2,4-D sodium 80 WP at 2.0 g along with glyphosate 71 SG 5 g/liter of water or 41 SL 10 ml/liter of water and 2,4-D sodium salt 80 WP 2.5 g/ liter of water appeared to be effective in lowering the shoots of *Ambrosia* up to 65 days after spraying.

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Management of weeds under the system of rice intensification

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The system of rice intensification (SRI) appears to be a viable rice production technology that not only saves the inputs in terms of less seed, water, chemical fertilizers, and pesticides, but also improves the quality of soil health and rice growing environment. However, it requires certain management practices for plants and soil. Weeding is a serious deterrent to SRI adoption (Satyanarayana *et al* 2007). The combination of wider spacing and saturated moisture condition in the rice field provides ideal conditions for several flashes of weed growth, which means that frequent weeding is necessary. Hence, appropriate weed management strategies are needed to fully exploit this technology. The present investigation was carried out to evaluate different weed management options under SRI method of cultivation.

METHODOLOGY

The field experiment was conducted during dry seasons of 2011 at the Institute Farm in the sandy clay loam soil with pH 5.8, medium in organic content with 0.63%. Six weed control treatments viz., chemical control by bensulfuron methyl + pretilachlor (70 + 700 g ha^{-1}), two mechanical control by a cono weeder (twice) and a finger weeder (twice), hand weeding (twice) along with weed-free and weedy as checks, were evaluated in a randomized complete block design with four replications. Fourteen day old seedlings of test variety "Naveen" (120 days) were transplanted on the well leveled plots with uniformity in water retaining capacity. The crop was fertilized through well rotten FYM @ 15 tonnes per hectare (0.62 % N, 0.13 % P and 0.46 % K) during the finale land preparation and the recommended dose of fertilizer was applied at the time of panicle initiation. The data collected on weed density, weed biomass, yield parameters, etc., were analyzed using ANOVA

RESULTS

Weed free treatment recorded maximum grain yield (4.86 t/ha and 5.21 t/ha) followed by weeding with cono-weeder treated plot (4.79 t/ha). Weedy recorded lowest yield (2.70 t/ha) which is 44.44%, 43.63%, 42.55%, 41.81% and 36.92% lower than weed free, conoweeder, herbicide, hand weeding and finger weeder treated plots, respectively. Satyanarayana *et al*, 2007 also reported that one or two weeding is usually sufficient to control most weeds. *Cyperus difformis* was the most predominant weed species in the weedy plots followed by *Sphenoclea zeylanica*. The sedges constituted 56% of the total weed population in the weedy plots followed by broadleaved weeds (28%), and grassy weeds (16%). Weed infestation was comparatively less in plots where the cono-weeder was operated at 15 and 30 days after transplanting (DAT) and bensulfuron-methyl + pretilachlor was applied at 10 DAT that showed higher weed control efficiency of 91 and 90%, respectively. However, highest benefit:cost ratio (1.93) was recorded in the herbicide-treated plots followed by the use of cono-weeder (1.83). The yield reduction in weedy plots was 45% compared to the weed-free check.

Table 1. Grain yield and economics as influenced by weed management practices in SRI

Treatment	Grain yield (t/ha)	Weed Biomass at 45 DAT (g/m^2)	Weed control efficiency (%)	Cost of cultivation (x 10^3 Rs/ha)	Net income (x 10^3 `./ha)	Benefit :Cost ratio
T_1 -Herbicide	4.70	9.3	89.6	26.350	15.276	1.93
T_2 - Weed free check	4.86	0.0	100	32.900	10.094	1.44
T_3 – Hand weeding (15 and 30 DAT)	4.64	10.1	88.7	31.050	10.564	1.50
T_4 - Cono weeder (15 and 30 DAT)	4.79	8.2	90.8	27.800	14.854	1.83
T_5 - Finger weeder (15 and 30 DAT)	4.28	14.8	83.4	28.950	10.126	1.53
T_6 -Weedy	2.70	89.2	0	23.800	.5736	1.42
LSD(P=0.05)	0.74	4.32	-	-	-	-

CONCLUSION

The results suggest that chemical weed control by low dose high efficacy herbicide mixtures, bensulfuron methyl + pretilachlor, provided broad-spectrum of weed control and was the most economic strategies for controlling weeds under SRI method of cultivation.

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Efficacy of herbicides mixture and sequential herbicidal application in cluster bean and their residual effect on succeeding mustard in two texturally different soils

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Cluster bean {(*Cyamopsis tetragonoloba* (L.) Taub.}, a *kharif* pulse crop popularly known as guar, is a drought tolerant and deep rooted legume crop requiring very low inputs. Guar being a rainy season crop; frequent rains increases weed population tremendously that compete vigorously for nutrients, moisture and space and reduce yield significantly. Season long competition with weeds in cluster bean causes huge yield reduction of 47 to 92% (Bhadoria *et al.* 2000 and Yadav 1998). Severity of losses depends on the weed infestation, their intensity and duration, but first 3-4 weeks are more critical. Imazethapyr applied in cluster bean has been observed with adverse affect on the succeeding crop of mustard under light soils of south west (SW) Haryana where cluster bean is a major crop. Farmer's practice of lower use rates of imazethapyr may kill some weeds of cluster bean notably *Digera arvensis*, but in the long run can stimulate herbicide resistance. Therefore, a better and more suitable approach is needed for effective control of weeds in cluster bean without any adverse effect on succeeding sensitive crops.

METHODOLOGY

Keeping these points in view, field experiments were carried out at two different locations; CCS HAU Hisar (sandy loam) and farmer's field, Kheri Batter, Bhiwani (loamy sand) in RBD design. Efficacy and phytotoxicity of different herbicide treatments (Fig. 1-3) in cluster bean during *kharif* of 2013 and their carryover effect on mustard crop was observed.

RESULTS

PRE application of pendimethalin + imazethapyr (Ready and Tank mix) and pendimethalin although provided 90-95% weed dry weight reduction over control upto 30 DAS, but at 60 DAS, due to new emergence of weeds, percent reduction of weed dry weight was lowered by 30 % in pendimethalin, though the other two treatments provided 85-90% control up to 60 DAS without any phytotoxic effect on cluster bean. At 60 DAS, highest reduction weed dry weight over control (90-95%) was recorded under POE application of imazethapyr 100 g/ha *fb* propaquizafop 62.5 g/ha which was at par with pendimethalin + imazethapyr (RM and TM) and imazethapyr + imazamox (Odyssey) 70 g/ha *fb* propaquizafop 62.5 g/ha, but the efficacy of Odyssey was lower under Hisar conditions due to heavy infestation of *Trianthema portulacastrum* as compared to other herbicidal treatments. Pendimethalin was more effective against *T. portulacastrum* compared to imazethapyr + imazamox (Odyssey), but provided similar effects to that of pendimethalin + imazethapyr (RM & TM) and higher rates of imazethapyr, though pendimethalin alone was not effective against *Amaranthus sp.*, *Celosia argentea*, *Mollugo sp.*, *Digera arvensis* and *Bulbostylis barbata* and had poor efficacy against *Cypreus rotundus*; their dominance in the absence of other weeds killed by pendimethalin were instrumental in lower efficacy of pendimethalin after 4-6 weeks of spraying. However, imazethapyr was effective against *C. argentea* and *Amaranthus sp.* Pendimethalin + imazethapyr (TM and RM) provided complete mortality of *T. portulacastrum and Echinochloa colona.* None of these herbicides were effective against *Convolvulus arvensis* infesting Hisar location. Sequential application of imazethapyr + imazamox 43.75, 52.5, 61.5 and 70 g/ha 3 WAS with propaquizafop 62.5 g/ha 6 WAS was more effective in reducing weed density as compared to its alone application. No crop phytotoxicity was observed under PRE applied herbicides. Only POE herbicides showed crop phytotoxicity and growth suppression. At initial stages, higher rates of imazethapyr + imazamox and imazethapyr applied POE resulted in chlorosis of leaves, suppression of growth and the plant height, though plants recovered after 2 weeks and no injury was observed at later stages. Percent increase in seed yield compared to weedy check was highest under POE imazethapyr 100 g/ha *fb* propaquizafop 62.5 g/ha, and pendimethalin 0.5 kg + imazethapyr 50 g/ha (TM) as PRE, but both were statistically similar to each other and pendimethalin + imazethapyr (Valor, RM) 1.0 kg/ha as PRE & imazethapyr + imazamox 70 g/ha *fb* propaquizafop 62.5 g/ha as POE at Kheri Batter, but at Hisar pendimethalin + imazethapyr (RM & TM) provided highest seed yield . There was no carry over effect of different herbicides used in cluster bean on succeeding mustard crop, probably due to microbial degradation or leaching because of higher temperature and moisture prevalent during the time of herbicide application and planting of mustard in 2013-14.

CONCLUSIONS

It may be concluded that application of PRE pendimethalin 0.5 kg + imazethapyr 50 g/ha (TM) and pendimethalin + imazethapyr (Valor, RM) 1.0 kg/ha, imazethapyr 100 g/ha 3 WAS *fb* propaquizafop 62.5 g/ha 6 WAS and imazethapyr + imazamox 70 g/ha at 3 WAS *fb* propaquizafop 62.5 g/ha 6 WAS provided effective control of weeds and higher yields. Persistence was not recorded even at highest use rates in this study which could be due to high moisture and temperature during the current season.

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Intercropping in jute with green gram for weed smothering

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About 40 per cent of total cost of cultivation in jute goes in weeding process alone. Selective herbicides commercially used in jute can control monocots and some dicot weeds only. Suppression of unwanted dicot weeds and *Cyperus rotundus* is possible using smothering ability of green gram in jute crop (*Cyperus rotundus* is suppressed by 54 per cent, Ghorai, *et al* 2010). Furthermore, the jute crop is losing its significance as field crop due to strong competition from its plastic counterparts. Production of pulses as intercrop will increase the net return per unit area per unit time and will strengthen the economy of poverty stricken jute farmers of south east Asia. Experiments were conducted at ICAR-CRIJAF since last seven years to develop suitable protocol for intercropping jute with green gram (1:1), that will smother weeds too. We find that using suitable premature flowering resistant jute (cv. JRO-204/NJ-7005) and short duration green gram (cv. TMB-37, Pant mung 4 and 5, Samrat and sonali etc) cultivars, 30-35 q jute fibre and 6-10 q pulse grain can be obtained (depending on grain size). As intercrop with jute, 15.6 q green gram/ha has also been harvested in farmers field in three pickings. The jute equivalent yield may reach up to 55 q /ha where sole jute production is around 35 q/ha only. Date of sowing is strictly in between 15th to 25th March (early sowing will lead to jute flowering and late sowing will destroy pulse seeds by rain). The intercrop [1:1 (20 cm: 20 cm)] is sown using modified multiple row CRIJAF seed drill (jute and green gram seeds in alternate drums) and direction of sowing is East to West. It can also be sown manually on shallow furrows developed by 9 tyne cultivators (fitted at 20 cm intervals) and planked later on. Jute Seed rate is 5 kg/ha and that of mung it is 15-25 kg/ha. Plant population of jute will be 55/m^2 under irrigated (2 only) or normal rainfall condition and 30/m^2 under high rainfall condition. The population of mung is 25-30/m^2 only.

Weed Control: For grassy weeds: i) As preemergence herbicide, apply Butachlor 5G or 50 EC@ 1.5 kg/ha and irrigate the crop. As post emergence herbicide, spray Quizalofop ethyl 5%EC @ 45-60 g/ha at 15-21 DAE ii) for composite weed control, Pretilachlor 50%EC @ 2.5 to 3 ml/l strictly between 45-48 hours of sowing with irrigation is advocated iii) For composite weed control, operation of CRIJAF nail weeder at 5-6 days after jute germination is also prescribed. For control of *Cyperus rotundus* and other established weeds scrapper can also be used at 15 DAE.

Fertiliser Application: Soils having high fertility (potato in particular) fertiliser application must avoided. A basal dose of N:P:K::20:70:70 for medium fertility is recommended. A top dressing 55-60 kg N/ha at 55 days after sowing and after mung harvest with one irrigation is recommended.

Pest management: i) Spray Bavistin (@ 2g/l and Imidacloprid @ 0.5 ml/l at 15 days interval against pest and diseases (a total of 3-4 spary) is required upto harvest). ii) Spray Deltamehrin @ 1.5 ml/l during evening hours to control Pulse pod sucking bugs (two times at pod development stage) if necessary.iii)To control pulse pod borer spray Emamectin benzoate (Missile @ 0.3g/l) twice during pod development stage, if required. **In case of rain during harvest spray Mancozeb/SAAF/Bavistin @ 2.5/2 /1.5 g/lit to avoid mould attack on pods due to moist micro weather within jute canopy.**

Harvesting and storage of pulses: Harvest the pulse crop by uprooting or pick pods as possible at 90-100 per-cent pod maturity at 54-70 DAS. Dry it in the field, thresh it and store well dried pulse grains in air tight container with one Allumimiun Phosphide tablet per q seed. Return the pulse threshing wastes in between jute row/use as fodder or dump it in manure pit. This pulse waste 2t/ha is equivalent to 10 tonnes FYM.

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Effect of pre-emergent herbicides on weed control and yield in sunflower

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Sunflower (*Helianthuss annus* L.) has emerged as one of the important oil seed crops in India because of its photo insensitivity, short duration, low water requirement and good quality oil. There are several constraints in sunflower production. Weed infestation is one of the major factors for loss in yield under assured rainfall conditions. It has now been well established that losses from weeds are far more than due to insect pests and diseases. Weed competition is an important stress during the early growth period and can affect the economic yields. Weeds not only compete with crop plants for nutrients, soil moisture space and sunlight but also serve as an alternate host for several insect pests and diseases. The yield reduction due to weeds in sunflower is estimated to be as high as 81 per cent. Therefore, timely weed control is essential for optimizing the yields of sunflower. Timely weed control is not possible manually due to scarcity of labourers and their high costs during peak period of farm operations. Hence, chemical weed management appears to hold a great promise in dealing with effective, timely and economic weed suppression. Keeping all these in view, the present study was carried out to evaluate the various pre emergent herbicides for their weed control efficiency and their influence on productivity of sunflower.

METHODOLOGY

The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India during *kharif* seasons of 2013 and 2014. The experiment was laid out in randomized block design with three replications. The soil of experimental field was medium deep black soil. The details of treatments are given in Table 1. Sunflower variety 'DSFH-2' was sown with plant spacing of 60 cm x 30 cm on flat beds. Recommended dose of fertilizers was applied as per package of practice. Weed density and dry weight of weeds (g/m^2) were recorded by putting a quadrant of square meter in each plot. Weed control index was calculated by standard formulae. The yield was recorded and analyzed. To work out net returns, prevailing market price was used for different outputs and inputs.

RESULTS

The efficiency of different herbicides used in the experiment in controlling the weeds in sunflower was found similar during both the years. Mean of the two year data indicated that, treatments receiving oxyfluorfen, alachlor and butachlor performed better with respect to weed density, weed dry weight and weed control index. The next best treatment was pretilachlor in terms of reduced weed density and weed dry weight with higher weed control index. Significantly higher grain yield and net returns were recorded in oxyfluorfen, alachlor, butachlor and pretilachlor and they were on par with recommended practice (2 intercultivations + 2 hand weedings). These results are in conformity with the findings of Abosofian *et al.* (2014).

Table 1. Weed density, weed dry weight, weed control index, grain yield and economics in Sunflower as influenced by pre emergent herbicides (Pooled over two years 2013-14 & 2014-15)

Treatment	Weed density (no./m^2)	Weed dry weight (g/m^2)	Weed control index (%)	Grain yield (kg/ha)	Gross returns (` /ha)	Net returns (` /ha)	B:C
Oxyfluorfen 0.15 kg/ha	3.40(10.98)*	1.51 (1.57)*	97.58	1975	61518	34573	2.37
Pendimethalin (EC) 1.0 kg/ha	4.90(23.51)	2.37 (5.02)	92.24	1677	49344	25610	2.03
Pendimethalin (CS) 700 g/ha	5.10 (25.15)	2.53 (5.71)	91.18	1587	52666	23036	1.93
Imazethapyr 0.10 kg/ha	4.47 (19.51)	2.07 (3.81)	94.12	1616	50535	23290	1.93
Alachlor 1.5 kg/ha	3.67 (12.83)	1.58 (1.80)	97.22	1991	58551	35067	2.41
Clomazone 300 g/ha	4.79 (22.48)	2.18 (4.04)	93.76	1508	47741	21408	1.92
Pretilachlor 1.5 kg/ha	4.09 (16.15)	1.94 (3.05)	95.29	1863	55852	31396	2.30
Butachlor 1.5kg/ha (Check)	3.73(13.31)	1.79 (2.51)	96.12	1856	55928	31408	2.31
Farmers' Practice (1IC + 1 HW) (Check)	3.73(13.33)	1.75 (2.33)	96.40	1864	54144	29763	2.15
Weedy Check	8.12(65.68)	8.07 (64.81)	---	835	28460	4527	1.24
LSD (0.05)	0.71	0.34	1.89	197	4967	5911	0.27

*Values in parantheses are original. Data transformed to square root transformation; One intercultivation common for herbicides treatments

CONCLUSION

Weed management by oxyfluorfen, alachlor, Butachlor and pretilachlor were most effective to control weeds resulting in higher yield and net returns in sunflower.

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Biology of horse purslane and integrated weed management for sustainable agriculture

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Trianthemae portulacastrum L. (Family: Aizoaceae), commonly known as horse purslane is a troublesome weed in Indian agriculture. The plant is indigenous to South Africa, but widely distributed in India and other neighbouring countries. It is known as Hand Qooqi in Arabic, Dewasapt in Persian and Horse purslane in English. The plant is found in tropical and subtropical countries of the world, and it is widely distributed in South East and West Asia, Africa and Tropical America and extensively distributed in India, Srilanka, Baluchistan Its infestation in cotton, maize and direct-seeded rice especially in rainy season is a matter of great concern and could reduce crop yields by 32-60%. In India, horse purslane has been reported in the states of Uttar Pradesh, Punjab, Haryana, Rajasthan and Delhi and considered as a number one problematic terrestrial weed by virtue of its infestation in various agricultural and vegetable crops such as mustard, maize, pigeon pea, mung bean, potato, onion, cotton, soybean, pearl millet and sugarcane, especially during the rainy seasons. The management of this weed in India became as foremost action due to the increasing losses of Agro-production. The systematic study was conducted in some field crops and the eco-physiological aspects of the weed evaluated for the effective management of horse purslane by inexpensive and eco-friendly tactics.

Crop establishment method and weed control techniques for zero-till wheat in IGP of India

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Wheat (*T. aestivum L.*) is the staple food crop and contributes 80% in Indian food basket along with rice crop. Recently, in India, conservation agriculture adoption in rice-wheat cropping system is increasing especially in Indo-Gangetic Plains of India (IGP). The productivity of wheat can be enhanced 10-25% with the adoption of zero tillage but little is known about weed flora shift and management. Management of weed is very crucial in conservation agriculture and the recent hike in labour prices has made farming uneconomical in India as most of the farmers in this region are marginal and resource poor. A substitute for hand weeding is required in which weed growth at later stages can be suppressed. To cut down one dose of herbicide application straw mulch was used to check initial growth of weed. Thereafter, post-emergence herbicide was used. A five year long term field experiment was conducted to assess the effects of different tillage and weed management practices on system productivity and weed control efficiency in zero - till wheat.

METHODOLOGY

The field experiment was conducted during 2010-11 to 2014-15 at the research farm of Indian Agricultural Research Institute, New Delhi. The treatments (16) comprised of combinations of 4 tillage and crop establishment techniques (conventional tillage – raised bed (CT-B); conventional tillage – flat bed (CT-F); zero tillage – raised bed (ZT-B) and zero tillage – flat bed (ZT-F) in main plots and 4 weed control strategies viz., no herbicide as control; Integrated weed management (IWM) (isoproturon 1.0 kg/ha POE + HW in wheat); sequential application of herbicides (SHA) (mesosulfuron + iodosulfuron 0.40 kg/ha POE 30 DAS in wheat) and conservation approach of weed management (CAWM) (soybean mulch+ isoproturon. 1 kg/ha POE) in subplots, allocated randomly in a split plot design and replicated thrice. Wheat (cv HD 2895) was sown in three row on each bed (70 cm centre to centre spacing). Wheat was sown in third week of November and harvested in third week of April across the years. A two-factor analysis of variance (ANOVA) was carried out to test the significance of treatments. Critical difference (CD at P=0.05) was used to determine whether means differed significantly or not.

RESULTS

The grain yield, weed density and weed control efficiency were significantly influenced ($P \leq 0.05$) by tillage and crop establishment techniques in wheat (Table 1). Over the years, conventional tillage gave more weed dry weight than zero tillage. Hence, weed control efficiency was found higher in zero tillage, irrespective of flat and raised bed. This is mainly due to exhaustion of seed bank over the years in zero tillage. Weed control strategies significantly influenced grain yield, weed density and weed control efficiency (Table 1).

Integrated weed management (IWM), sequential application of herbicides (SHM) and conservation approach of weed management (CAWM) was found at par in terms of grain yield of wheat. The highest weed control efficiency was found in IWM over the rest of treatment. The apparent visible control of weeds could be a possible reason that instead of higher cost of hand weeding, this practice is still popular amongst farmers. The CAWM was found at par with SHM with respect to % yield increase over control. This is mainly due to retention of straw at soil surface, which improved soil health (Sepat *et al* 2013). This could be a potential strategy to control weed in future.

CONCLUSION

From present investigation it can be concluded that zero-tillage with flat bed is suitable for the wheat crop under IGP of India. Application of isoproturon 1.0 kg/ha POE + HW in wheat can be substituted by sequential application of herbicides viz., mesosulfuron + iodosulfuron 0.40 kg/ha POE 30 DAS in wheat. Conservation approach of weed management that is straw mulch followed by post emergence herbicide application can be a better alternative in long term.

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Castor an alternative crop for South West Haryana

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Castor (*Ricinus communis L.*) is one of the ancient oilseed crops of the world. India accounts for nearly 68 % of the world's castor area and 76 % of world. Castor productivity in India is more than the world average and it ranks first among the major producing countries viz., China and Brazil(Anonymous 2003).In sandy soils of Haryana where fertility is poor, low water holding capacity and limited irrigation facilities farmers used to grow Bajra- Mustard, cluster bean- wheat and fallow- Mustard. Mustard (*Brassica juncea*) is major rabi crop grown on an 48 % area of approximately 1.6 lakh ha in Bhiwani district. Bhiwani is characterized by light textured soils with low fertility status, high infiltration rate, low water holding capacity and undulated topography. The mean annual rainfall is less than 300 mm. The ground water depletion is a serious problem in the tubewells areas as it is going 3-5 ft. deeper every year. Under these circumstances mustard used to be a very remunerative crop for the farmers of Bhiwani district. But for the last 6-7 years the infestation of *Orobanche aegyptiaca*, a parasitic weed has emerged as a serious threat to its cultivation in last decade. Severe infestation of *Orobanche* causes heavy losses i.e. upto 70 per cent in yield of mustard. Because of limited choice for crop rotation many of the farmers were forced to leave the cultivation of mustard.

METHODOLOGY

Through farmers participatory approach FLDs on mustard, castor, pearl millet, mung bean and cluster bean were undertakenat farmers' field in Bhiwani district of Haryana(India)during 2014-15 . A total of 20 FLDs and OFTs were organized in an area of 8 ha scattered in the district randomly. Field demonstrations and on farm trials were conducted during year2014-15 at different locations (Gignau,Surpura,Haripur) of Bhiwani district of Haryana in the *Orobanche* infested areas of adjoining areas of Rajasthan. Castor hybrid DCH 177, Mustard cv. RH 0749, Pearl millet cv. HHB67 (i),Cluster bean cv. HG 365 with full package of practice were used in the demonstrations . The soils under the demonstrations are light to medium in texture and pH varies from 7.8 to 8.2. It is largely dry and sandy with undulating topography.

RESULTS

Mustard yield was observed 1500 kg/ha net returns of 2178 and B: C ratio of 1.04 due to the effect of *Orobanche* weed on the yield of mustard, while sole castor showed yield of 2058 kg/h, net returns of 30588 and B: C ratio of 1.67. Growing of castor with mung bean(1600 kg/ha + 900 kg/ha) and cluster bean(1600 kg/ha + 1000 kg/ha) gave income of (Rs. 61311) & 62291) and and B:C ratio of (2.34, 2.36). Cluster bean + Mustard & pearl millet + mustard yield was observed(1700+1500 kg/ha, 3100+1100 kg/ha) that directly reflects into their income(30158,10536) and B:C ratio of (1.15, 1.02) .It shows that alone mustard and in the cropping system with pearl millet and clusterbean is no more a remunerative crop than castor alone and intercropping of castor with mung bean and cluster bean.

Technology Assessed	Production	Net Return (Profit) in Rs. / unit	BC Ratio
Sole Castor	2058 kg/ha	30588	1.67
Sole Mustard	1500 kg/ha	2178	1.04
Intercropping with mung bean (1:3)	1600 kg/ha + 900 kg/ha	61311	2.34
Intercropping with guar (1:3)	1600 kg/ha + 1000 kg/ha	62291	2.36
Pearl millet + Mustard	3100+1100 kg/ha	10536	1.02
Cluster bean + Mustard	1700+1500 kg/ha	30158	1.15

Price of Castor: 3400, Mustard: 3400, Pearl millet: 1200,Clusterbean: 5000

CONCLUSION

Castor crop can help to restore the income of farmers in orobanche affected areas and Intercropping of Castor alone and intercropping with mung bean and cluster bean has been found very economical in different on farm trials and demonstrations conducted during 2014-15. So castor could be best alternative crop in *orobanche* affected areas of Haryana adjoining to Rajasthan.

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Biological control agents of invasive alien plant species in Nepal

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Rapid spread of invasive alien plant species (IAPS) has negative ecological and socio-economic consequences both in developed and developing countries of the world. There are nearly two dozens of IAPS in Nepal. As a part of integrated approach to control IAPS, various biological control agents have been released in different parts of the world. In Nepal, biological control agent has been reported only for two IAPS; a fungal parasite *Passalora ageratinae* Crous and AR Wood and a stem galling insect *Procecidochare utilis* Stone for *Ageratina adenophora* (L.) King and Robinson, and a winter rust *Puccinia abrupta* Dietel & Holw. var. *partheniicola* (H.S. Jacks.) Parmelee and a leaf feeding beetle *Zygogramma bicolorata* Pallister for *Parthenium hystrophorus* L. (Winston *et al*. 2014). These biological control agents were not released intentionally in Nepal but arrived from the neighboring countries, particularly India, through natural dispersal (Shrestha *et al*. 2015). In Nepal spatial pattern of the distribution of these biological control agents is largely unknown.

METHODOLOGY

During nation-wide survey of IAPS along roadside vegetation conducted during 2013 rainy season (June-August), we recorded the presence of biological control agents of *Ageratina adenophora* and *Parthenium hysterophorus*, and assessed their impacts on these IAPS. Roadside vegetation of 4200 km road, which included all national highways and district level feeder roads, was scanned. IAPS and their biological control agents were examined at an interval of 10 km in plain and 5 km in hilly regions. Some opportunistic observations between these locations were also made.

RESULTS

We did not find fungal parasite (*Passalora ageratinae*) of *Ageratina adenophora* while the winter rust (*Puccinia abrupta* var. *partheniicola*) of *Parthenium hysterophorus* was found localized only in Kathmandu valley. Damage by winter rust on *P. hysterophorus* was insignificant. Stem galling insect (*Procecidochare utilis*) of *A. adenophora* and leaf feeding beetle (*Zygogramma bicolorata*) of *P. hysterophorus* were frequently present. Out of 293 locations where *A. adenophora* was present, the stem galling insect was present at 193 locations (66%). However, the impact was insignificant. At a given location, stem galling was found nearly in 1/4th of the stem and the damage on the plant growth was only marginal without noticeable damage at population level. Out of 362 locations where *P. hysterophorus* was present, the leaf feeding beetle was present at 144 locations (40%) and the damage on the plant was noticeable (>10 leaf damaged) at nearly half of these locations (Figure 1).

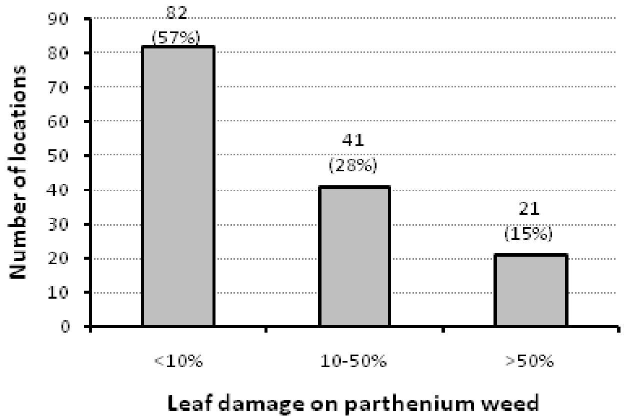

Figure 1. Number of survey locations with varying levels of leaf damage on parthenium weed (*Parthenium hysterophorus*) by the leaf feeding beetle. The value inside parenthesis above each bar is the percentage of total locations.

Though the stem galling insect has been present in Nepal for more than four decades, its impact on the weed has been insignificant. But with less than a decade of residence time of leaf feeding beetle in Nepal, its' damage is noticeable and likely to increase in future with natural population build-up.

CONCLUSIONS

Biological control agents of two invasive alien plant species *Ageratina adenophora* and *Parthenium hysterophorus* arrived and have spread naturally in Nepal with apparently no damage to the former and noticeable damage to the later.

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Effect of integrated weed management on weed control, yield attributes and yield of aerobic rice

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Rice productivity under upland condition in Marathwada region is very low (520 kg/ha) (Anonymous, 2014). Singh *et al.* (2005) reported reduction in grain yield by 75.8, 70.6 and 62.6 % under dry seeded, wet seeded and transplanted rice, respectively due to uncontrolled weeds. Weed infestation is one of the major reasons for poor productivity in direct-seeded rice. Weeds interfere with normal crop growth by competing for available nutrients, light and water. Uncontrolled weeds reduce the grain yield by 96% in direct-seeded rice and 61% in wet –seeded rice (Maity and Mukerjee 2008). In direct-seeded rice, initial 30 to 40 days of crop growth is critical. The yield decreases in direct-seeded rice with the increase in competition duration during the initial period. Manual and mechanical methods are not effective in controlling of weeds in direct-seeded rice because of high labour cost, scarcity of labour during the critical period of weed competition and unfavourable weather at weeding time. Hence usage of herbicides is becoming increasingly popular as a viable alternative to hand weeding. Therefore the present study was undertaken to evaluate different herbicides to control the weed flora in direct-seeded rice.

MATERIAL AND METHODS

The field investigation was conducted during *Kharif* season of 2013 at Upland Paddy Research Scheme Farm, Vasantrao Naik Marathwada Agricultural University, Parbhani (Maharashtra) The soil of the experimental site was clayey in texture with pH 7.8, organic carbon 0.52, available N 200 kg/ha, available P 21 kg/ha and available K 420 kg/ha. The experiment was laid out with three replications in randomized bock design with eleven treatments. The total rainfall received during the cropping season was 1132 mm during *kharif* 2013-2014.

RESULT AND DISCUSSION

Experimental results revealed that, 2 hand weeding + 2 hoeing (T_9) recorded significantly higher grain yield (3.71 t/ha), straw yield (5.80 t/ha), and NMR (29650 Rs/ha), lowest weed index (5.12) and higher weed control efficiency (72.59 per cent) over rest of the weed control treatments. Amongst herbicides or combinations of herbicide with cultural practices/another herbicide, PE-Butachlor 1.00 kg/ha + one HW (T_8) recorded the highest grain (3.71 t) and straw (58.00 q) yield, and NMR (30550 Rs/ha) than rest of the herbicides or integrations of herbicides. Amongst herbicides and integrations of herbicide either with cultural practices or herbicide, PE-Butachlor at 1.00 kg/ha + 1HW (T_8) recorded the lowest weed count, weed dry weight, weed index (7.69) and highest weed control efficiency (68.55%) than rest of the herbicide or integration of herbicides at 60 DAS. Amongst herbicides or herbicide combinations, PE Pendimethalin (30 EC) 1 kg/ha + POE bispyribac-sodium (10% SC) 35 g/ha (T_3) recorded the highest grain (3.5 t/ha), straw yield (5.5 t/ha) and NMR(28980 Rs/ha) than rest of the herbicides or herbicide combinations and was at par with PE butachlor (50 EC) 1.5 kg/ha + POE- bispyribac-sodium (10% SC) 35 g/ha (T_4). Amongst herbicides and combination of herbicides, PE pendimethalin (30EC) at 1 kg/ha + POE bispyribac-sodium (10% SC) 35 g/ha (T_3) recorded the lowest weed count, weed dry weight, weed index (10.25) and highest weed control efficiency (75.63%) than rest of the herbicides or combination of herbicides and was at par with PE butachlor (50 EC) 1.5 kg/ha + POE bispyribac-sodium (10% SC) at 35 g/ha (T_4) at 60 DAS. Per cent NMR loss due to unweeded control (T_{11}) was 90% comparable to weed free plot. Per cent reduction in NMR with PE butachlor at 1 kg/ha + 1HW (T_8) and PE- pendimethalin (30EC) 1 kg/ha + POE- bispyribac-sodium (10%SC) at 35 g/ha (T_3) was 6.14 and 11.05, respectively comparable to weed free plot.

Table 1. Effect of different weed management treatments on yield attributes and rice grain yield.

Treatment	Mean no. of panicle per m^2	Mean length of panicle (cm)	Test weight (g)	No. of filled grains / panicle	No. of unfilled grains/ panicle	Panicle weight (g)	Grain yield (t/ha)	Harvest index (%)
T_1 - POE-Bispyribac-sodium (10% SC) at 35 g/ha	190.00	20.50	24.35	70.11	31.37	2.00	2.50	37.77
T_2 - POE-Bispyribac-sodium (10% SC) at 35 g/ha *fb* one hoeing	204.00	21.63	24.50	81.22	18.22	3.09	3.30	38.59
T_3 - PE-Pendimethalin (30EC) at 1.00 kg/ha *fb* POE-Bispyribac-sodium (10% SC) at 35 g/ha	219.00	21.97	24.61	86.27	15.33	3.28	3.50	38.88
T_4 - PE-Butachlor (50 EC) at 1.5 kg/ha *fb* POE-Bispyribac-sodium (10% SC) at 35 g/ha	210.00	21.80	24.53	83.02	17.01	3.02	3.40	38.68
T_5 - PE-Pendimethalin (30 EC) at1.00 kg/ha *fb* POE-MSM *fb* CME (20WP) at 40 g/ha	199.00	21.75	24.48	78.21	23.10	3.07	2.90	36.25
T_6 - PE-Butachlor (50EC) at 1.00 k g/ha *fb* POE-MSM *fb* CME (20WP) at 40 g/ha	195.00	20.35	24.41	75.11	21.87	3.05	2.80	35.85
T_7 - POE-Azimsulfuron at 20-30 g/ha	186.00	20.17	24.30	66.02	32.11	2.06	2.40	37.50
T_8- PE-Butachlor at 1.00 kg/ha *fb* 1 HW	230.00	23.29	24.77	87.30	13.20	4.10	3.60	38.58
T_9- 2 Hand weeding *fb* 2 hoeing	238.00	25.46	24.77	88.02	13.35	4.17	3.71	38.94
T_{10}- 3 Need based hand weeding	253.00	25.88	24.89	89.11	11.20	4.20	3.90	39.39
T_{11}- Unweeded control	165.00	17.30	23.20	47.50	40.00	1.60	1.50	34.09
LSD (P=0.05)	10.74	1.79	NS	4.13	1.48	0.31	0.19	-

Figures in parentheses are transformed values

Associated weeds:

Associated monocot weeds in present research plots were *Echinocholoa colonum, Brachiria eruciformis, Ischemum rugosum, Eleusine indica, Cynodon dactylon,* whereas, amongst the dicot weeds were *Ipomoea spp., Portulaca oleracea, Argemon maxicana, Convulvulus arvensis, Phylanthus niruri, Acalypha indica, Xanthium strumarium, Parthenium hysterophorus, Celosia argentia* etc. and in sedges *Cyperus rotundus*. Similar results were reported by Mishra *et al.* (2007) in respect of *Echinochloa colonum, Ipomoea spp., Phylanthus niruri, Acalypha indica, Alternanthera sessilis,* and *Cyperus spp.*

CONCLUSION

Post emergence application of bispyriback-sodium (10% SC) at 35 g/ha at 10-15 DAS along with pre emergence application of pendimethalin (30 EC) at 1 kg/ha or butachlor (50 EC) at 1.5 kg/ha showed highest weed control efficiency, grain yield, straw yield and net monitory returns amongst various combination of herbicides in present investigation.

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Effective control of weeds by paraquat dichloride in grape vineyard under Peninsular Indian conditions

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A field experiment was conducted in grape (*Vitis vinifera* L) cv Tas-A-Ganesh grafted on Dogridge rootstock at ICAR-National research Centre for Grapes, Pune during year 2014. Paraquat dichloride was applied @ 2, 3, 4, 8 ml/l and commercial paraquat dichloride @ 4 ml/l and Diuron @ 3.2 g/l were also applied in replicated random block designed experiment. Results revealed that paraquat dichloride controls the complex flora of grassy and broad leaf weeds in vine yard. The maximum control of *Lagasca mollis* (97.26 %), *Chochorus trilocularis* (97.26 %), *Bidens biternata* (96.87 %), *Commelia benghalensis* (96.76%), *Parthenium hysterohorous* (96.01 %) and *Euphorbia geniculata* (95.84 %) was recorded when paraquat dichloride was applied @ 8 ml/l. and 4 ml/l. was effective to control *Amaranthus blitum* (97.97 %), *Acalypha malabarica* (97.97 %) and *Cynodon dactylon* (97.53 %). Similarly, *Cynotis axillaris* (97.71 %) was effectively controled when diuron was applied @ 3.2 g/l.

Environmental Impact of Herbicides Anilofos, Alachlor and Butachlor in Soil

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Keywords: Anilofos, Alachlor, Butachlor, Adsorption, GUS

The main aim of this study is to estimate the potential of herbicides (anilofos, alachlor and butachlor) to contaminate groundwater. Persistence of pesticides and binding ability of pesticides to soil particles are used to obtainGustafson Ubiquity Score (GUS) values.Environmental fate and dissipation of anilofos, alachlor and butachlorherbicides was investigated in two different soil types (alfisol and inceptisol).Soil samples were collected at predetermined intervals and analyzed for the residues. The dissipation data followed first-order kinetics. The half-life (DT50) values for herbicideswere: anilofoswas 3.67days in alfisoland 4.55 days in inceptisol;alachlorwas 1.92 days in alfisol and 2.72 days in inceptisol; butachlorwas 3.28days in alfisol and 4.13days in inceptisol. Adsorption of anilofos, alachlor and butachlor was studied in top soil from alfisol and inceptisol. The soil sorption coefficient K and soil organic carbon coefficient K_{oc} values are the basic parameters that describe the environmental fate of the herbicides. K_{oc} values were :anilofos -1528 in alfisol and 1984.62 ininceptisol; alachlor - 866 in alfisol and 1196.15 ininceptisol; butachlor - 1086 in alfisol and 1288.46 ininceptisol. Persistence of pesticides and binding ability of pesticides to soil particles are used to obtainGUS values.

A combination of degradation data ($t_{1/2}$-soil) and organic carbon based sorption (Koc) data of herbicides have been used to assess the pesticides environmental impact in soils through GUS). The GUSvalues were: anilofos - 0.46 in both soils (alfisol and inceptisol);alachlor – 0.30in alfisol and0.40in inceptisol; butachlor- 0.50in alfisol and 0.55 in inceptisol respectively.

Diversified weed management practices in Bt. Cotton for controlling late emerged weeds

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Cotton being a wide spaced and long duration crop suffers from heavy weed competition during the early stages of the crop growth. Critical period of crop weed competition is up to 60-70 days after sowing. The weed problem gets more severe due to certain unforeseen conditions such as inefficient weeding or inter culture coupled with continuous rains during the critical period. Pre emergence herbicides at recommended dose are generally capable of controlling annual weeds up to 30 days after sowing (Pawar *et al.* 2000). In the absence of interculture, and occurrence of intermittent monsoon rains during the critical period weeds emerge in different spells and compete with the crop plant. Hence there is a need to go for sequential application of pre emergence herbicide followed by post-emergence herbicides to manage the late emerging weeds and eliminate competition from weeds during the period.

METHODOLOGY

A field experiment was carried out for three consecutive years at the research farm of Regional Agricultural Research Station, Lam from *Kharif* 2011-12 to 2013-14 with an objective to find out the effective and economic method of weed control in Bt cotton. The experiment consisted of seven treatments involving various weed management practices in a randomized block design with three replications. The predominant weed flora observed were broad leaved weeds like *Commilina bengalensis, Digera aravens, Cynotis sp. Phyllanthus niruri, Celotia argentia, Trianthema portulacastrum, Physalis minima*; grasses like *Echinochloa colonum, Dinebra arabica, Digitaria sanguinalis, Panicum javanicum, Cynodon doctylon*, and sedges like *Cyperus rotundus*. The soil of the experiment is clayey soil with high waterholding capacity, with pH 7.8, EC. 0.24 dSm^{-1}. medium in available N, and high in available Phophorus and potassium. Herbicides were applied with knapsack sprayer. The quantum of spray fluid used was 500l/ha.

RESULTS

Higher values of growth parameters *viz.* plant height, sympodial branches, yield attributes *viz.* number of bolls per plant, weed control efficiency (WCE), were observed with the treatment pendimethalin at 1.0 kg/ha fb quizalofop ethyl 50g+ Pyrithiobac sodium at 63 g at 20, 40 and 60 days after sowing (DAS) and resulted in highest seed cotton yield (2495 kg/ha). However, the seed cotton yield observed with the Pendimethalin at 1.0 kg/ha fb Interculture at 20, 40 and 60 DAS, hand weeding at 20 40 and 60 DAS, and mechanical weeding with power weeder at 20, 40 and 60 DAS were comparable with that of Pendimethalin at 1.0 kg/ha *fb* quizalofop-ethyl 50 g + Pyrithiobac sodium at 63 g at 20, 40 and 60 DAS.

Table 1. Mean values of Weed control efficiency, Plant height, boll number per plant, seed cotton yield, net returns and benefit cost ratio as influenced by weed management practices in bt. Cotton

Treatment		WCE (%)	Pl ht (cm)	Sympodial branches/ plant	Bolls/ plant	Seed cotton yield (kg/ha)	Net returns (Rs/ha)	BCR
T1	Weedy check	--	158	19.3	27.9	1193	15,983	1.52
T2	Hand weeding at 20, 40 and 60 DAS	57	157	22.5	32.6	2207	33,017	1.62
T3	Intercultivation at 20, 40 and 60 DAS	24	150	20.7	30.7	1922	33,182	1.79
T4	Intercropping with greengram	26	147	18.3	27.7	1363	18,853	1.55
T5	Mechanical weeding with power weeder at 20, 40 and 60 DAS	44	164	23.3	38.5	2193	38,583	1.82
T6	Pendimethalin at 1.0 kg/ha fb I.C at 20, 40 and 60 DAS	30	163	22.9	35	2394	46,314	1.98
T7	Pendimethalin at 1.0 kg/ha fb Quizolofop ethyl 50g + pyrithiobac at 63 g at 20, 40 and 60 DAS	50	188	26	42.1	2495	51,845	2.14
	LSD (P=0.05)	---	23	4	8.5	324	---	---

The pooled data of the three years indicates that, though the seed cotton yield of Pendimethalin at 1.0 kg/ha fb quizalofopethyl 50 g + Pyrithiobac sodium at 63 g at 20, 40 and 60 DAS, hand weeding at 20, 40 and 60 DAS, mechanical weeding with power weeder at 20, 40 and 60 DAS, Pendimethalin at 1.0 kg/ha *fb* Interculture at at 20, 40 and 60 DAS were comparable with each other, the low cost of the herbicidal treatment made the Pendimethalin at 1.0 kg/ha *fb* quizalofop-ethyl 50 g + Pyrithiobac sodium at 63 g at 20, 40 and 60 DAS a most effective and economical method of controlling weeds of diversified weed flora in cotton as it was indicated in terms of the highest net returns (Rs 51,845) and benefit cost ratio (2.14).

CONCLUSION

Application of Pyrithiobac sodium at 63 g + quizalofop ethyl 50g at critical period of crop weed competition can be used as an effective and economic method for control of late emerging diversified weed flora in cotton.

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Exploring herbicides in managing weeds in additive series of sugarcane-wheat intercropping system in North India.

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Sugarcane is planted during spring (Feb.–Mar.), summer (Apr.–May) and autumn (Sept.–Oct.) seasons in northern part of India. Autumn sugarcane gives 15–20% higher cane yield and 0.5 unit more sugar recovery than spring planted crop, as it gets longer period for tillering than spring and summer planted cane (Rana *et al.* 2006). Plateau yield level, declining factor productivity and increasing production cost in recent years have posed serious concerns for the cane growers and mill owners. Moreover, in Punjab, farmers prefer to grow wheat and paddy in order to fetch better returns and secondly for narrowing the gap in income generation i.e. once in a year from sugarcane to twice in a year from paddy-wheat rotation. Since sugarcane is a crop which grows slow initially and gives income after about a year of planting, sufficient research has been conducted to diversify the cropping system by introducing intercrops. Wheat being the staple crop of Punjab, fits well as an intercrop in widely spaced sugarcane crop. Farmers face a greater complexity of weed management in an intercropping system. The losses caused by weeds in sole and intercropped sugarcane range from 26 – 75% (Patil *et al*., 1991; Srivastava *et al.* 2005). A number of herbicides has been recommended for control of weeds in sole wheat, but their feasibility in controlling weeds when intercropped in sugarcane is yet to be established in sub-tropical India. Hence, the current investigations were taken up to generate the information for safe herbicides in sugarcane–wheat intercropping system.

METHODOLOGY

A field experiment was carried out during autumn season of 2008-09 and 2009-2010 at Sugarcane experimental area (Ladhowal), Punjab Agricultural University, Ludhiana to test the efficacy of various herbicides for control of weeds in sugarcane – wheat intercropping system. Two rows of wheat were planted in between two rows of sugarcane spaced 90 cm apart. Ten treatments comprising of various post emergent herbicides recommended in wheat (see table 1) at recommended dose and 1.5 times of the recommended dose and hand weedings were arranged in a randomized block design with three replications. Sugarcane variety CoJ 85 and wheat variety PBW 550 were sown during first fortnight of Oct. and 1st week of Nov. during both the years respectively with recommended package of practices. All the herbicides were sprayed post emergence after first irrigation i.e. 35-40 days after sowing during both the years, ensuring the presence of sufficient moisture at the time of spraying. The fertilizer dose to sugarcane were applied using urea at 487.5 kg/ha in 3 splits and to intercropped wheat was applied using, urea, SSP and muriate of potash at 135kg/ha, 187.5 kg/ha and 50 kg/ha respectively. Data on weed growth and yield performance was recorded.

RESULTS

Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest weed count of 64.0/m^2 in 2008-09 and 41.3 m^2 in 2009-10 was observed under Atlantis 3.6 WDG (Mesosulfuron + Iodosulfuron) 400 g/ha and it was at par to all the herbicidal treatments and two manual hand weedings but significantly better than the control in both the years of study (Table 1). The minimum weed dry weight of 55.9 g/m^2 and 42.7 g/m^2 was recorded with the post emergence application of Leader 75 WG (Sulfosulfuron) 32.5 g/ha and 48.75 g/ha during the first and second year, respectively. But it was at par to all other herbicidal treatments as well to two hand weedings during both the years. Weed control index ranged from 63.1% to 71.8% during 2008-09 and from 44.2% to 70.3% during 2009-10 indicating sufficient control with the post emergence application of herbicides. The highest cane equivalent yield of 94.8 t/ha and 86.8 t/ha (table 1) during 2008-

Table 1. Weed growth, weed control index, and yield as influenced by different weed control treatments in sugarcane - wheat cropping system during 2008-09 (Yr 1) and 2009-10 (Yr 2)

Treatment	Weed count/m^2		Weed dry weight (g/m^2)		Weed control index (%)		Cane equivalent yield (t/ha)		Wheat yield (q/ha)		Cane yield (t/ha)	
	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2
Leader 75 WG (Sulfosulfuron) 32.5 g/ha	74.7	58.7	55.9	58.8	71.8	59.1	92.0	80.7	36.8	31.5	71.7	63.3
Leader 75 WG (Sulfosulfuron) 48.75 g/ha	81.3	57.3	65.1	42.7	67.2	70.3	84.0	84.1	33.5	32.9	65.5	66.0
Axial 5.0 EC (Pinoxaden) 1.0 lt/ha	86.7	56.0	69.2	80.2	65.1	44.2	85.4	84.0	30.3	33.9	68.7	65.4
Axial 5.0 EC (Pinoxaden) 1.5 lt/ha	72.0	45.3	65.4	61.8	67.0	57.0	85.2	78.1	34.8	29.6	66.0	61.8
Total 75 WG (Sulfosulfuron + Metsulfuron) 40 g/ha	74.7	62.7	67.7	55.8	65.9	61.1	94.8	86.8	35.9	32.6	75.1	68.9
Total 75 WG (Sulfosulfuron + Metsulfuron) 60g / ha	88.0	56.0	73.3	56.3	63.1	60.8	87.0	83.0	30.4	34.5	70.3	64.0
Atlantis 3.6 WDG (Mesosulfuron + Iodosulfuron) 400 g/ha	64.0	41.3	66.7	81.9	66.4	43.0	88.5	78.8	29.9	31.4	72.1	61.6
Atlantis 3.6 WDG (Mesosulfuron + Iodosulfuron) 600 g/ha	80.0	45.3	71.0	77.4	64.2	46.1	94.7	84.5	36.4	33.7	74.7	66.0
Algrip 20 WP (Metsulfuron) 25 g/ha	82.7	60.0	58.2	77.7	70.7	45.9	90.0	82.3	31.0	32.0	73.0	64.7
Aim 40 DF(Carfentrazone-ethyl) 50 g/ha	76.0	66.7	65.5	69.2	67.0	51.8	85.7	82.3	31.7	29.2	68.3	66.2
Two hand weedings (before and after 1st irrign.) to wheat.	72.0	54.7	49.7	61.8	74.9	57.0	91.4	79.6	39.0	30.4	69.9	62.9
Control (No hoeing and no herbicide application)	201.3	184.0	198.5	143.7	0.0	0.0	63.7	56.0	23.2	20.6	50.9	44.7
LSD (P=0.05)	35.6	31.0	26.9	39.9	-	-	12.5	11.6	8.2	7.2	12.3	11.2

Note: Prices of sugarcane and wheat for calculating cane equivalent yield were taken as Rs. 180/qtl and Rs. 1000/qtl. during 2008-09 (Yr 1) respectively. '. 200/qtl and 1100/qtl during 2009-10 (Yr 2), respectively.

09 and 2009-10, respectively was obtained when Total 75 WG (sulfosulfuron + metsulfuron) was sprayed as post emergence 40.0 g/ha to wheat crop and this being at par with all the doses of Leader 75 WG, Axial 5.0 EC, Atlantis 3.6 WDG, Algrip 20 WP, Aim 40 DF treatments was significantly better than the unweeded control. The increase in cane equivalent yield with post emergence spray of all the herbicides over the unweeded control varied from 31.9 to 48.8 % during 2008-09 and 28.3 to 55.0% during 2009-10. Weed control with herbicides in vegetables intercropped in sugarcane has also been reported by Kaur *et al*. 2015; and Bhullar *et al*. 2006.

CONCLUSION

For effective weed control in wheat intercropped in sugarcane, apply Total 75 WG, Leader 75 WG, Axial 5.0 EC, Atlantis 3.6 WDG, Algrip 20 WP, Aim 40 DF as in case of sole wheat crop. The adoption of the chemical weed control in wheat intercropped in sugarcane will help in timely control of weeds, reduce yield losses and increases total productivity. This technology will also help in increasing the area under autumn sugarcane with intercropping of wheat crop. Herbicides also reduce labour dependence for weed control in sugarcane - wheat intercropping system.

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Crop losses and the economic impact of weeds on agriculture of Pakistan

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The role of agriculture in the economy of Pakistan cannot be ruled out as it is a huge sink of labour force for the expending population of the country as well as a big sector for the income of the agrarian country. However, this sector losses a lot of hard currency due to weeds in terms of weed competition with crop plants, as a cost of weed control and in terms of environmental pollution and pesticide poisoning due to the large scale use of herbicides for weed control. Weed competition is the major factor in crop yield reduction. The current study is the estimated losses of production of major crops of the country due to weeds, their cost of control and the hazards and poisoning of herbicides to the environment and consequently to the human beings. Data showed that weeds cause 34.66 or about 35% losses on the average to every crop and as a whole to the backbone of the economy i.e. the agricultural sector of Pakistan, which is a reduction of approximately 55.50 million tons on annual bases in the production of staple food crops like wheat, rice, maize, sugar crops like sugar cane and sugar beet, oilseed crops like sunflower, brassica, canola, fruits and orchards like guava, pears, apples, plums, apricots, banana, grapes, strawberries, melons, etc. vegetables like potato, tomato, okra, cabbage, cauliflower, turnips, radish, carrots, marrows, cucumbers etc., condiments like onions, garlic, chillies, gingers, and turmeric, fiber crop like cotton and cash crop like tobacco. In monetary terms these losses exceeds Rs. 1492.32 Billion which is 34.68 % of the budget of Pakistan for the year 2014-15 and approximately equal to the provincial share in federal revenue receipts during the budget 2013-14. In order to manage weeds losses several weed management strategies are adapted out of which the herbicides use outweigh the rest. The use of herbicides not only increase the cost of production but also cause indirect losses in the form of detrimental effects on human health, human and animal poisoning and death, loss of biodiversity, environmental pollution (estimated total losses of Rs. 1658.311 Billion). The consumption of herbicides in Pakistan was 20,647 tons worth Rs. 1.3 billion during 1993-94. The indirect losses due to weeds and herbicides are $1.05 billion/yr to pollution-related health costs, about $ 353 million/yr to agricultural land degradation costs, up to $ 160 million/yr due to loss of rangeland and losses to wildlife, fisheries and non-target sensitive crops are still to be measured.

Management of binding weeds in sugarcane

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Sugarcane is one of the most important crops commercially grown and India is a major producer as well as consumer of sugar in the world. In sugarcane production, cane yield losses ranging from 20-90% were reported due to weeds in different countries of the World. If not controlled they may compete with sugar cane and interfere in the harvest operations. In Kerala, the binding weeds are the major weeds in sugar cane . Among these *Ipomoea, Mikaenia micrantha and Clitoria spp.* are the major ones. A combination of pre and post herbicides were effective for the control of *Ipomoea spp.* in sugarcane (Bhullar *et al.* 2012). Hence the present investigation was undertaken to control the binding weeds in sugar cane.

METHODOLOGY

A field experiment was carried out during the three year period from 2009 to 2012 at Agricultural Research Station ,Thiruvalla to evaluate the different herbicides for control of binding weeds and creepers in sugar cane. Geographically the area is located at an altitude of 18m above the mean sea level and at latitude of of 9° 16' 0" N and longitude of 76° 47' 0" E. The soil of the experimental area was riverine alluvium. The ten treatments were Control (weedy check), Hoeing at 30, 60 and 90 DAP, Atrazine 2 kg/ha (P.E) followed by 2,4-D (1.0 kg/ ha) at 60DAP, Atrazine 2.0 kg/ha after first irrigation and hoeing followed by 2,4-D 1 kg/ha at 75 DAP, Metribuzin 1.25 kg/ha (P.E) followed by 2,4-D at 1.0 kg/ha at 75 DAP, Atrazine 2.0 kg/ha (P.E) + Almix 20 g/ha at 75 DAP ,Metribuzin 1.25 kg/ ha (PE)+Almix 20 g/ha at 75 DAP, Atrazine 2.0 kg/ha (PE)+Ethoxysulfuron 50 g at 75 DAP, Atrazine 2.0 kg/ha (PE) + Dicamba 350 g/ha at 75 DAP, Metribuzin 1.25 kg/ha (PE) + Dicamba 350g ai/ha at 75 DAP.The treatments were arranged in a randomised block design with three replications. The variety was Madhuri .

RESULTS

The pooled data of the experiment revealed that the weed control measures had significantly influenced the weed density, cane and sugar yield. All the weed control measures resulted in significant reduction for weed dry weight.

Among the growth parameters the highest cane length and girth were recorded in the Pre-emergant application of Metribuzin 1.25 kg/ha followed by 2, 4-D 1 kg/ha during 75 DAP and lowest was reported in the unweeded control plot. The millable cane count has contributed to the final cane yield significantly. The millable cane count and CCS% were also follow the same trend.

Table1. Cane yield and juice quality as influenced by various weed management practices (Pooled Data)

Treatment	Cane length (cm)	Cane girth (cm)	Cane weight (kg)	MCC ('000/ ha)	CCS (%)	Cane yield (t/ha)	Sugar yield (t/ha)	Weed Dry wt. (g/m^2)	Benefi -Cost Ratio
Control	196.08	8.01	1.07	54.95	8.34	58.69	4.93	95.95	1.53
Hoeing	252.90	9.31	1.47	85.11	9.88	104.79	10.35	27.87	2.48
Atrazine+2,4-D60DAP	225.66	8.42	1.22	73.63	8.76	77.02	6.78	49.46	1.93
Atrazine +2,4-D 75DAP	221.44	8.33	1.18	70.37	8.62	73.29	6.35	59.77	1.77
Metribuzin+2,4-D	263.83	9.46	1.51	91.34	10.08	110.13	11.11	23.07	2.72
Atrazine + Almix	208.66	8.41	1.15	66.38	8.70	70.10	6.18	66.49	1.76
Metribuzin +Almix	227.81	8.34	1.33	76.81	8.80	83.08	7.34	40.48	2.05
Atrazine +Ethoxysulfuron	209.51	8.27	1.12	64.10	8.70	67.79	5.98	73.54	1.68
Atrazine +Dicamba	205.66	8.16	1.09	61.68	8.52	67.51	5.81	83.70	1.69
Metribuzin +Dicamba	241.10	8.56	1.30	79.85	8.98	89.97	8.09	34.07	2.22
LSD (0.01)	8.77**	0.43**	0.09**	6.12**	0.35**	8.64**	0.87**	1.2**	

The unweeded check recorded the lowest millable cane count. Pre-emergant application of Metribuzin at 1.25kg ai/ha followed by 2, 4-D at1 kg/ha during 75 DAP had significantly controlled the weed population and recorded the lowest weed dry weight. But it was closely followed by hoeings at 30, 60 and 90 DAP .The treatment with Pre Emergent application of Metribuzin at 1.25 kg/ha followed by 2,4-D 1 kg/ha as post emergence at 75 DAP had produced maximum cane yield(110.13 t)and sugar yield (11.11 t) (Table 1). The increased cane yield might be due to the higher uptake of nutrients due to less weed interferance which in turn might have increased the dry matter production. Herbicidal treatments resulted in considerably lower cost of cultivation and the B : C ratio was found maximum (2.72) with the Pre-emergant application of Metribuzin 1.25 kg/ha followed by 2, 4-D at 1 kg/ha during 75 DAP

CONCLUSION

Application of metribuzin 1.25 kg/ha as pre emergent spray followed by 2,4-D at 1.0 kg/ha at 75 days after planting is very effective in controlling binding weeds and getting profitable yield.

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Bio- efficacy evaluation of flumioxazine on weed growth and yield of soybean

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Soybean (*Glycine max* [L.]Merrill) is a crop of multiple qualities as it is both a pulse and oilseed crop and the world's foremost provider of protein and oil. In India total area under soybean was 12.03 million hectares with a production of 12.98 million tonnes and a productivity 1079 kg ha^{-1} during 2013. According to estimates, yield losses in soybean due to weed infestation were 35 to 80% (Mohammadi and Amiri, 2011). As cultural and mechanical methods of weed control are not always effective in first 45 days, it necessitates provision of suitable herbicides that can be cost effective and cope up with the scarcity of labour. Several new molecules are being tested for their weed control efficacy in soybean. An attempt has been made to find the effectiveness of a new contact herbicide flumioxazine 50% SC (N-phenylphthalimide) which acts on weeds by inhibiting protoporphyrinogen oxidise enzyme.

METHODOLOGY

Field experiment was conducted during *Rabi* season of 2013-14 at ARS Bhavanisagar, Tamil Nadu, to test the bio efficacy of flumiozaxine against weeds. The soil of the experimental field was red sandy clay loam in texture belonging to *Typic Paleustalfs*. A total of 11 treatments consisting of varying doses of flumioxazine along with pendimethalin, oxyflourfen, chlorimuron ethyl and hand weeding were arranged in a randomized block design with three replications. Variety CO (Soy) 3 was taken in the field according to recommended package of practices given by TNAU with gross plot size of 4.0x4.0 m^2 and net plot size of 2.8x3.6 m^2. Fertilizers were applied @ 20:80:40 NPK/ha respectively in a single dose as basal. Data on weed growth at 45 DAS, yield and economics were recorded.

RESULTS

The major proportion of the weed flora comprised of grasses at all the stages of growth and at later stages the weed density was higher when compared with early stages *Panicum flavidum* among grassy weeds, *Cyperus rotundus*, among sedges and *Euphorbhia hirta*, *Trianthema portulacastrum*, etc. among broad leaved weeds were more dominant. Among the treatments lowest weed density (23.3 No/m^2) was observed under flumioxazine 250g/ha followed by flumioxazine 150g/ha (31.7 No/m^2) (Table1). Minimum weed dry weight was also recorded in these treatments which was significantly lower than all the others. During the cropping period higher weed control efficiency was obtained with flumioxazine 250g/ha (89%) at 45 DAS. lowest (62%) with herbicidal treatment Chlorimuron ethyl 9g/ha.

Table 1. Effect of treatments on weed growth and yield of soybean

Treatment	Weed density (No/ m^2)	Weed dry weight (g/ m^2)	WCE (%)	Grain yield (t/ha)	Haulm Yield (t/ha)	Net return (`/ ha)	B:C ratio
Flumioxazine 75g/ha	10.4 (106)*	6.82 (44.5)*	68	1.62	2.25	22811	1.88
Flumioxazine 100g/ha	8.70 (73.7)	6.44 (39.5)	72	1.75	2.31	26680	2.03
Flumioxazine 112.5g/ha	7.31 (51.7)	5.54 (28.7)	80	1.90	2.44	30947	2.19
Flumioxazine 125g/ha	6.43 (39.3)	5.07 (24.0)	84	1.43	2.41	19381	1.75
Flumioxazine 150g/ha	5.80 (31.7)	4.69 (20.0)	86	1.40	2.34	15985	1.61
Flumioxazine 250g/ha	5.03 (23.3)	4.30 (15.6)	89	1.32	2.07	13464	1.51
Pendimethalin 1.0kg/ha	7.01 (47.3)	6.43 (35.7)	75	1.88	2.43	29144	2.07
Oxyflourfen 125g /ha	9.04 (80.0)	6.87 (45.3)	68	1.60	2.23	21329	1.80
Chlorimuron ethyl 9g/ha	11.1 (122)	7.43 (53.3)	62	1.45	2.11	17308	1.66
Hand weeding on 25 & 45 DAS	8.48 (70.0)	6.16 (36.1)	75	1.81	2.30	17411	1.47
Unweeded check	19.4 (374)	12.0 (141)	-	0.98	1.69	4931	1.20
LSD (p=0.05)	**1.05**	**0.73**		**261**	**287**		

*Figures in parenthesis are original subjected to "¯X+0.5 transformations

Among herbicidal treatments highest grain yield (1.9t/ha) was recorded under flumioxazine 112.5g/ha followed by pendimethalin 1.0kg/ha (1.88t/ha) and lowest (0.98t/ha) was under flumioxazine at 250g/ha. Similar was the haulm yield. The increased yield obtained under flumioxazine 112.5g/ha is due to lesser competition and least phytotoxity. Sangeetha *et al.* (2011) obtained maximum seed yield of soybean from weed free environment by different weed control treatments. Highest net return (30947 '/ha) and B: C ratio (2.19) was higher in flumioxazine 112.5g/ha and it was followed by pendimethalin 1.0kg/ha (29144 '/ha and 2.07). This could be due to less labour requirement for weeding operation and higher growth parameters, yield attributes as a result of reduced competition between weeds and crop for water and nutrients.

CONCLUSIONS

On the basis of result, It was concluded that the application of flumioxazine 112.5g/ha as pre-emergence herbicide provides an option to farmers to manage weeds effectively along with improved growth leading to higher productivity of soybean**.**

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Management of *Vicia sativa* in rice fallow blackgram

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Rice fallow pulse is the major cropping system in the North Coastal zone of Andhra Pradesh especially in the Srikakulam and Vizianagaram districts covering an area of 60,000 ha. The area under the rice and black gram in Andhra Pradesh is 14.84 lakh ha. and 3.76 lakh ha respectively, of these 42420 ha is under the rice-black gram system in the north coastal zone of A.P. The productivity of pulse crops in this zone is very low (5-7q/ha). *Vicia sativa* (locally referred to as *rangam minimu*) has become the single most important weed which poses a serious threat to the productivity and sustainability of rice fallow pulses in the North coastal Zone. .It is a crop specific weed capable of causing total yield loss The weed is both soil and seed borne .As both the weed and the crop belong to the pulse group (fy:leguminosae), screening for herbicidal selectivity to blackgram/greengram against this weed were not successful. However, some more herbicides effective against broad leaved weeds may have to be screened. Hence, keeping in view these points, the present trial to manage this weed was undertaken.

METHODOLOGY

A field experiment was carried out for two consecutive years during the *rabi* seasons of 2012-13 and 2013-14 at Agricultural Research Station, Ragolu(A.P) to effectively manage the problematic weed of rice fallow pulses Vicxia sativa by chemical method of weed control. Nine treatments consisting of the pre emergence sand mix application of the weedicides viz., Pendimethalin,Pretilachlor, Butachlor, Oxyflourfen and Imazethapyr at different doses were tested along with hand weeding and control in a randomized block design in three replications. Blackgram variety 'LBG 752' was sown as test variety with recommended package of practices.Rice fallow blackgram was grown on residual moisture and residual fertility. Pre sprouted blackgram seed was broadcasted in standing crop of rice 5 days before the harvest of *kharif* rice. Data on weed density and dry weight of *Vicia sativa*, yield attributes and yield of rice fallow blackgram were recorded and statistically analysed.

RESULTS

Density and dry matter of *Vicia sativa* weed was significantly lowest at 30 DAS with Hand weeding at 15 and 35 DAS (6.04/m^2 and 1.51g/m^2). Among the weedicide treatments the lowest density and dry weight of *Vicia sativa* was recorded with pre emergence sand mix application of Oxyflourfen at 0.4 kg/ha (23.67/m^2 and 5.07g/m^2) and was comparable with pre emergence sand mix application of Pendimethalin at 0.75kgha for density of *Vicia sativa*. At 50 DAS also exactly same trend was observed. Hand weeding at 15 and 35 DAS recorded the significantly lowest density and dry matter of *Vicia sativa* and among the weedicide treatments the lowest density and dry weight of *Vicia sativa* was recorded with pre emergence sand mix application of Oxyflourfen at 0.4 kg/ha was comparable with pre emergence sand mix application of Pendimethalin at 0.75 kg/ha for density of *Vicia sativa*. Highest Weed control efficiency (WCE) at 30 DAS and 50 DAS was obtained with HW at 15 and 35 DAS (91.55 and 80.30 %). The treatments pre emergence sand mix application of Oxyflourfen at 0.4 kg/ha and Pendimethalin at 0.75 kg/ha were at par with hand weeding indicating their efficiency in controlling the problematic weed during the critical period for crop weed competition.The superior performance of hand weeding and new weedicide molecules in controlling *Vicia* was also reported by Pramod kumar and Nagaich (2013) and Rana *et al.*(2013). The treatments did not differ with respect to number of branches per plant. With respect to number of pods per plant all the treatments were in parity with hand weeding (11.60/plant) treatment except that of control. Seed yield was the highest with oxyflourfen at 0.4 kg/ha (752 kg/ha) and was comparable with hand weeding at 15 and 35 DAS. This clearly indicated that treatmental variation for yield was due to differences in the density and dry weight of *Vicia sativa* and the might be due to the differences in final plant population. The yield was reduced by 48% in the control treatment due to the predominance of this single problematic weed.

Table 1. Weed growth *Vicia sativa*, yield attributes and yield of rice fallow blackgram as influenced by different weed management treatments (pooled data)

Treatment	Weed density (no/sq.m)		Weed dry matter (g/sq.m)		Weed Control Efficiency (%)		No. of branches/ plant	No. of pods/ plant	Seed yield (kg/ha)
	30 DAS	50 DAS	30 DAS	50 DAS	30 DAS	50 DAS			
PE-Pendimethalin @0.75kg/ha	32.59	48.17	7.99	18.77	7.56(56.62)*	7.04(49.03)	2.34	11.20	592
PE-Pretilachlor @0.5 kg/ha	47.67	55.34	9.74	19.35	6.60(43.03)	6.25(38.52)	2.30	10.59	571
PE-Butachlor @ 1.0 kg/ha	40.59	51.50	8.62	20.59	6.99(48.31)	6.26(38.75)	2.44	9.67	607
PE-Oxyflourfen @ 0.3 kg/ha	41.42	52.00	9.07	16.45	7.00(48.47)	7.02(48.79)	2.44	11.67	624
PE-Oxyflourfen @ 0.4 kg/ha	23.67	36.10	5.07	13.77	8.62(73.78)	8.16(66.15)	3.07	12.67	752
PE- Imazethapyr @ 0.75 Kg/ha	38.00	48.00	11.67	20.85	5.99(35.43)	6.50(41.77)	2.72	11.60	718
PE-- Imazethapyr @ 1.0 Kg/ha	38.50	53.17	9.47	21.45	6.89(46.91)	6.39(40.38)	2.77	10.57	650
HW at 15 and 35 DAS	6.04	17.50	1.51	7.83	9.59(91.55)	8.99(80.30)	2.60	11.60	694
Control	63.92	69.50	23.34	35.86	0.71(0.00)	0.71(0.00)	2.30	8.54	390
LSD (P=0.05)	9.76	12.46	2.22	4.14	2.11	2.33	NS	3.35	75

*Values in the parenthesis are original. Data are transformed to square root transformation

CONCLUSION

It was concluded that *Vicia sativa* in rice fallow blackgram can be effectively controlled by hand weeding at 15 and 35 DAS and among weedicides pre emergence sand mix application Oxyflourfen at 0.4 kg/ha was the most effective in controlling the problematic weed *Vicia sativa* in rice fallow blackgram in North Coastal Zone of Andhra Pradesh.

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Performance of different herbicides on production of Bt. Cotton.

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Cotton (*Gossypium* spp.) is an important commercial fibre crop grown under diverse agro-climatic conditions around the world. In Karnataka it is grown in an area of 5.49 lakh ha with production of 13.1 lakh bales and productivity of 406 kg ha^{-1} (Anonymous, 2012). Bt Cotton is often portrayed as that technological revolution in Indian cotton cultivation which has changed the cotton scenario in India and pushed it to higher yields to make India the second largest producer of cotton in the world. In long duration, initial slow growth crop like cotton weeds flourish even after critical period of crop weed competition and it is difficult to achieve effective weed control with single application of herbicides (pre emergence or post emergence). Hence, in order to control weeds for a longer period of crop growth there is needs to apply herbicides on sequential basis.

METHODOLOGY

A field experiment was carried out at Agricultural Research Station of University of Agricultural Sciences, Dharwad (Karnataka) during *Kharif* seasons of 2011-12 and 2012-13 to evaluate the performance of different herbicides on production of Bt. cotton. The experiment was laid out in randomized complete block design with ten treatments and replicated thrice. Seven herbicides *viz*. Pendimethalin 30% EC at 1.5 kg/ha , Pendimethalin 38.7% CS at 0.68 kg/ha, Alachlor 50% EC 2.0 kg/ha, Butachlor 50% EC 1.5 kg/ha, Diuron 80% WP at 1.0 kg/ha, oxyfluorfen 23.5% EC 0.2 kg/ha and Pyrithiobac-sodium 10% EC at 0.125 kg/ha were applied as pre emergence and these herbicides were applied again as post emergence in sequence on same treatments at 30 days after sowing (DAS) and were compared with recommended practice, weed free check and unweeded check. Bt. Cotton hybrid Mallika was sown in the experimental plots during both the seasons with recommended package of practices (RPP). Fertilizers were applied uniformly through urea, diammonium phosphate and muriate of potash at 100:50:50 kg N, P_2O_5 and K_2O/ha, respectively. Weedicides were sprayed with knapsack sprayer using 1000 lit/ha water.

RESULTS

The dominant weeds observed in the experimental area were, *Brachiaria eruciformis, Cynodon dactylon, Dinbra retraflexa and Digitaria marginata* among the grassy weeds, *Cyperus rotundus* among the sedges and among the broad leaved weeds *Acalypha indica, Ageratum conyzoides, Amaranthus viridis, Commelina benghalencis, Crozophora rottleri, Digera arvensis, Mollugo disticha, Parthenium hysterophorus, Phyllanthus medraspatensis* and *Trichodesma zeylanicum*. All the herbicide treatments performed significantly superior over unweeded check. Among the herbicide treatments, pre emergence application of Oxyfluorfen 23.5% EC at 0.2 kg/ha showed some toxicity symptoms up to 35 DAS and later crop recovered. Pre emergence application of Pyrithiobac-sodium 10% EC at 0.125 kg/ha followed by pyrithiobac-sodium 10% EC at 0.125 kg/ha as post emergence at 30 DAS recorded significantly lower weed number (14.94) and dry weight (56.92 g) per m^2 compared to other herbicide treatment except Butachlore fb Butachlore.

Table1: weed growth, yield and economics of Bt. Cotton as influenced by different weed control treatments

Treatment	Weed density (no./m^2)	Weed dry weight (g/m^2)	Weed index (%)	Seed cotton yield (kg/ha)	Cost of cultivation (`/ha)	B:C ratio
Pendimethalin 30% EC *at* 1.5 kg/ha *fb* Pendimethalin 30% EC *at* 1.5 kg/ha	5.74 (32.17)	9.66 (93.33)	25.46	2416	45683	1.98
Pendimethalin 38.7% CS *at* 0.68 kg/ha *fb* Pendimethalin 38.7% CS *at* 0.68 kg/ha	4.90 (23.33)	8.48 (72.50)	15.94	2725	44930	2.28
Alachlor 50% EC *at* 2.0 kg/ha *fb* Alachlor 50% EC *at* 2.0 kg/ha	5.71 (32.00)	9.80 (97.33)	23.93	2468	44454	2.08
Butachlor 50% EC *at* 1.5 kg/ha *fb* Butachlor 50% EC *at* 1.5 kg/ha	4.30 (17.84)	7.84 (62.50)	12.45	2830	44308	2.41
Diuron 80% WP *at* 1.0 kg/ha *fb* Diuron 80% WP *at* 1.25 kg/ha	5.41 (28.72)	9.13 (83.92)	21.13	2548	43820	2.19
Oxyfluorfen 23.5% EC *at* 0.2 kg/ha *fb* Oxyfluorfen 23.5% EC *at* 0.2 kg/ha	4.73 (21.72)	8.46 (72.25)	15.07	2738	45931	2.25
Pyrithiobac-sodium 10% EC *at* 0.125 kg kg/ha Pyrithiobac-sodium 10% EC *at* 0.125 kg/ha	3.89 (14.94)	7.39 (56.92)	11.43	2863	49178	2.20
RPP: Pendimethalin 30 EC *at* 1.5 kg/ha + HW at 40 DAS + IC at 60 DAS	5.07 (25.22)	8.73 (77.08)	17.26	2675	51717	1.95
Weed free check	2.31 (4.34)	1.71 (1.92)	-	3219	71302	1.71
Unweeded check	10.93 (119.33)	27.69 (769.17)	76.56	763	33178	0.86
LSD (P=0.05)	0.68	1.09	6.48	278	-	0.23

fb: followed by, IC: Intercultivation, HW: hand weeding,. Values in parentheses are original. Data transferred to square root transformation

All the weed control treatments recorded significantly higher seed cotton yield than the unweeded check. Among the herbicide treatments significantly the highest seed cotton yield was recorded with Pyrithiobac-sodium fb Pyrithiobac-sodium (2863 kg/ha) and the lowest with Pendimethalin 30% EC *fb* Pendimethalin 30% EC (2416 kg/ha). The yield loss due to uncontrolled growth of weeds as compared to weed free check was 76.50%. Such yield reduction due to weed competition was also observed by Bharathi *et al.* (2011). All the herbicide treatments resulted in considerably lower cost of cultivation compared with RPP and weed free check. The cost benefit ratio was significantly higher with Butachlore fb Butachlore and which was on par with Pyrithiobac-sodium *fb* Pyrithiobac-sodium and Pendimethalin 38.7% CS *fb* Pendimethalin 38.7% CS.

CONCLUSION

Based up on the results it was concluded that, effective and economical weed control can be achieved with sequential application of Pyrithiobac-sodium fb Pyrithiobac-sodium , Butachlore *fb* Butachlore and Pendimethalin 38.7% CS *fb* Pendimethalin 38.7% CS.

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Feasibility of using problematic weeds as manurial resources for organic rice production

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The competition from weeds for space, sunlight, nutrients and moisture is well known. Problematic weeds like Eupatorium (*Chromolaena adenophorum L.*), water hyacinth (*Eichhornia crassipes* (Mart.) Solms) etc., pose a serious menace for crop production. Eupatorium is one of the troublesome weeds in non-crop lands and orchards particularly in high rainfall areas. It is a branched fast growing shrub belonging to family Compositae. Its seed being very light and non-dormant get air-borne easily and spread to non-infested areas very fast (Saini, 2002). It thrives on all types of well drained soils and can grow on soils relatively low in fertility. Once established it competes aggressively with herbs, grass and shrubs in open areas. The inhabitate of this weed is considered to suppress the growth of fodder grasses under shade slowly eliminating them completely. Eupatorium is reported to be highly allelopathic to nearby vegetation and may reduce the population of nematodes. The water hyacinth is the most predominant, persistent and troublesome aquatic weed in India. It exploits fresh water habitat for efficient utilization of solar energy. It reproduces vegetatively by means of slender horizontal runners (stolons). A single plant is capable of infesting an area of one acre in a year. It produces greater dry matter content and converts solar energy more efficiently than many other plants. Weed biomass may be a potential source of plant nutrients if managed properly (Rajkhowa *et al*. 2002). Use of the weeds as resources for supplementing the nutrition of crop will not only reduce the dependence on external inputs but also limit the damage by these weeds. Rice (O*ryza sativa* L.), being the major crop of low lying areas in the West coast region with potential for organic production, field trials were carried out to assess the feasibility of using problematic weeds as a source of nutrition for organic production.

METHODOLOGY

Field experiments were conducted at ICAR Research Complex for Goa, Old Goa for five years during 2009 to 2013 in a Split–plot design with three replications in laterite soils to standardize the practices for organic rice production by involving three varieties (Red kernelled rice Revathy, high yielding variety Karjat-3 and scented rice Pusa Sugndh-5) as main plot treatments and seven manurial resources including problematic weeds as sub-plot treatments. Eupatorium used in the study had a nutrient content of 2.70% N, 0.21% P and 1.54% K while water hyacinth contained 2.58% N, 0.40% P and 3.17% K. All the manurial resources were chopped and applied before planting and incorporated into the soil.

RESULTS

The pooled mean results of the study indicated that high yielding rice variety Karjat-3 and red kernelled rice variety Revathy recorded significantly more productive tillers (8.99 and 8.94/hill, respectively) and panicles per unit area (276 and 262 per m^2, respectively) over scented variety Pusa Sugandh-5. Application of recommended fertilizers recorded significantly higher productive tillers (9.3/hill), total dry matter (26.1 g/hill) and panicles per unit area (268/m^2). Rice variety Karjat-3 recorded significantly higher grain yield (3.13 t/ha) over Revathy (2.50 t/ha) and Pusa Sugandh-5 (1.80 t/ha). Although, application of recommended fertilizers recorded higher grain yield of rice during first year of experimentation and the pooled mean (3.15 t/ha and 3.09 t/ha, respectively), use of *Glyricidia* along with Eupatorium each at 5 t/ha yielded 87% of the yield (2.69 t/ha) recorded with recommended fertilizers indicating its feasibility for use as nutrient source for organic rice production. Higher increase in organic carbon was observed with FYM at 10 t/ha (1.44% O.C.) and paddy straw with water hyacinth each at 5 t/ha (1.36% O.C.).

Table 1. Pooled mean nutrient content of the organic manurial resources used in the experiment (on dry weight basis)

Nutrients	N (%)	P_2O_5 (%)	K_2O (%)
FYM	1.10	0.85	0.33
Vermicompost	1.59	1.01	0.25
Glyricidia	4.13	0.45	1.85
Eupatorium	2.52	0.05	1.58
Paddy straw	1.68	0.05	0.45
Water hyacinth	3.51	0.23	3.33
Sesbania rostrata	3.79	0.04	0.90

Application of *Sesbania rostrata* at 10 t/ha significantly influenced higher microbial growth in soil in terms of fungi ($10.39x10^3$ CFU/g), bacteria (17.5×10^5 CFU/g) and actinomycetes (10.28×10^4 CFU/g).

CONCLUSION

Use of Eupatorium along with *Glyricidia* each at 5 t/ha can be used as an alternate source of organic nutrition in rice under West coast region. Water hyacinth alongwith paddy straw each at 5 t/ha was also found to enhance the soil organic carbon.

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Post emergence weed management in narrow row cotton

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Weeds were allowed to germinate with initial rains, which were burned down by glyphosate at 6 ml/L along with residual herbicide pendimethalin effectively controlled weeds for 37 days. However, it did not work in an *El nino* year of delayed monsoon with desiccating winds. Early post emergence graminicides quizalopfop ethyl, fenoxoprop methyl, propaquizafop at 1.8 ml/L, glyphosate directed spray 2-4 ml/L alone or alongwith pyrithiobac sodium, were evaluated in narrow row cotton in shallow and medium deep soils in a year of excess rains (2013) and drought (2014) respectively. Pyrithiobac sodium 1.8 ml/L or glyphosate 2 ml/L were able to significantly control the major weeds such as *Cyanotis auxillaris*, *Commelina benghalensis* and *Digera arvensis* when the weeds were 20 days old. Glyphosate 2 ml/L was effective against young grasses where as 4 ml/L is more effective as 2nd spray directed application when weeds were grown for one month. Quizalofop and fenoxoprop could control both *Commelina benghalesis* and *Digera arvensis*. However, propaquizafop could control only *Diagera arvensis*.

Weed management in sugarcane

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Sugarcane is one of the important commercial crops grown in Andhra Pradesh. Weeds have been reported to reduce the cane yields to the extent of 12-72% by competing for moisture, nutrients and light during the growing season, besides harboring pests and diseases during off season. Planting of setts at wider spacing, slow initial growth of the seedlings, low canopy coverage during initial 60 days period, cultivation of sugarcane under heavy fertilization and irrigation aggravates the weed problem in sugarcane. Heavy weed infestations can also interfere with sugarcane harvest by adding unnecessary harvesting expenses.

Major weed flora in sugarcane:

In India about 63 weed sps belonging to 29 families were found to infest sugarcane fields. Generally grasses compete with sugarcane followed by sedges and broad leaved weeds. Twining weeds like *Ipomea carnea*, *Ipomea hidereta*, *Convolvulus arvensis*, *Coccina indica*, *Cardiospermum helicacabum* are also becoming more problematic which consume more labour and delay in harvesting. Knowledge on occurrence of dominant wed flora, their stage of appearance, flowering and fruiting time are important to develop and follow an effective weed management practice. Most common weed flora observed in sugarcane fields include *Cyperus rotundus*, *Cynodan dactylon*, *Digtraria sanguinalis*, *Imperata aurandinacea*, *Sporobolus coromandelianum*, *Cenchrus ciliaris*, *Eleusine aegyptciaca* among monocots and *Trianthema portulosastrum*, *Cleome viscosa*, *Gynandropis pentaphylla*, *Merrimia emerginanta*, *Tridax procumbens*, *Phyllanthus niruri*, *Amaranthus viridis*, *Mimosa pudica*, *Parthenium hysterophrous* among dictos.

Successful weed control by adopting integrated weed management is essential for economical sugarcane production. Several experiments were carried out at Regional Agricultural Research Station, Anakapalle being the lead centre for sugarcane research in Andhra Pradesh. Results of experiments conducted over a period of time are summarized hereunder.

Weed management in sugarcane plant crop:

Pre – emergence spraying of sencor at 1.0 kg/ha + hoeing at 60 DAP registered significantly higher cane (96.1 t/ha) and sugar (13.2 t/ha) yield and found on par with 2,4-D at 4.5 kg/ha + gramoxone at 2.5 lt/ha twice at 20 and 60 DAP (cane yield : 95.9 t/ha, sugar yield : 13.7 t/ha) and hand weeded plots (102.4 t/ha and 14.8 t/ha). Higher net returns also obtained with these treatments (1990 and 1991).

Pre emergence application of metribuzine at 1.0 kg/ha followed by one hand weeding at 60 DAP (79.6 t/ha) proved effective in controlling the weeds there by higher cane yield and found on par with hand weeding thrice at 30,60 and 90 DAP (82.1 t/ha). Un weeded control plot registered the lowest cane yield of 61.8 t/ha (2000 and 2001)

Metribuzin at 1.0 kg/ha as per emergence + 2,4-D at 1.0 kg/ha at 60 DAP + hoeing at 90 DAP (93.2 t/ha) registered higher cane yield than unweeded control plot (73.6 t/ha) but found on par with metribuzine as pre emergence + hoeing at 60 DAP (91.2 t/ha) or hand weeding plot (95.4 t/ha) (2002 and 2003).

Weed management in sugarcane ratoon crop:

Spraying atrazine at 1.0 kg/ha at ratooning + 2,4D (Na salt) at 1.0 kg/ha after irrigation and off baring gave higher cane yield (85.7 t/ha) and higher net profit (Rs.28,567 /ha) and found on par with conventional practice of three weedings / hoeings at 30,60 and 90 DARI (cane yield 90.2 t/ha; net profit: Rs 27,725 t/ha). The weedy plot recorded lowest cane yield (68.4 t/ha) with a net profit of Rs.18,750 /ha only (1992 and 1993)

Spraying metribuzine 1.0 kg/ha at ratooning + hoeing at 45 DARI gave higher cane yield (101.6 t/ha) with 76.9% weed control efficiency and found on par with hand weeding thrice at 1st, 4th and 7th WARI (cane yield: 100.0 t/ha; WCE 79.4%) in ratoon crops. The next best treatment was trash mulching in alternate rows followed by hoeing at 1st and 6th WARI (cane yield: 95.9 t/ha, WCE 73.7%) (2006 and 2007)

Management of binding weeds (creepers) in sugarcane:

Pre emergence spraying of metribuzine @ 1.25 kg a.i/ha followed by post emergence application of almix @ 20 g/ha at 75 days after planting (85.1 t/ha) or metribuzine @ 1.25 kg a.i/ha as pre emergence followed by dicamba @ 350 g a.i/ha at 75 days after planting (81.1 t/ha) registered significantly higher cane yield after controlling the binding weeds effectively and found on par with conventional practice of weeding and hoeing thrice at 30,60 and 90 DAP (83.8 t/ha). Un weeded control registered the lowest cane yield of 66.4 t/ha. (2009-2011)

Efficacy of metribuzine a selective post emergence weedicide in sugarcane:

Spraying of metribuzine at 1 kg/ha + 2,4-D at2 kg/ha at 20 DAP and 90 DAP or 2,4-D@ 4.5 kg/ha + Gramoxone at 2.5 lit/ha at 20 and 60 DAP can be adopted for controlling weeds effectively and getting higher yields than other weed control treatments. (2011-2013)

Allelopathic Efficacy of *Nelumbo nucifera* and *Sagittaria sagittifolia* on the Germination and Growth of Wheat and its Associated Noxious Weeds

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A lab experiment was conducted to investigate the allelopathic effect of two noxious aquatic weeds i.e. Lotus *(Nelumbo nucifera*) and Arrowhead weed *(Sagittaria latifolia)* on the germination and growth of Wheat *(Triticum aestivum)* and its associated troublesome weeds like Wild oat (*Avena fatua*) and milkthistle *(Silybum marianum)* during May 2014, at Weed Science Research Laboratory, Department of Weed Science, the University of Agriculture Peshawar, Pakistan. Aquatic plant were collected, dried and ground to powder. The powdered materials were dissolved in distilled water @ 100 g/L. The solution was kept for 48 hours, then filtered from muslin cloth and kept in air tight containers. The seeds of test species were soaked in the respective concentration for 24 hours and then transferred to the petri dishes for germination test. The petri dishes were watered as per need of the seeds for germination with distilled water. The design used for experiment was Completely Randomized Design (CRD) with three replications. Data were taken on germination (%), shoot length (cm), shoot and root weight (g). Result revealed that wild oat has been more affected (1.99) than wheat (10.66) and milk thistle (21.33) in case of seed germination. While with increasing the concentration of extract of both the allelopathic plants increased inhibition was noted in seed germination of the all test species as compared to control. The germination of *Silybum* was decreased from 20.00 to 13.33 and wild oat from 3.33 to 0.00%, yet wheat germination were enhanced (16.66 to 20.0%) with increasing lotus extract concentration from 5-10%. While increasing the extract concentration of arrowhead weed from 5% to 10% decreased wheat seed germination (6.66 to 0.00%), wild oat (3.33 to 0.00%) and milk thistle (40.00 to 16.66%), respectively. Similarly in case of shoot length wild oat (0.73) has been more affected than wheat (1.81) and milk thistle (2.66). Increase in the extracts concentration of lotus from 5% to 10% increased the shoot length of wheat (4.00 cm) and milk thistle (2.22 cm) while decreased the shoot length of wild oat (0.00).While increasing the extract concentration of arrowhead from 5% to 10% decreased the shoot length of all test species (wheat 0.00 cm, wild oat 0.00 cm and milk thistle 3.00 cm) as compared to lotus where increasing concentration (5% to 10%) increasing shoot length of wheat by 4.00 cm and milk thistle by 2.22 cm, while wild oat was negatively affected. In case of shoot weight Milk thistle (0.11 g) has been more affected than wheat (0.97 g) and milk thistle (2.41 g). By increasing lotus extracts concentration (5% to 10%) decreased the shoot weight of wheat (0.06 g), wild oat (0.00 g) and milk thistle (0.06 g). Increasing the extract concentration of arrowhead decreased the shoot weight of wheat (0.00 g), wild oat (0.00 g) and milk thistle (0.15 g). And both plant extracts showed antagonistic effect on the entire plant species. In case of root weight, Wheat (0.02 g) has been more affected than rest of milk thistle (0.09 g) and wild oat (1.33 g). Increased in the extracts concentration of lotus from 5% to 10% increased the root weight of wheat (0.04 to 0.05 g) and milk thistle (0.05 to 0.32 g) while in case of wild oat increasing the concentration from 5 t0 10 % decreased the root weight from 3.33 to 0.00 g. While increasing the extract concentration of arrowhead from 5% to 10% decreased the root weight of wheat and wild oat (0.01 to 0.00 g) and milk thistle (0.08 to 0.03 g).

Evaluation of bioefficacy and phytotoxicity of odyssey 70% WG (imazethapyr 35% +imazomox 35% WG) in Soyabean.

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Soybean is an important oilseed crop, containing 20% oil and 40% protein and is called as "wonder crop". In India it is cultivated in 8.53 million ha area with the annual production of 9.43 million tonnes. There are several reasons for low productivity, out of these weed has paramount importance. Weed infestation is one of the major problems in soybean cultivation which causes 37% reduction in yield. Weeds if not controlled during critical period of weed-crop competition, there is reduction in the yield of soybean from 58-85%, depending upon type and weed intensity. The period of crop-weed competition lies between 15-45 days to sowing; after that the crop cover and takes care of emergent late shift of weeds and are smothered by the lush canopy of soybean crop. The production potential of the crop can not be realized fully if weeds are not controlled within the critical period of crop-weed competition. Weed control through hand weeding is tedious and labour consuming. Odyssey (imazethapyr +imazomox) is a new molecule which reportedly kills the post emergence weeds in soybean (Pratiksha *et al.*, 2013). The present experiment was conducted to know the exact concentration of chemical needed for control and also to know if there is any phytotoxicity on crop and residual effect on succeeding crop.

METHODOLOGY

A field experiment was carried out during *kharif*,2008 at College of Agriculture, PJTSAU (formerly ANGRAU) Hyderabad, to test the efficacy of odyssey 70 % WG (imazethapyr 35 % +imazamox 35 %) in soyabean against weeds. Nine treatments consisting of odyssey 70 % WG at varying doses along with other herbicides like chlorimuron ethyl 25 % WP , imazethapyr 10%SL, imazomox 12 % SL and Fenoxoprop ethyl 9% EC were arranged in a randomised block design with three replications along with unweeded control for comparison. Soybean variety *'JS 335'* was used. All the herbicides were applied as post emergence at 2-3 leaf stage of the weeds.

RESULTS

Predominant weed flora infesting the crop indicated that, among grasses *Echinocloa spp.* was dominant weed followed by *Digitaria spp.;*among the sedges, *Cyperus rotundus* and among the BLWs *Commelina benghalensis* was dominant followed by *Euphorbia spp*. The data on weed dry matter (g/m^2) indicated that odyssey 70 % W.G. at 87.5g/ha in combination with surfactant and ammonium sulphate was superior in reducing the weed dry matter. Odyssey 70% WG 87.5 g/ ha + Cyspread at 1.5 ml/ L, ammonium sulphate at 2.0 g/ L water was effective in controlling grasses, sedges and broad leaved weeds which was indicated by higher weed control efficiency(%) and lower weed Index (%) and higher B:C ratio. The least weed control efficiency was observed with chlorimuron ethyl 52 %WP. Maximum seed yield of 1855 kg/ha was recorded with odyssey at 100 g/ ha . Significantly lowest seed yield of 635 kg/ ha was recorded with unweeded control. No phytotoxic effect of herbicides was observed on soybean and there was residual effect of the herbicide odyssey on succeeding greengram crop

Table 1. Effect of different treatments on weed control, yield and economics of soybean

Treatment	Weed density			Weed dry matter (g/m^2)	WCE (%)	Seed yield (kg/ha)	Cost benefit ratio
	Sedges	Grasses	BLW'S				
Odyssey 70% WG 100 g/ha	2.2	7.4	7.8	42.7	75	1516	1.78
Odyssey 70 % WG 75 g/ha + Cyspread 1.5 ml/L+ ammo.sulphate 2 g/L	3.4	14.3	12.1	64.5	64	1229	2.20
Odyssey 70 % WG 87.5 g/ha+cyspread 1.5 ml/L+ammo. sulphate 2 g/L	1.5	7.5	6.7	38.7	78	1532	2.64
Odyssey 70% WG 100 g/ha+ Cyspread 1.5 ml/L+ ammo. sulphate 2.0g/L	1.0	4.3	5.8	28.7	84	1855	2.24
Imazethapyr 10% SL 100 g/ha+ Cyspread 1.5 ml/L + ammo. sulphate 2.0g/L	1.5	8.7	9.6	42	76.9	1653	2.37
Imazamox 12% SL 42 g/ ha + Cyspread 1.5 ml/L+ammo. sulphate 2.0 g/L	1.7	7.4	9.1	43.3	76	1577	2.23
Chlorimuron ethyl 25 % WP at 37.5 g /ha	2.5	35.1	10.7	67.3	62	1502	2.32
Fenoxoprop ethyl 9% EC at 67.5g/ ha	9.8	8.3	28.4	70.6	60	1622	1.09
Control	10.5	43.8	37.5	178	-	637	
LSD (P=0.05)				6.0		180	

CONCLUSION

Odyssey 70 % W.G. 87.5 g/ ha+ Cyspread at 1.5 ml/ L, ammonium sulphate at 2.0 g /L can be recommended for efficient weed control and also for higher yield of soybean without any phytotoxicity and residual effect on succeeding crop.

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Rapid diagnosis of herbicide resistance as a first step of HR management

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Herbicide resistant (HR) weeds are the most challenging problem in the current weed management. Rotation of herbicides with different modes of action (MOA) is most frequently proposed to manage HR. However, farmers have no good knowledge on herbicide MOA, so implementation of rotating herbicide is not much practical. Usually farmers follow advices from specialists in agrochemicals, so use herbicide with different MOA after they notice weeds resistant to a specific herbicide. In a practical sense, it is important to diagnose HR as early as possible in a field condition, so that alternative herbicide can be advised to manage HR weeds. Therefore, rapid diagnosis of HR weeds is essential for HR management. In this presentation, various methods for rapid diagnosis of HR will be presented, such as growth pouch test, chlorophyll fluorescence assay, and plant phenomic tools, in comparison with the conventional whole plant assay.

METHODOLOGY

Whole plant herbicide dose-response assay was conducted with herbicide resistant and susceptible biotypes of weed species. Alternative herbicide dose-response methods were then tested at various growth stages; growth pouch test at the seed germination stage, trimmed seedling or tiller test at the juvenile stage before stem elongation, and stem node test after heading stage. Chlorophyll fluorescence assay and spectral image analysis were also conducted to diagnose herbicide resistance in weeds.

RESULTS

The GR_{50} values of herbicide resistant and susceptible weeds estimated from the whole plant herbicide dose-response assay at the juvenile growth stage were compared with those from various alternative herbicide dose-response methods conducted at relevant growth stages. Comparison of the GR_{50} values of herbicide resistant and susceptible weeds, R/S ratio, revealed that the alternative diagnostic methods tested in this study showed similar accuracy in discriminating between resistant and susceptible weeds in a much shorter duration (Table 1). In particular, chlorophyll fluorescence assay and spectral image analysis could diagnose herbicide resistance with no destruction of testing weeds.

Table 1. Diagnostic methods for rapid diagnosis of herbicide resistance

Diagnostic methods	Growth stage	Assessment	Duration (days)
Whole plant assay	Juvenile	Shoot fresh weight	20 ~ 30
Growth pouch test	Germination	Root length	7
Trimmed seedling test	Juvenile	New shoot length	7
Trimmed tiller test	Juvenile	New shoot length	7
Stem node test	Heading	New shoot FW New root length	7
Chlorophyll fluorescence assay	Juvenile ~ heading	Fluorescence	4 ~ 10
Spectral image analysis	Juvenile ~ heading	Body temperature Fluorescence	2 ~ 7

CONCLUSION

Alternative diagnostic methods presented in this study showed a similar diagnosis of herbicide resistance weeds to the whole plant assay, and could save time to diagnose herbicide resistance, suggesting that they can be incorporated into the HR management system.

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