PROCEEDINGS II

15TH ASIAN-PACIFIC WEED SCIENCE SOCIETY CONFERENCE

APWSS

TSUKUBA
JAPAN
JULY 24-28
1995

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THE ORGANIZING COMMITTEE OF
THE 15TH ASIAN-PACIFIC WEED SCIENCE SOCIETY CONFERENCE
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CONTENTS

ALLELOPATHIC EFFECT OF SEVERAL PLANT SPECIES IN CONTROLLING WEEDS IN JUTE (VAR. 0-4).

M. Abdul Gaffer

Department of Agronomy,
Bangladesh Agricultural University, Mymensingh
BANGLADESH

Key Words: Allelopathy, Plant material, weed control.

ABSTRACT

The study was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during April to August, 1990 with tosha jute var. 0-4 to evaluate the effect of plant material incorporated into soil on the weed intensity and consequent impact on yield and yield contributing character of jute. The experiment consisted of four plant species viz. *Amaranthus spinosus, Cyperus rotundus, Echinochloa colonum* and *Imperata cylindrica* whose fresh materials were incorporated into soil at the rate of 0.50, 0.75 and 1.00 kg/m^2 including control plots. The experiment revealed that incorporation of plant biomass reduced weed infestation and consequently yield increased. Among the four plant species, Imperata cylindrica was much more effective in controlling the infesting weeds and had positive influence on yield and yield components of Jute. The relative efficiency of plant species in controlling weed population is *I. cylindrica* > *C. rotundus*> *E.colonum* > *A. spinosus.*

INTRODUCTION

Allelochemicals released by different plants interact with surrounding plants (Rice, 1979). Many plants are reported to release allelochemicals (Satoh, *et al.*, 1989) and weeds incorporated into the soil is also inferred to be of a potential role in modifying or controlling population densities explaining vegetation pattern (Whittaker, 1970). Rizvi and Rizvi (1984) reported that allelochemicals have essential features of herbicide alternative of synthetic chemicals. Allelochemicals released by weeds may reduce intensity of weed infestation. Research work pertinent in this line is scarcely available. Therefore, the experiment was undertaken to investigate the effect of plant materials incorporated in soil on weed density and performance of jute.

MATERIALS AND METHOD

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from April to August, 1990. Two experiments, one in field (Exp1) and another in pots (Exp2) were conducted for confirmation of finding in Exp1. The experimental field was medium high land (Silty Loam texture, P^H 6.5 and organic matter content 1%) belongs to Agro-ecological zone of Old Brahmaputra Flood Plain (BARC, 1989). The experiment consisted of (i) four plant species viz. *Amaranthus* *spinosus, Cyperus rotundus, Echinochloa colonum* and *Imperata cylindrica*) and (ii) three doses of fresh chopped biomass of each species viz. 0.50, 0.75 and 1.00 kg/m^2 including control plots. The treatment combinations were assigned in a randomized block design with three replications. The treatment combinations were as follows:

T_1 : control (no plant materials applied)
T_2 : *A. spinosus* at the rate of 0.50 kg/m^2.
T_3 : *A. spinosus* at the rate of 0.75 kg/m^2.
T_4 : *A. spinosus* at the rate of 1.00 kg/m^2.
T_5 : *C. rotundus* at the rate of 0.50 kg/m^2.
T_6 : *C. rotundus* at the rate of 0.75 kg/m^2.
T_7 : *C. rotundus* at the rate of 1.00 kg/m^2.
T_8 : *E. colonum* at the rate of 0.50 kg/m^2.
T_9 : *E. colonum* at the rate of 0.75 kg/m^2.
T_{10} : *E. colonum* at the rate of 1.00 kg/m^2.
T_{11} : *I. cylindrica* at the rate of 0.50 kg/m^2.
T_{12} : *I. cylindrica* at the rate of 0.75 kg/m^2.
T_{13} : *I. cylindrica* at the rate of 1.00 kg/m^2.

Fresh plant materials of the scheduled species were collected, chopped and incorporated into the soil as per experimental specifications. The unit plot size was 1 m^2. The land was finely prepared and fertilized with 45 N, 10 P_2O_5 20k_2O kg/ha through urea, triple super phosphate and muriate of potash. Seeds were sown continuously in 15 cm apart rows. Two weedings were done manually at 20 and 45 days after sowing (DAS). During weeding data pertinent to plant materials applied were recorded. Weed species at each weeding including at harvest were uprooted and oven dried at 105^{0}C for 24 hours and dry weight of each sample was recorded. The intensity of weed infestation was recorded with the following formula.

$$\text{Intensity of weed infestation} = \frac{\text{No. of weed stands/unit area}}{\text{No. of crop plants/unit area}}$$

Data on yield and yield components of jute were also recorded.

Exp2. A pot experiment was conducted as per specification of exp1, taking the same soil as media. Data on weeds intensity and dry matter, yield and yield component of jute were also recorded.

All the collected data were subjected to statistical analysis and means were compared by DMRT.

RESULTS AND DISCUSSION

The name of weed species and their density of infestation have been presented in Table 1a and 1b. About 12 species of weeds representing 6 families were found to grow and to infest the crop both in field and pot experiments. The infesting species of weeds were shama (*Echinochloa crus-galli*), Mutha (*Cyperus rotundus*). Joina (*Fimbristylis littoralis*), Durba (*Cynodon dactylon*), Gaicha (*Paspalam commersonii*), Halud saillaya (*Setaria glauea*), Keshuti (*Eclipta alba*), Kakpaya (*Dactyloctenium aegyptium*), Kanainala (*Cyanotis axillaris*), Chapra (*Eleusine indica*), Katanotey (*Amaranthus spinosus*), and Foskabegur (*Physalis heterophylla*). Thus the monocot weed species represented the major share of the infesting weeds. It was revealed that shama, mutha, joina, durba and gaicha constituted the major bulk of the total weed population. These five weeds dominated in field as well as in pot culture. The weeds offered much more competition to the jute plants and caused serious damage to the crop. It was revealed from table 2 that among the four plant materials incorporated to the jute field, *Imperata cylindrica* was much more effective in controlling the infesting weeds and produced lowest absolute density both in field and pot culture than those of others. The weed infestation was the highest in control plots than the plots incorporated with weed materials. Among the plant materials incorporated plots weed bulk was more in *A. spinosus* treated plots. With the increase in dose of weed material application, the weed infestation reduced. This indicated that weed biomass released allelochemicals which showed herbicidal activity and suppressed the weed population.

Incorporated weed biomass significantly influenced yield and yield components. Plant height, stem diameter, bark area, stick and fibre yields were significantly influenced with incorporation of weeds (Table 4). *Imperata cylindrica* was much more effective against weeds and had significant positive influence on yield and yield components. Most of the plots treated with weed biomass produced significantly higher yield over control. At higher dose of weed biomass incorporation, the yield and yield components were higher.

The result indicated that *Imperata cylindrica* produced more toxic chemicals or herbicidal chemicals reducing weed infestation and conseqnently favours the crop growth. The relative efficiency of four weeds in controlling weed population is *I. cylindrica* > *C. rotundus* > *E. colonum* > *A. spinosus*.

Table 1a. Absolute density of infesting weed species as affected by different treatments in jute (O-4) at field experiment.

Infesting weeds	Scientific name	Density of infesting weeds per m^2 at different treatments.												
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
Shama	*Echinochloa crus-galli*	12.0	11.3	11.3	10.0	11.3	11.0	10.3	10.0	9.0	9.0	10.3	10.3	9.7
Mutha	*Cyperus rotundus*	11.0	11.0	10.3	9.7	10.0	9.0	9.0	9.7	9.3	9.0	10.0	9.7	9.0
Joina	*Fimbristylis littoralis*	9.7	9.0	9.0	8.3	9.3	9.0	8.3	9.0	8.7	8.7	9.0	8.3	8.3
Durba	*Cynodon dactylon*	8.3	8.0	8.3	7.7	8.0	8.0	7.3	8.0	7.3	7.0	7.3	7.3	6.7
Gaicha	*Paspalam commersonii*	7.7	6.7	6.3	5.7	7.3	7.0	6.7	7.7	7.0	6.7	7.0	7.0	6.7
Halud Shailleja	*Setaria glauca*	6.0	6.0	5.7	5.0	6.7	6.0	5.3	6.3	6.0	5.7	6.0	5.7	5.3
Keshuti	*Eclipta alba*	4.7	4.0	4.0	3.7	5.3	5.3	5.0	5.7	5.0	4.0	5.3	5.0	4.7
Kakpaya	*Dactyloctenium aegyptium*	4.0	4.0	3.7	3.3	5.3	5.0	4.0	5.3	5.0	4.0	5.3	5.0	4.0
Kanainala	*Cyanotis axillaris*	3.7	3.0	2.7	2.7	4.3	4.7	3.7	4.3	4.0	3.3	3.3	3.0	2.3
Chapra	*Eleusine indica*	3.0	3.0	2.3	2.0	3.7	3.0	3.0	2.3	2.7	2.0	2.7	2.3	2.3
Katanotey	*Amaranthus spinosus*	1.7	1.7	1.0	0.3	1.3	1.3	1.3	0.7	0.7	0.3	0.7	0.3	0.3
Foskabegun	*Physalis heterophylla*	1.0	0.3	0.3	0.0	0.3	0.7	0.3	0.3	0.3	0.3	0.3	0.0	0.0

Table 1b. Absolute density of infesting weeds in Jute (O-4) under pot condition as affected by different treatments.

Infesting weeds	Scientific name	Density of infesting weeds per m^2 at different treatments.												
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
Shama	*Echinochloa crus-galli*	12.3	12.0	9.0	8.3	10.0	9.3	9.0	10.7	10.0	9.3	9.0	8.3	6.7
Mutha	*Cyperus rotundus*	11.6	10.7	9.3	8.0	10.3	9.3	8.0	11.3	10.7	9.0	9.3	9.3	9.0
Joina	*Fimbristylis littoralis*	11.0	10.7	10.7	9.7	8.3	8.0	8.0	9.7	8.7	6.3	9.3	7.7	7.3
Durba	*Cynodon dactylon*	7.7	6.3	6.3	6.0	8.3	7.3	7.0	8.7	7.3	6.7	8.3	7.3	6.0
Gaicha	*Paspalam commersonii*	5.3	5.0	4.3	4.3	6.3	6.0	5.0	8.0	7.3	6.3	7.0	6.7	6.3
Halud Shailleja	*Setaria glauca*	5.0	4.7	4.3	4.0	5.7	5.7	5.0	7.3	6.7	6.0	6.7	6.3	5.0
Keshuti	*Echipta alba*	4.7	4.3	4.3	4.0	5.0	4.7	4.3	6.3	5.7	4.7	6.3	5.7	5.0
Kakpaya	*Dactyloctenium aegyptium*	4.7	4.3	3.0	3.0	4.3	4.3	4.0	5.3	4.7	4.3	4.3	4.7	4.0
Kanainala	*Cyanotis axillaris*	4.3	3.7	3.3	3.0	4.7	4.0	3.0	4.3	4.3	4.0	4.3	4.0	4.0
Chapra	*Eleusine indica*	3.7	3.7	3.0	2.0	4.0	4.0	3.0	4.3	4.0	3.0	3.6	3.6	3.3
Foskabegun	*Physalis heterophylla*	2.0	2.0	2.0	1.7	3.0	2.7	2.3	2.7	2.7	2.0	2.0	1.7	1.3
Katanotey	*Amaranthus spinosus*	2.0	2.0	1.0	0.7	1.3	1.0	0.7	1.3	1.0	0.3	1.0	0.7	0.3

2. Absolute density and dry matter production of weeds in jute (O-4) as afected by allelopathic effect of weeds incorporated into soil.

Treatment	Absolute density of weeds (No. of weeds/m²)		Weed dry weight (g/m²)	
	Exp1	Exp2	Exp1	Exp2
Weeds incorporated				
A. spinosus	81.67a	87.39a	49.42a	63.49a
C. rotundus	70.35ab	74.34ab	33.67b	56.11ab
E. colonum	78.05ab	61.93b	35.46ab	43.09b
I. cylindrica	64.91b	60.08b	33.19b	38.87b
Dose of weed application (kg/m2)				
0.00	80.34ab	97.40a	44.36ab	66.49a
0.50	98.47a	83.73ab	53.39a	54.21ab
0.75	70.63ab	74.12b	32.21b	44.61b
1.00	62.09b	67.98b	30.21b	39.91b

The figures in a column bearing same letter(s) do not differ significantly at 0.05 level.

Table 3. Yield and yield components of jute (O-4) as influenced by weed biomass incorporation into the soil.

Treatment	Plant height at hervest (cm)		Diameter of stem (cm)		Bark area of Plant (cm^2)		Stick yield (g/m^2)		Fibre yield (g/m^2)	
	Exp-1	Exp-2	Exp-1	Exp-2	Exp-1	Exp-2	Exp-1	Exp-2	Exp-1	Exp-2
Weeds incorporated										
A. spinosus	353.8b	305.1b	1.10c	1.08ab	1223.22c	1035.41b	1423.75c	1955.40c	473.88c	639.67b
C. rotundus	358.1ab	311.8ab	1.30ab	1.06b	1402.90ab	1038.79ab	1778.36ab	2280.52ab	571.20b	774.65ab
E. colonum	349.2b	307.6b	1.27b	1.06b	1393.90ab	1024.83c	1703.34b	2175.82b	573.07ab	762.91b
I. cylindrica	368.7a	313.3a	1.39a	1.10a	1566.98a	1083.07a	1874.42a	2354.56a	577.12a	787.56a
Dose of weed application (kg/m^2)										
0.00	341.7b	298.1c	1.13c	1.06b	1313.61c	993.21b	1414.71c	1390.13bc	560.31c	476.21bc
0.50	308.5bc	307.6ab	1.09d	1.03bc	1056.95d	966.82b	1361.28bc	1411.90b	540.21cd	483.57bc
0.75	371.9ab	306.6ab	1.35ab	1.08ab	1578.01b	1040.74ab	1748.20b	1418.65b	590.11b	502.30b
1.00	375.1a	314.3a	1.40a	1.09a	1650.23a	1076.82a	1861.70a	1603.46a	630.70a	575.81a

The figures in a column bearing same letter(s) do not differ significantly at 0.05 level.

Table 4. Effect of interaction of weed materials and dose of their application on the yield and yield components of jute(O-4).

Treatment	Plant height at harvest (cm)		Diameter of stem (cm)		Bark area of plant (cm^2)		Stick yield (g/m^2)		Fibre yield (g/m^2)	
	Exp-1	Exp-2	Exp-1	Exp-2	Exp-1	Exp-2	Exp-1	Exp-2	Exp-1	Exp-2
T_1	361.26	286.89	1.21	1.08	1373.80	973.77	1053.33g	1861.34b	360.17d	746.47b
T_2	358.61	306.57	1.19	1.06	1341.18	1021.30	1283.33ef	1893.28ab	430.17d	786.57b
T_3	368.23	296.83	1.20	1.09	1388.73	1016.84	1558.33cd	1657.74c	515.17c	701.32bc
T_4	372.11	311.08	1.27	1.11	1485.22	1085.21	1800.00b	1930.56ab	590.00b	830.56ab
T_5	364.20	311.12	1.23	1.05	1407.87	1026.68	1871.67ab	1740.41bc	568.40b	741.50b
T_6	364.11	317.26	1.24	1.09	1418.96	1086.82	1825.00ab	1877.9bb	558.50b	793.00b
T_7	366.81	317.20	1.26	1.06	1452.54	1086.64	1983.33a	1899.11ab	560.40b	820.06ab
T_8	367.65	288.11	1.17	1.06	1351.88	959.80	1703.33bc	1791.57bc	563.40b	722.59bc
T_9	361.27	303.79	1.26	1.97	1430.60	926.11	1795.00b	1971.08ab	548.53bc	863.54ab
T_{10}	371.90	331.57	1.32	0.98	1542.83	1042.06	1890.00ab	2030.55ab	631.93ab	891.66ab
T_{11}	367.64	273.31	1.18	1.08	1363.39	909.27	1841.68b	1767.62bc	568.60b	721.01bc
T_{12}	360.63	323.88	1.21	0.79	1371.40	987.35	1858.33ab	1887.01b	570.00b	803.54ab
T_{13}	370.08	326.09	1.24	0.92	1442.23	942.85	1986.67a	2083.59a	638.40a	899.91a

The figure in a column bearing the same letter(s) do not differ significantly at 0.05 level.

REFERENCES

BARC. 1989. Bangladesh Agricultural Research council (BARC). Fertilizer Recommendation Guide. BARC Soils Publication No. 32. P.41

Rice, E.L. 1979. Allelopathy-an update. Bot. Rev. 45: 15-109.

Rizvi, S.J.H. and Rizvi, V. 1984. Allelopathy a new strategy in weed control. Proc. of the First Tropical weed Sci. Conf. Vol. II. PP.: 393-400.

Satoh, M., Y. Usami and H. Koizumi. 1989. Allelopathic effect of *Chenopodium album* and several plant species incorporated into medium. Weed Res. 34(4): 285-291.

Whittaker, R.H. 1970. The biochemical ecology of higher plants. *In* chemical Ecology. *Eds*. E. Sondheimer and J.G. Simeone. Academic Press. new York. P. 336.

Environmental Weeds - the next Global Invasion

J T Swarbrick*
Weed Science Consultancy
Toowoomba, Queensland, Australia

Abstract. Environmental weeds are plants which invade areas set aside for the conservation of native vegetation and its associated fauna and cultural heritage. Usually introduced into the area (often as ornamentals), successful environmental weeds thrive in suitable environments when freed from their co-evolved biological controls. They often dominate the local vegetation and destroy the processes necessary for its survival, leading to exotic vegetational complexes and loss of local fauna and cultural value. Environmental weed invasion is happening throughout the world, but is only noticed when communities place a value on their natural vegetation and its associated fauna and cultural heritage. A study of environmental weeds throughout Australia shows that over a thousand species have invaded nearly every disturbed and undisturbed habitat. Conclusions are drawn on the implications of this global invasion for other Asian-Pacific countries.

Key words: natural environment, weed, invasion, global.

Introduction

Environmental weeds are plants which invade and become a nuisance in areas set aside for the conservation of the natural environment, eg National Parks and other national, state and local reserves. Environmental weeds are usually not local to the area, but have been introduced into it either from other countries or from other parts of the same country. They may have been deliberately introduced as ornamentals, crops, pastures or forest trees, or accidentally introduced either through human error or carelessness.

There are three possible fates for an introduced plant - it may fail to naturalise, it may naturalise but remain local and in small numbers, or it may naturalise, multiply, and spread outwards from the point of introduction. It is the latter group which tend to become environmental weeds.

The extent to which an introduced plant naturalises and spreads depends on the suitability of the new physical, chemical and biological environment in which it finds itself. If the physical, chemical or biological environment is unsuitable the plant is unlikely to become established or to become a weed. If some aspect of the environment is unsuitable the plant may persist until there is an environmental shift in its favour or perhaps until it evolves to meet the adverse condition. There are several good examples of weeds undergoing such a lag phase after introduction, later becoming significant environmental weeds.

A third requirement for establishment and spread of an introduced plant may be a suitable disturbance regime, which creates appropriate open niches for its establishment. However, most natural and seminatural environments are at least somewhat disturbed by natural causes and are likely to offer suitable niches for invasion of a previously well-adapted plant.

Once established in a new area, a well-adapted exotic plant may invade local natural or seminatural ecosystems. As weed scientists we are all familiar with the invasion of cropping lands by exotic weeds. Many of us, however, will be less aware of the invasion of natural ecosystems by exotic plants, and this often only comes to public attention when we begin to call these areas National Parks or to otherwise value them for their natural vegetation. Weeds which invade and establish in natural environments such as native grasslands, woodlands and forests, seashores, riverbanks, marshes and mountains are generally called environmental weeds.

Since they lack effective biological control the populations of environmental weeds often increase until they dominate the local flora, at which stage they may have very serious ecological effects. These include well known effects including competition for light, water and nutrients and allelopathy. Other effects may be more subtle, such as increasing or decreasing fire frequency or severity, denying movement to or irritating human visitors, excluding food resources to essential local pollinators or seed dispersers, increasing or decreasing mulch or soil nutrient levels until they are unsuitable for the germination or growth of native plants, interfering with some essential activity of local fauna, or degrading the heritage value of the area. Although these effects may be independent of each other, they often seem to be cumulative or synergistic and may eventually be catastrophic to the native vegetation.

Natural ecosystems are often ignored and undervalued by weed scientists, who are more interested in weeds of agricultural or other systems. Environmental weed invasion and impact may therefore go unnoticed for many years, either until it is unavoidably obvious or until the area becomes valued for its natural vegetation, perhaps as a National Park or other conservation area promoted to international tourists. The extensive invasions of pond apple (*Annona glabra* L.) in the freshwater and saline mangrove swamps of northern Queensland went almost unnoticed for decades until they became part of a World Heritage Area, since when their ability to shade out local herbs and shrubs and seriously reduce natural fire regimes and the regeneration of native trees has led to research and expensive efforts at control (Swarbrick 1993).

There are many good examples of serious degradation of native ecosystems throughout the world caused by the invasion and unchecked proliferation of environmental weeds. Such impacts and invasions are particularly well documented in Australia, which is fortunate in being a single continental country and in having a high level of research and publication on environmental weeds and their effects. Humphries et al (1991) have surveyed the extent and impact of environmental weeds on Australian ecosystems, whilst Swarbrick and Skarratt (1994) have produced what is perhaps the only national or continental database of environmental weeds.

The Australian experience

Humphries et al. (1991) conducted a review of the introduced terrestrial and aquatic plants which have invaded Australian natural ecosystems, including those that have been transposed from one area of Australia to another. They found that broadscale infestations of single species appear to be characteristic of the relatively undisturbed ecosystems of northern Australia, whilst multispecies invasions are more common in the relatively fragmented ecosystems in the southern half of the continent. Riparian ecosystems are at particular risk throughout the continent.

Eighteen species of invasive weeds are considered by these authors to be capable of totally and permanently modifying the natural ecosystems which they invade. Six of these are trees or shrubs, 6 are perennial grasses, 3 are herbaceous or woody vines, 2 are floating freshwater herbs and 1 is a marine alga. All are exotic to Australia.

Humphries et al. considered that the regeneration of native vegetation is seriously threatened by competition from exotic plants, that new introductions and current land management practices are continuously increasing the problem, that control of most exotic species is only partially or locally successful, and that the conservation impact of environmental weeds is insufficiently appreciated by the Australian public and decision makers.

In 1994 Swarbrick and Skarratt produced the second edition of a national database on Australian environmental weeds and their control. It lists over 1000 species of plants which are considered to be invasive of a very wide range of natural ecosystems, including deserts, grasslands, shrublands, woodlands and forests, rocky areas and riparian and littoral situations. Information is given on their areas of origin, probable reasons for human dispersal, biology, geographic distribution as environmental weeds, the ecosystems that they have invaded, and the methods known to be available for their control in natural and seminatural environments. All entries are referenced to a list of over 400 entries.

Regional implications

It is reasonable to assume that the processes which are at work in Australia are also at work in most other countries of the region, though with national variations.

The two factors which do most to promote environmental weed invasion are the importation and widespread growth of exotic plants and serious human disturbance of natural ecosystems. The first of these provides plants which are less likely to be controlled by existing native biocontrol agents, and the second provides niches for their invasion and naturalisation.

Throughout our history there has been a significant importation of ornamental, pasture, crop and other potentially useful plants into Australia, as well as a significant but largely accidental importation of known weeds and invasive plants. Significant but probably lower levels of importation must have existed into most of the other countries of the Asian-Pacific region. How many of these plants have become naturalised? How widespread are they now? Which natural and seminatural ecosystems have they invaded, to what extent, and with what consequences?

Rising human populations throughout our region are putting increasing pressures on the remaining native vegetation for timber, pasture, cropland, fuel wood, living space, domestic and overseas tourism and transport corridors. These pressures both cause disturbance of the natural ecosystem and provide opportunities for weed seeds to invade previously inaccessible and undisturbed ecosystems. I suspect that significant invasion of these areas is already underway in many if not most countries throughout the region, even if it is not yet recognised. Preliminary surveys of mainly agricultural and horticultural weeds for the South Pacific Commission (Swarbrick 1998, 1989) suggest that this is so.

The future implications of environmental weed invasion will vary throughout the Asian-Pacific region, but will only become obvious as countries begin the recognise and develop the values of their remaining areas of native vegetation. The most likely of these values to be recognised is international ecotourism, currently of significant potential value to a number of southeast Asian countries. To what extent will the value of this industry be degraded by environmental weeds?

The author would be pleased to know of and co-operate in any national or regional research into the invasion and impact of environmental weeds within the Asian-Pacific region, and particularly in Southeast Asia.

References

Humphries S E, Groves R H and Mitchell D S (1991). Plant Invasions of Australian Ecosystems. A Status Review and Management Directions. Kowarri 2.

Swarbrick J T (1988, 1989). Weeds of the Tropical South Pacific. Reports to the South Pacific Commission. South Pacific Commission, Suva, Fiji. Unpublished reports.

Swarbrick J T (1993). Pond apple (*Annona glabra*) - a new and aggressive weed of wetlands in tropical Queensland. Proceedings 10th Australian & 14th Asian-Pacific Weeds Conference, Brisbane 2: 148.

Swarbrick J T and Skarratt D B (1994). The BUSHWEED 2 Database of Environmental Weeds in Australia. The University of Queensland Gatton College, Gatton, Queensland, Australia.

NOXIOUS WEEDS AND THEIR CONTROL IN BRAZIL

Edivaldo Domingues **VELINI**[1]
Dagoberto **MARTINS**[1]
Kiyoshi **KOJIMA**[2]

[1] Faculdade de Ciências Agronômicas - Universidade Estadual Paulista. Botucatu - SP - Brazil.
[2] Kyushu National Agricultural Experimental Station. Chikugo, Fukuoka, Japan.

Abstract: In Brazil, the most important annual and perennial crops are soybean, sugarcane, rice, corn, pastures, coffee, forestry and citrus (mainly orange). In **soybean**, besides *Brachiaria plantaginea* and *Bidens pilosa* that are important weeds spread all over production regions, some other species like *Euphorbia heterophylla*, *Desmodium tortuosum*, *Senna obtusifolia* and *Hyptis suaveolens* have been selected by continuous use of herbicides. In **sugarcane**, *Digitaria horizontalis* used to be the only species with great importance. As a result of herbicide selection, introduction of the crop into traditional pastures and characteristics of production systems, *Brachiaria decumbens*, *Panicum maximum*, *Cynodon dactylon* and *Cyperus rotundus* have become important weeds with very difficult control. In almost all **rice** fields, weedy types of rice (*Oryza sativa* with red pericarp and normal or black glumes) are a constant problem contaminating and reducing the value of the harvested grains, whereas yield decrease is mainly due to *Echinochloa colonum*, *Echinochloa crussgalli* and *Aeschynomene* spp. Although herbicide utilization is a normal practice in modern **corn** fields, the most of the Brazilian production comes from small farms where generally the weeds are controlled by hand or machine cultivation. Although many weeds can be important in corn fields, *Brachiaria plantaginea* is considered the main one. In **perennial crops**, there are various control systems such as hand, mechanical, chemical and integrated ones, which lead to a great diversity of weed flora. In **pastures** and **citrus** orchards, *Vernonia* spp and *Brachiaria* spp can be pointed out as major weeds, respectively. The most important **herbicides** for the mentioned crops are listed as follows. Soybean: bentazon, chlorimuron-ethyl, fomesafen, imazaquin, metolachlor, metribuzin, sethoxydim and trifluralin. Sugarcane: ametryn, 2,4-D, diuron, hexazinone and tebutiuron. Rice: 2,4-D, molinate, oxadiazon and propanil. Corn: atrazine, metolachlor and simazine. Pastures: 2,4-D + picloran. Forestry: glyphosate and oxyfluorfen.

Key words: Brazil, weeds, weed control.

INTRODUCTION

The total area of Brazil is more than 8,5 million km², covering a wide range of latitudes. As a result, several crops can be cultivated and different production systems are used in different regions.

Some crops like soybean, cassava, beans, forestry, pastures and corn are cultivated almost all over the country. Rice is produced mainly in the south. The most of sugarcane (for sugar and alcohol) and orange is produced in São Paulo State. High yielding coffee orchards are restricted to areas were high altitudes can promote stable temperatures around 22°C, with no risk of frost. Cocoa is produced mostly in northeast States.

As a result of crop and climate diversity, there is a large number of weed species. The main weeds of brazil have been listed and described by Lorenzi(1991), Kissman (1991), Kissman & Groth (1992), Lorenzi et al. (1994), Kissman & Groth (1995). These authors point a total of about 500 important species and, in general, *Cyperus rotundus* (L.) and *Brachiaria plantaginea* (Link) Hitchc. are considered the most important perennial and annual ones, respectively.

Different weed control practices are used in different regions and crops. Herbicides are used in almost 100% of soybean and sugarcane area. Hand weeding is yet an important practice in forestry. Mechanical and hand control are common is small corn fields.

Not only crops but also industrial and urban areas, roads and railways are infested by weeds. In Brazil, aquatic weeds are becoming more important every year, as they can spread and grow vigorously in dumps made for electricity generation, causing several problems.

In Brazil, precise statistics about costs of weed control and herbicide consumption, for each crop and compound, are not available. Publications about the importance of major weeds in each crop and region are not available either. So, the most of the informations presented in this paper are personal experiences.

CONSUMPTION OF HERBICIDES

Data about total consumption of pesticides and herbicides (for main crops) are presented in Figures 1 and 2. In decreasing order, soybean, sugarcane, corn and rice are the most important herbicide markets. At present time, herbicides are responsible for over 50% of total pesticide sales in Brazil. Statistics about hand and mechanical weeding are not available.

Glyphosate is sold in highest total volume, but imazaquin is the first in sales value. Also trifluralin, the first widespread herbicide in Brazil, is still very important as the less expensive option for the control of grass-weeds in broadleaf crops.

The prices of glyphosate drooped from US$ 25 to US$ 7 in ten years. Now, weed control systems based on this herbicide became very inexpensive and are under use or development for several markets, like forestry, citrus and coffee orchards, non-crop areas and aquatic weeds. This herbicide has high efficiency against grass weeds, but, at normal rates it fails to control some broadleaf weeds like *Ipomoea* spp and *Commelina benghalensis* L., promoting fast weed shift if continuously used.

MAJOR WEEDS IN SOYBEAN AND THEIR CONTROL

Brachiaria plantaginea and *Bidens pilosa* L. are important weeds spread over all production regions in Brazil, but some other weeds can be important depending on the

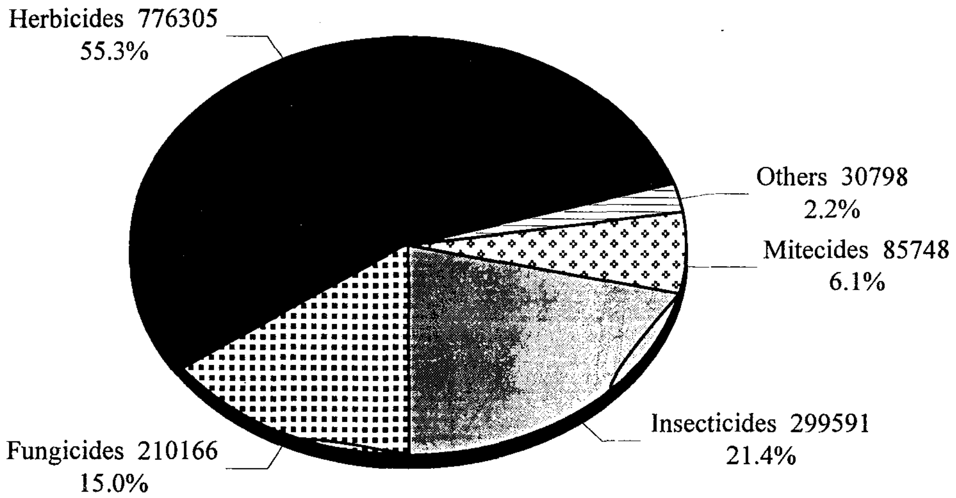

Figure 1 - Distribution and values (US$) of pesticide sales in Brazil in 1994 (From SINDAG - Sindicato das Indústrias de Defensivos Agrícolas).

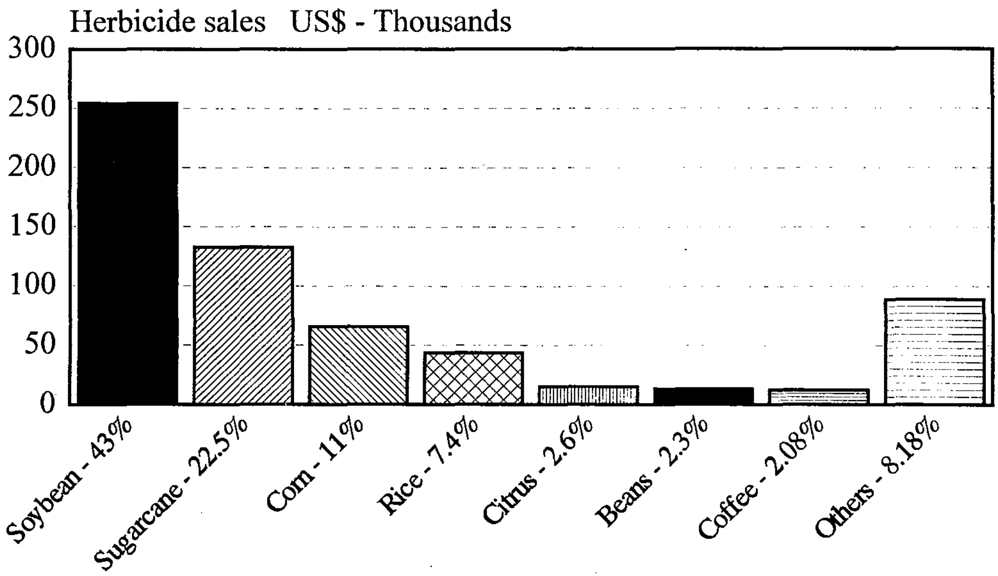

Figure 2 - Distribution and values of herbicide sales in Brazil in 1994 (From SINDAG - Sindicato das Indústrias de Defensivos Agrícolas).

location. In the center of the country, *Hyptis suaveolens* (L.) Poit. is an important broadleaf weed. In the south, mainly in Paraná State, *Euphorbia heterophylla* (L.) was selected by the continuous use of herbicides like metribuzin and bentazon, ineffective on its control; for several years, these two herbicides were the only two options for the control of broadleaf weeds in soybean. *Senna obtusifolia* (L.) Irwin & Barneby, *Acanthospermum australe* (Loefl.) Kuntze, *Acanthospermum hispidum* DC. and *Desmodium tortuosum* (Sw.) DC. are other major weeds with quite difficult control in soybeans. Sedges have limited importance in this crop. The total area infested with *Commelina benghalensis* is increasing.

In the case of *D. tortuosum*, high populations are correlated to the use of some herbicides, but also to low seeding rates, a normal practice in some regions. Melhorança (1994) has shown that normal seeding rates can decrease the growth of this species in more than 65% when compared to low seeding rates.

None of the herbicides registered for use in soybean fields can give good control of all mentioned species. If any compound is continuously used, for sure weed shift will happen. For example, imazaquin has high efficiency against *E. heterophylla*, the main lack of several other herbicides, but has poor control of *D. tortuosum, S. obtusifolia* and *A. hispidum*; Metribuzin can control *D. tortuosum* but has low efficiency for *S. obtusifolia, E. heterophylla, A. australe* and *A. hispidum.*

There are several options to control grass weeds in soybeans. Trifluralin (several trade names) and sethoxydim are the most important pre and post-emergence grass herbicides, respectively. Metolachlor and fluazifop-ρ-butyl are also major compounds for grass control.

Imazaquin is the main herbicide for the control of broadleaf weeds. It is selective to soybean in any type of soil and, as mentioned, effective to control *Euphorbia heterophylla*, a lack of almost all other compounds. For the same purpose, bentazon, chlorimuron-ethyl, fomesafen and metribuzin are also important herbicides. In the case of no tillage-areas, glyphosate and paraquat are used as total action herbicides.

Precise informations are not available, but probably harvesting machines are the most efficient and important vehicles for spreading weed seeds within the same soybean field and to other farms or even regions. Renting harvesters is a normal practice, nevertheless, no special care is taken for cleaning them after ending the work in each field or farm.

MAJOR WEEDS IN SUGARCANE AND THEIR CONTROL

In sugarcane, *Digitaria horizontalis* Willd. used to be the only species with great importance. As a result of herbicide selection and absence of care in cleaning machines used for soil preparation, *Cyperus rotundus* and *Cynodon dactylon* (L.) Pers. are widespread in sugarcane fields now. Both species can promote severe reductions in sugarcane tillering and yield. In the case of *C. rotundus*, the effects have been attributed to allelopathic compounds.

The control of *C. rotundus* is generally done by spraying 2,4-D or glyphosate (directed to the sedges). Imazapyr have been also used in low dosages. Two new compounds, sulfentrazone and halosulfuron, can control *C. rotundus* selectively to sugarcane, but both compounds are yet under development.

The total sugarcane area highly infested with *C. rotundus* is over 700,000 ha. In the case of high populations (more than 1,000 sprouts / m^2), yield reduction is over 30%. In total, yield decrease due to purple nutsedge, in absence of control, would be similar to sugarcane production in Australia.

In the last 20 years, the total area cultivated with sugarcane increased a lot to support alcohol consumption by cars. The crop was introduced in traditional pasture areas. As a result, *Brachiaria decumbens* Stapf and *Panicum maximum* Jacq. became major weeds in sugarcane.

The most important herbicides for sugarcane are ametryn, 2,4-D, diuron, hexazinone, tebuthiuron. Ametryn and diuron are considered major compounds due to high selectivity and efficiency, low prices and combined pre and post-emergence action.

MAJOR WEEDS IN CORN AND THEIR CONTROL

Brachiaria plantaginea is considered the main weed in corn fields in Brazil. This species is a annual grass with vigorous growth and high production of seeds. In some areas the populations are over 2,000 plants / m^2 and yield reductions can be observed even in fields treated with very effective herbicides.

Other important species are *Sida* spp, *Impomoea* spp, *Bidens pilosa, Cyperus rotundus* and *Commelina benghalensis*. In the case of *Ipomoea* spp, and also other convolvulaceae, besides competitive effects, they can reduce the efficiency of harvesting machines.

Although herbicide utilization is a normal practice in modern corn fields, an important part of Brazilian production comes from small farms where generally weeds are controlled by hand or mechanical cultivation. In some areas, inexpensive herbicides are combined with other practices.

Atrazine, metolachlor and simazine are major herbicides in corn. The most of the fields are treated with the mixtures atrazine+metolachlor and atrazine+simazine. Atrazine is a key compound because it is selective, has low price and combines actions in pre and early post-emergence. EPTC is also an important herbicide as it can control purple nutsedge; selectivity to corn is due to the safener 2,2,5-trimethyl-3-(dichloroacethyl)-1,3-oxazolidine.

MAJOR WEEDS IN RICE AND THEIR CONTROL

In Brazil, wet seeded and dry seeded are the prevalent paddy-field rice production systems. As a result, weedy types of rice (*Oryza sativa* L., with red pericarp and normal or black glumes) are a constant problem, contaminating and reducing the quality of harvested grains, whereas yield decrease is mainly due to *Echinochloa colonum* (L.) Link, *Echinochloa crussgalli* (L.) Beauv. and *Aeschynomene* spp.

The control of weedy types of rice in rice fields is a great challenge for Brazilian weed scientists. Up to now, crop rotation and glyphosate based systems have been the most successful, but used by a few farmers, only. In the case of glyphosate system, after preparation, soil is wetted and its surface is slightly compacted promoting the germination of weedy rice; some days later, glyphosate is applied and cultivated rice is seeded.

The main herbicides for rice are 2,4-D, molinate, oxadiazon and propanil. Two other important compounds are clomazone and pirazosulfuron-ethyl. Clomazone can promote good control of grasses, and at rice rates (~0.5 kg i.a./ha) it is one of the most inexpensive herbicides registered for this crop. Pirazosulfuron-ethyl can promote good control of sedges.

MAJOR WEEDS IN PERENNIAL CROPS AND THEIR CONTROL

Citrus, coffee, pastures and forestry are the main perennial crops. In **citrus and coffee** orchards there are several weed control systems such as hand, mechanical, chemical and integrated ones, which leads to a great diversity of weed flora and makes difficult to point out major weeds for both crops. Anyway, in coffee orchards, *Amaranthus* spp, *Commelina benghalensis*, *Portulaca oleracea* L., *Digitaria horizontalis*, *Bidens pilosa* and *Brachiaria plantaginea* can be considered major weeds and glyphosate, oxyfluorfen and paraquat are the most important herbicides. In citrus orchards *Brachiaria* spp are prevalent species and diuron, glyphosate and paraquat are the three widest used herbicides.

In **pastures**, *Vernonia* spp are the main species. Hand and mechanical are prevalent weed control methods. The mixture 2,4-D+picloran is the most important herbicide; it is applied by knapsack sprayers, tractor mounted boom sprayers or airplanes.

The consumption of herbicides in **forestry** is very small when compared to soybean or sugarcane, but this does not mean weeds are not important at all. In many fields, weeds are controlled by hand or machines. *Eucalyptus* spp and *Pinus* spp are cultivated in almost 100% of total forestry area. *Eucalyptus* spp grows vigorously in early stages and the control of weeds is necessary only in the first year after planting. *Pinus* spp has very slow early growth and weed control practices most last up to three years after planting. Hand weed control can cost up to US$ 360 / ha and US$ 900 / ha in *Eucalyptus* and *Pinus*, respectively. The major weeds are *Melinis minutiflora* Beauv., *Brachiaria decumbens* and *Imperata brasiliensis* Trin. Strong allelopahic effects of *B. decumbens* on *Eucalyptus grandis*, the most important *Eucalyptus* species in Brazil, have been reported by Souza et al. (1993), Souza (1994) and Souza et al. (1995).

The main herbicides for forestry are glyphosate and oxyfluorfen. Glyphosate most be applied on a selective way as it can damage *Eucalyptus* and *Pinus* species. Oxyfluorfen is selective to *Pinus* and to *Eucalyptus* species with non hairy leaves. Now, the most of the farmers are changing from traditional production system with soil preparation at each crop cycle (~7 and ~20 years for *Eucalyptus* and *Pinus*, respectively) towards no-tillage system.

In this new system, planting is done by hand. Weeds are controlled prior to crop planting by glyphosate application. A thick layer of plant materials will remain on soil surface making almost impossible to use oxyfluorfen. In this system, glyphosate has been the only option for chemical weed control, but it is very difficult to apply it safety in early stages of the crops; many times weeds in the rows have to be controlled by hand. Weed shift can also occur and is common in *Pinus* areas, where applications most be done continuously for three years.

Up to now, there is a lack of selective and effective herbicides for no-tillage production system in forestry, making necessary the use of expensive hand weeding practices.

MAJOR WEEDS IN NON-CROP AREAS AND THEIR CONTROL

In **urban and industrial areas**, *Eleusine indica* (L.) Gaertn., *Digitaria horizontalis*, *Brachiaria decumbens*, *Cynodon dactylon*, *Panicum maximum* and *Cyperus rotundus* are major species. Generally the control is very expensive and done by hand weeding. In some cases, mainly in industrial areas, herbicides like glyphosate, imazapyr, diuron or bromacil+diuron are used.

In **roads and railways**, the most important species are *Panicum maximum*, *Brachiaria plantaginea*, *Melinis minutiflora*, *Digitaria horizontalis*, *Digitaria insularis* (L.) Mez ex Ekman, *Rynchelytrum repens* (willd.) Hubbart and *Bacharis* spp. In roads weed control is generally done by hand. In railways, chemical control is predominant; because of low price and environmental safety, glyphosate is the widest used herbicide.

In the more developed regions of Brazil, almost 100% of electricity is produced by water turbines. This requires the building of big dumps; over 30,000 ha of water surface is a normal size. As a result, **aquatic weeds** became an important problem in several regions of the country.

The major species are *Eichornia crassipes* (Mart.) Solms, *Pontederia cordata* L., *Pistia stratiotis* L., *Thypha angustipholia* L. and *Egeria densa* Planch. They can cause great problems to navigation, water use for irrigation and human consumption, amusement activities, and electricity generation. Control practices efficient against aquatic weeds and safe to environment are not available up to now, and must be developed in a very near future.

THE MOST IMPORTANT CHALLENGES TO WEED SCIENTISTS IN BRAZIL

- Control of weedy types of rice in rice fields
- Control of *Cyperus rotundus* and *Cynodon dactylon* in sugarcane
- To avoid weed shift in fields continuously cultivated with soybean
- Development of efficient and selective herbicides for no-tillage production system in forestry
- Development of control systems effective against aquatic weeds and safe to environment
- Evaluation and prevention of herbicide accumulation in soil and environment

REFERENCES

KISSMAN, K. G. Plantas Infestantes e Nocivas. Vol. 1. Basf, São Paulo - SP - Brazil, 1991. 608 p.

KISSMAN, K. G & GROTH, D. Plantas Infestantes e Nocivas. Vol. 2. Basf, São Paulo - SP - Brazil, 1992. 798 p.

KISSMAN, K. G & GROTH, D. Plantas Infestantes e Nocivas. Vol. 3. Basf, São Paulo - SP - Brazil, 1995. 683 p.

LORENZI, H. Plantas Daninhas do Brasil. Author's edition, Nova Odessa - SP - Brazil, 1994. 299 p.

LORENZI, H., PELISSARI, A., SILVA, A. A. et al. Manual de Identificação e Controle de Plantas Daninhas. Plantarum, Nova Odessa - SP - Brazil, 1994. 299 p.

MELHORANÇA, A. L. **Interferência entre plantas de *Desmodium tortuosum* (SW.) DC. e *Glycine max* (L.) Merrill**. Botucatu: FCA / UNESP, 1994. 94p. (PhD Thesis).

SOUZA, L. S., VELINI, E. D. & MAIMONI-RODELLA, R. C. S. Avaliação do efeito alelopático de 18 espécies de plantas daninhas sobre o crescimento inicial de *Eucalyptus grandis*. In: CONGRESSO BRASILEIRO DE HERBICIDAS E PLANTAS DANINHAS, XIX, Londrina, 1993. Proceedings ... Londrina: SBHED, 1993. p. 27-28.

SOUZA, L. S. **Avaliação de possíveis efeitos alelopáticos de diversas espécies de plantas daninhas sobre o crescimento inicial de eucalipto *Eucalyptus grandis* (*Eucalyptus grandis* Hill ex Maiden)**. Botucatu: FCA / UNESP, 1994. 120 p. (Ms. Thesis).

SOUZA, L. S., VELINI, E. D. & MAIMONI-RODELLA, R. C. S. Avaliação dos efeitos de proporções crescentes de Brachiaria decumbens Stapf sobre o desenvolvimento inicial de eucalipto (*Eucalyptus grandis* Hill ex Maiden). In: CONGRESSO BRASILEIRO DE HERBICIDAS E PLANTAS DANINHAS, XX, Florianópolis, 1995. Proceedings ... Florianópolis: SBHED, 1995. p. 27-28.

The significance of weeds in rural landscapes

J.Mitchley and M. Nemoto

Environment Section, Wye College, University of London, Ashford, Kent TN25 5AH, UK and National Institute of Agro-Environmental Sciences, Kannondai, Tsukuba, Ibaraki 305, Japan.

Abstract. The definition of a weed is very subjective and depends on the individual viewpoint and on value judgements; one person's weed is another's wildlife species or unit of biodiversity. We define a weed very broadly as any non crop plant in the agroecosystem. We distinguish between weeds that are actually or potentially damaging to human welfare and term these "undesirable species". However, many so-called "weeds" have value from wildlife conservation or amenity viewpoints and these we term "desirable species". Traditional rural landscapes frequently harbour a rich diversity of desirable species (as well as undesirable ones!) maintained by low intensity agricultural practices. Unfortunately, the intensive agricultural systems which have developed in the mid-late 20th century have resulted in reduction of biodiversity in the agroecosystem and the rural landscape. Losses of habitat, species and amenity have been severe and thus opportunities for reintroducing desirable species to the rural landscape must now be encouraged through appropriate, targeted agro-environmental policies. Even quite crude policy instruments such as the set-aside scheme (the subsidised rotational or semi-permanent abandonment of arable land) currently operating throughout the European Union can result in biodiversity enhancement and some general techniques and for biodiversity enhancement in rural landscape are proposed.

Introduction

The plants that occur in rural landscapes include native wild plants as well as exotic introductions, aliens and naturalised species. Humans tend to apply value judgements to these species, some are labelled as noxious weeds while others are treasured for their aesthetic, rarity or even economic value. A broad definition of a weed is any non-crop plant in the agroecosystem, though it may be argued that weeds include only those plants which are actually or potentially harmful to crop yields or some other economic measure. As attention is increasingly paid to environmental protection, which must include biodiversity conservation, we believe it is more than ever important to distinguish those plants which are actually or potentially harmful to human welfare from those that are neutral (harmless) or even beneficial (desirable). By first classifying non-crop plants in this way, effort can be directed more efficiently towards eradication of the undesirable together with conservation of the desirable. To highlight some of the key issues surrounding non-crop plants in the rural landscape this paper develops four inter-related points:

- Defining weeds in the rural landscape
- Classification of weeds: desirable and undesirable species
- Status of desirable species in the rural landscape
- Techniques for reintroducing desirable species into the rural landscape

Defining weeds in the rural landscape: a question of viewpoint

Usually, our definition of weeds and our assessment of their impact depends on a series of value judgements relating to our particular preoccupations, which may be agricultural, ecological, conservation or amenity. The agriculturalist is most frequently concerned with the impact of weeds on crop yield and his attention is focused on eradication of undesirable species. However weeds also compete with other weeds and the presence of certain weeds may result in overall benefits in terms of crop yield and ecological control of the more pernicious weeds (Nemoto & Mitchley 1995). The ecologist is often concerned with total biodiversity in the landscape and may seek to enhance biodiversity of the agroecosystem through practices which favour the desirable species while at the same time controlling the undesirable ones (Burch *et al* 1995). The conservationist, on the other hand, may be primarily concerned with the impact of "environmental weeds" in natural and semi-natural ecosystems and protected areas. Finally, in amenity horticulture a wide range of desirable species ("wild flowers") are often employed in naturalistic landscape planting (Asai *et al.* 1995; Burch *et al.* 1995; Kondo 1995).

Classification of weeds: desirable and undesirable species

As we have noted, the definition of weeds in the landscape depends as much on our particular values and perspective as on the actual nature and impact of the plant species concerned. Putting aside for the moment the problem of defining exactly what is meant by the term weed, we can certainly identify a number of plant characteristics which may determine whether a plant is likely to be a noxious weed (undesirable) or a beneficial species (desirable; see Table 1).

Feature	Undesirable species	Desirable species
Competitive ability	High	Low
Growth rate	High	Low
Growth form	Tall-growing	Short-growing
Phenotypic plasticity	High	Low
Flowering	Early	Late
Germination	Easy	Difficult
Seed production	Prolific	Sparse
Dispersal (space and time)	Wide	Limited
Origin	Alien/introduced	Native
Landscape status	Common	Uncommon/rare
Utilitarian status	Harmful	Valuable

Table 1. Characteristics of non-crop plants ("weeds") in the agroecosystem

While we may be able to recognise suites of desirable and undesirable species by their particular combination of characteristics, the situation is far from straight forward. For example, although high competitive ability as often a feature of successful weeds (as well as successful crops!), there are cases when such a characteristic is also a feature of desirable species. An example here is the use of the tall-growing, rhizomatous grass weed *Imperata cylindrica* for the stabilisation of river embankment slopes (Asami *et al.* 1995). Nemoto and Mitchley (1995) argue that plant growth form provides an ecological basis for classifying weeds into desirable and undesirable species. Their analysis of tall-growing and short-growing weeds in the agroecosystem concludes that, while tall-growing weeds will very often provide serious obstruction to crop yield or amenity, short-growing weeds may actually compete with the tall-growing weeds and provide actual economic benefits or at least contribute to agroecosystem biodiversity and conservation or amenity value.

Desirable plant species in the rural landscape

The agroecosytem is a dynamic system comprising crop-producing areas within a matrix of marginal, buffer and connecting areas (e.g. ditches, hedgerows, banks, tracks and adjacent natural and blocks of semi-natural habitat). In the latter half of this century, intensive agriculture has resulted in often quite severe degradation of these components, e.g. water pollution and loss of biodiversity and amenity (Green 1990). In the UK the majority of wildlife habitat is semi-natural, i.e. derived from and maintained by human interference; cropping, grazing, mowing etc. Changes in agricultural practices this century, notably increased field size and increased use of chemical fertilisers, herbicides and pesticides, have resulted in significant losses of both habitat and species within these semi-natural areas. For example, in southern England, the chalk escarpment of the North Downs around Wye College in Kent, is designated an "Area of Outstanding Natural Beauty" and includes habitats rich in native plant and animal species. The pastures which occur on the steep slopes of these escarpments, locally termed chalk grassland, comprise a species-rich biotope of high wildlife and amenity value (Hillier *et al.* 1990). These chalk grasslands have been maintained through centuries of grazing management by domestic sheep and cattle and wild rabbits. The maintenance of high species richness depends upon continued grazing management and maintenance of low substrate fertility, both of which favour short-growing broad leaved herbaceous species over taller, more competitive grasses. Both removal of grazing and application of fertilisers results in rapid growth of grasses and reduced diversity. At least 80% of these grasslands have been lost or significantly damaged since the 1940s and wildlife conservation efforts in the UK currently aim to restore appropriate management intervention, for example by reintroducing grazing animals to derelict sites.

Another option for redressing habitat loss is through natural regeneration of chalk grasslands on ex-arable land on suitable soils. Recently such opportunities have arisen as a consequence of the so-called "set-aside" scheme. Set-aside is one of many agro-environmental policy measures introduced as part of the Common Agricultural Policy of the European Union (Clarke 1992). The set-aside scheme was introduced into Britain in 1988 as part of an EU initiative to reduce large surpluses of arable crops and pays farmers to take 15-18% of their arable land out of production on a rotational (1 year) or semi-permanent (5-20 year) basis. There are a number of rules which must be followed by the farmer, for example he must establish a green cover on the land by natural regeneration or by sowing a grass cover and the vegetation must be cut at least once a year to control pernicious weeds. Set-aside is a controversial policy, not least because a common perception of the scheme is that farmers are paid for doing nothing with their land. Nonetheless, set-aside now represents a major land use in Europe. In fact, land abandonment, whether government subsidised or not, is an increasing feature in a wide range of countries throughout the world, including , for example , Japan (Ohkuro *et al.* 1995). Much of this abandoned arable land could provide suitable areas for re-establishment of semi-natural wildlife habitat and therefore set-aside, and related policies, provides the potential for biodiversity enhancement in the rural landscape which represents a major environmental benefit of the scheme.

Techniques for reintroducing desirable species into the rural landscape

Vegetation will spontaneously develop on ex-arable land through the processes of secondary succession, but it is often possible and even desirable to direct the rate and direction of succession through appropriate management practices. At Wye we have carried out large-scale field experiments on set-aside land to investigate the establishment and management of species-rich grassland biotopes on ex-arable land (Table 2).

North Sidelands 1 (1988)	**North Sidelands 2 (1993)**	**Brookwood (1994)**
• Shallow calcareous rendzina soil, previous crop oil seed rape • Sown commercial wild flower seed mixture (30 species) • Sown *Lolium perenne* grass cover • Natural regeneration after ploughing (oil seed rape) • +/- nitrogen fertiliser • +/- annual cutting	Rendzina soil, previous crop barley • Sown *Lolium perenne* grass cover • Sown *Festuca rubra* grass cover • Sown *Cynosurus cristatus* grass cover • Natural regeneration after ploughing • Natural regeneration from stubble (barley) • +/- additional weed seeds sown • +/- sown desirable grassland species	Clay soil, previous crop field beans • Sown *Lolium perenne* grass cover • Sown amenity grass seed mixture • Natural regeneration from stubble (beans) • +/- annual cutting

Table 2. The range of treatments studied in experiments on vegetation establishment on set-aside land at Wye College

The longest running experiment was set up in 1988, the first year of set-aside in the UK. Our experiment included three sward treatments , two cutting treatments and two fertiliser treatments. The species composition of the plots was recorded in detail in 1991 and again in 1995. Table 3 provides some results seven years after the start of the experiment and illustrates the importance of cutting management and of low substrate fertility for biodiversity enhancement.

Sward treatment	**No cut** **No Nitrogen**	**Cut** **No Nitrogen**	**No Cut** **Nitrogen**	**Cut** **Nitrogen**
Wildflower mix	7.2	11.5	4.5	9.4
Natural regeneration	5.2	9.1	3.4	5.1
Ryegrass	4.7	9.5	2.8	5.3

Table 3. Mean number of species recorded per 20 x 20 cm quadrat in the North Sidelands set-aside experiment in summer 1995 (mean values derived from four replicate blocks each with twenty quadrats per treatment).

A further experiment was commenced in 1993 to investigate establishment methods in more detail, this was monitored in 1994 and 1995 (Burch *et al* 1995). Most recently an experiment was set up in 1994 to widen the range of biotopes studied to include development of woodland and damp lowland grassland.

The results from these experiments to date suggest the following broad guidelines for biodiversity enhancement on set-aside land. We believe that these principles may find general validity for biodiversity enhancement on abandoned agricultural land over a wide geographical area in the world.

- The proximity of set-aside land to existing semi-natural habitats is of vital significance in determining the colonisation by desirable and undesirable species
- Where establishment of desirable species is problematical, e.g. due to distant sources of propagules, desirable species may be introduced by sowing seed mixtures or planting mature plants
- The establishment method used to initiate vegetation development determines colonisation by desirable species and the degree of control of undesirable species (Burch *et al* 1995)
- Cutting management increases the richness of desirable species and reduces undesirable species
- Soil fertility has the reverse effect, i.e. high fertility reduces richness of desirable species and increases undesirable species
- The above considerations taken together strongly suggest that targeting of set-aside land in terms of location, establishment method and management will maximise the potential for biodiversity enhancement and control of undesirable species.

References

Asai, K., Ito, M. & Kusanagi, T. 1995. Management of clover cover for weed suppression ina temperate region. *Abstracts of the 15th Asian Pacifiic Weed Science Society Conference* : 2.

Asami, K., Akamatsu, H. & Hattori, H. 1995. Revegetation of embankment slopes with cogongrass (*Imperata cylindrica* var. *koenigii). Proceedings of the 15th Asian Pacifiic Weed Science Society Conference* **I(A):** 406-412.

Burch, F.M., Mitchley, J. & Green, B.H. 1995. Weed communities on set-aside land in Great Britain: balancing the desirable and the undesirable. *Proceedings of the 15th Asian Pacifiic Weed Science Society Conference* **I(A):** 400-405.

Clarke, J. ed. 1992. *Set-aside*. British Crop Protection Council Monograph No 50. Farnham, UK: BCPC Publications.

Green, B.H. 1990. Agricultural intensification and the loss of habitat, species and amenity in British grasslands: a review of historical change and assessment of future prospects. *Grass and Forage Science*, **45**, 365-372.

Hillier, S.H., Walton, D.W.H. & Wells, D.A. eds. 1990. *Calcareous grasslands - ecology and management*. Huntingdon, U.K: Bluntisham Books.

Kondo, T. 1995. Germination characteristics and population management *of Aster ageratoides* subsp, *ovatus* Kitam. for landscaping with wildflowers. *Proceedings of the 15th Asian Pacifiic Weed Science Society Conference* **I(A):** 413-418.

Tjitrosemito, S. 1995. Weed management in rubber plantations with special reference to minimum tillage cultivation. *Proceedings of the 15th Asian Pacifiic Weed Science Society Conference* **I(A):** 112-123.

Ohkuro, T., Matsuo, K. & Nemoto, M. 1995. Succession of weed communities of abandoned paddy fields in mountainous regions of Japan. *Proceedings of the 15th Asian Pacifiic Weed Science Society Conference* **I(A):** 376-379.

Nemoto, M. & Mitchley, J. 1995. Weed species diversity and its conservation value. *Proceedings of the 15th Asian Pacifiic Weed Science Society Conference* **I(A):** 394-399.

THE COMPETITION EFFECT OF RICE AND BARNYARDGRASS AT VARIOUS DENSITIES UNDER TWO FERTILIZER RATES

Chaiyot Supatanakul and Paitoon Kittipong
Botany and Weed Sci. Div., Dept. of Agriculture, Bangkok 10900, Thailand

Abstract The field trial was conducted at Weed Science Sub Division, Chatuchak, Bangkok to study on the competitive effect between barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) and rice(RD.23).They were planted at various population under two rates of one basal application fertilizer(16-20-0). The studied indicated that the density of barnyardgrass increased; the transpiration rate, chlorophyll content, tiller number of rice and barnyardgrass, and rice panicle were decreased; whereas the mortality of rice and barnyardgrass was increased. Increased application of fertilizer from 187.5 to 375.0 kg/ha resulted that transpiration rate of rice and barnyardgrass increased at 30 days after planted but decreased it at 50 and 60 days after planted. Increased of rice population from 80 to 160 plants/m^2 had a tendency to reduce chlorophyll content and tiller number of both plants. Rice grain yields at 80 plants/m^2 were reduced 27.33, 50.08, 67.28 and 75.88 percent when barnyardgrass population was 20, 40, 80 and 160 plants/m^2, respectively; at rice population of 160 plants/m^2, yield was reduced 22.28, 40.73, 57.55 and 78.43 percent ,respectively. Rice grain yield was increased 10.61, 2.96, 2.45, 5.87 and 6.42 percent with increase in fertilizer. Rice grain yield rose 33.16, 40.32, 60.55, 73.42 and 26.71 percent with increasing rice population and the barnyardgrass population 0, 20, 40, 80 and 160 plants/m^2, respectively.

Keywords. barnyardgrass, rice, weed density, weed competition, transpilation.

Introduction

Barnyard grass (*Echinochloa crusgalli* L. Beauv.) is the serious weed in wet-seeded rice or pre-germinated rice. Its infestation were 54.44% of the paddy weeds in Thailand.(Anon, 1984). It was reported to be one of the 10 worst weeds in the world (Holm et al., 1977). It has strong competitive ability to absorb light and nutrients (Kleining and Noble, 1963); in paddy field it grows much quickly than rice. Barnyardgrass might have allelopathic effects on other plants, and inhibit the growth of crops (Li et al., 1992). These might be the reasons for the decreasing production of rice. Heavy infestation of barnyardgrass reduce rice yield by 50%, and also reduce the number of panicle, plant height, weight of grains and number of grain per panicle; rice yields may be reduced by 2,000 to 4,000 kg/ha (Holm et al., 1977). Grain yield of rice increased at the crop stand increased when a constant population of barnyardgrass competed with rice(Smith, 1988). In rice-density research, rice density stand by 3, 10, and 31 plants/ft^2 reduced grain yields 80, 66 and 59% respectively, in a population of 5 barnyardgrass/ft^2 (Smith, 1968). However, Barnyardgrass population increased, rice grain yields of direct-seeded or transplanted rice decreased (Noda et al, 1968; Smith, 1968). The barnyardgrass competition at densities of 1, 5 and 25 plants/ft^2 reduced grain yields of 3 rice plants/ft^2 on an average of 57,80 and 95% respectively (Smith, 1968). The weed crop competition were effected by fertilization high fertility enhanced interference of barnyardgrass at low densities compared to that grown at lower fertility (Kleining and Noble,1989), especially nitrogen, increase barnyardgrass interference (De Datta et al., 1969). This experiment was designed to deter mine effects of barnyardgrass densities with two population of rice plants at two level of basal fertilizers on plants growth and rice yield.

Materials and Methods

The experiment was conducted on Bangkhen clay soil at Weed science Sub Division, Department of Agriculture, during rainy season of 1993. Experimental field was plowed and puddling as normal, established in a split-split plot design, Seedling rice (RD.23) and barnyardgrass counted 1.0-1.5 leafstages or 4.-5 days after planted were transplanted. The barnyardgrass seedling of 0, 20, 40, 80 and 160 plants/m^2 were transplanted in sub-sub plots, sub plots were transplanted with rice seedling at 80 and 160 plants/m^2. The basal application fertilizer (16-20-0) of 187.5 and 350.0 kg/ha were applied in main plots. At panicle initiation stage of rice all plots were applied once with 125.0 kg/ha of ammonium sulfate (21%N). Weed other than barnyardgrass were removed by handweeding. Transpiration rate of rice and barnyardgrass was measured at 30 day after transplanting, determined by Li-1600 steady state porometer. Chlorophyll content was determined by Minolta, SPAD-501.

Results

Transpiration rate of rice. At 30 days after planted (Table 1) there were not significant difference (P=0.05) in transpiration rate of rice between fertilizer and between rice density treatments. However, fertilization at 375.0 kg/ha increased transpiration rate of rice by about 52.85% (on mean). The transpiration rate of rice were observed between barnyardgrass density, there were not significant difference (P=0.05) when fertilization at 182.5 kg/ha where as significant difference (P=0.05) when fertilization at 350.0 kg/ha, increasing barnyardgrass density reduced transpiration rate of rice.(Table 2).

Table 1 Effect of barnyardgrass density and fertilizer levels on transpiration rate (μg/cm^2/s) of rice at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0 kg/ha		
	rice(plants/m^2)			rice(plants/.m^2)		
(plants/m^2)	80	160	means	80	160	means
0	19.66a[1]	14.81a[1]	17.23a	29.90a[1]	31.24a[1]	30.27a
20	15.87a[1]	14.94a[1]	15.40a	22.69 b[1]	23.97 b[1]	23.33 b
40	15.31a	14.07a	14.69a	19.51 b	22.93 b	21.22 b
80	12.27a	13.61a	12.94a	16.37 b	22.42 b	19.39 b
160	12.44a	14.39a	13.42a	17.50 b	18.80 b	18.15b
means	15.11	14.36	14.74	21.19	23.87	22.53

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.

Table 2 Effect of barnyardgrass density and fertilizer levels on transpiration rate (μg/cm^2/s) of rice at 60 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
0	35.29a[1]	36.98a[1]	36.14a	35.78a[1]	34.19a[1]	34.98a
20	25.11b[1]	29.63ab[1]	27.37b	26.67ab[1]	33.70a[1]	30.18a
40	19.92b	22.12bc	21.02bc	17.59b	23.52b	20.56b
80	22.01b	16.70c	19.35c	21.16b	18.87b	20.02b
160	14.70b	14.90c	14.80c	17.50b	17.71b	17.61b
means	23.41	24.07	23.74	23.74	25.60	24.67

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.

At 60 days after planted.(Table 2) the transpiration rate of rice between fertilizer and rice density did not significant difference (P=0.05). The transpiration rate of rice between barnyardgrass density were significant difference (P=0.05).Increasing barnyardgrass density from 0, 20, 40, 80 and 100 plants/m^2 reduced transpiration of rice by about 0, 24.27, 41.84, 46.40 and 59.05% respectively when fertilization at 187.5 kg/ha, by about 0, 13.72, 41.22, 42.75 and 49.66% respectively when fertilization at 350.0 kg/ha.

Transpiration rate of barnyardgrass. There were not significant, difference (P=0.05) in transpiration rate of barnyardgrass between fertilizer, rice density and barnyardgrass density (Table 3 and 4). In this experiments, the transpiration rate of barnyardgrass lower than rice.

Table 3 Effect of barnyardgrass density and fertilizer levels on transpiration rate (μg/cm²/s) of barnyardgrass at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m²)			rice(plants/m²)		
(plants/m²)	80	160	means	80	160	means
20	7.98	12.75	10.36	13.83	12.91	13.37
40	8.66	8.96	8.81	13.54	15.68	14.61
80	8.28	8.43	8.36	13.40	13.77	13.59
160	7.59	7.69	7.64	12.14	12.97	12.55
means	8.13	9.46	8.79	13.23	13.83	13.53

Table 4 Effect of barnyardgrass density and fertilizer levels on transpiration rate (μg/cm²/s) of barnyardgrass at 60 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m²)			rice(plants/m²)		
(plants/m²)	80	160	means	80	160	means
20	15.89	16.73	16.31	15.77	15.42	15.60
40	17.17	16.19	16.68	15.85	14.39	15.12
80	16.11	17.23	16.67	16.78	15.42	16.10
160	16.97	16.68	16.83	17.20	16.34	16.77
means	16.54	16.71	16.62	16.40	15.39	15.90

Chlorophyll content of rice. There were not significant differences (P=0.05) in chlorophyll content of rice between fertilizer and rice density, but significant differences (P=0.05) in chlorophyll content were observed between barnyardgrass density (Table 5); increasing barnyardgrass density from 0, 20, 40, 80 and 160 plants/m², reduced chlorophyll content of rice at 30 days after planted by about 0, 3.77, 6.60 and 6.92% respectively when fertilization at 187.5 kg/ha, by about 0, 3.66, 6.71, 9.15 and 9.76% respectively when fertilization at 350 kg/ha. Chlorophyll content of barnyardgrass, there were not significant difference(P=0.05) in chlorophyll contents of barnyardgrass between fertilizer, rice density, and barnyardgrass density.(Table 6).

Table 5 Effect of barnyardgrass density and fertilizer levels on chlorophyll content (mg/100cm²) of rice at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m²)			rice(plants/m²)		
(plants/m²)	80	160	means	80	160	means
0	3.25a[1]	3.11a[1]	3.18a	3.36a[1]	3.19a[1]	3.28a
20	3.10ab[1]	3.02a[1]	3.06ab	3.19ab[1]	3.11ab[1]	3.15ab
40	3.12ab	3.01a	3.06ab	3.10b	3.02ab	3.06bc
80	2.98b	2.95a	2.97b	3.03b	2.93b	2.98c
160	2.98b	2.91a	2.95b	2.98b	2.95b	2.96c
means	3.08	3.00	3.04	3.13	3.04	3.09

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.

Table 6 Effect of barnyardgrass density and fertilizer levels on chlorophyll content (mg/100cm^2) of barnyardgrass at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
20	3.93	3.76	3.85	3.95	3.75	3.85
40	3.83	3.67	3.75	4.01	3.78	3.89
80	3.75	3.67	3.71	3.81	3.63	3.72
160	3.75	3.58	3.66	3.94	3.56	3.75
means	3.81[1]	3.67[1]	3.74	3.93[1]	3.68[1]	3.81

Remark

1. Two means at each fertilizer rates had LSD(5%) = 0.1727

Tiller number. There were not significant difference (P=0.05) in tiller number of rice and barnyardgrass between fertilizer, but significant difference (P=0.05) in tiller number of rice and barnyardgrass were observed between rice density and barnyardgrass density (Table 7 and 8). Increasing rice density from 80 plants/m^2 to 160 plant/m^2 reduced tiller number of rice by about 16.58% and tiller number of barnyardgrass by about 18.78% when fertilization at 350.0 kg/ha, increasing rice density from 80 plants/m^2 reduced tiller number of rice by about 21.72% and tiller number of barnyardgrass about 12.65%. Increasing barnyardgrass density from 0, 20, 40, 80, and 160 plants/m^2 reduced tiller number of rice by about 0, 14.10, 21.44, 26.87 and 31.57% respectively, when fertilization at 187.5 kg/ha, by about 0, 10.29, 21.98, 21.98 and 28.79% respectively.

Table 7 Effect of barnyardgrass density and fertilizer levels on tiller number of rice (tiller/hill) of rice at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
0	7.60a[1,3]	6.02a[1,3]	6.81a	8.53a[1,3]	5.85a[1,3]	7.19a
20	6.60ab[1]	5.10a[1]	5.85 b	7.33ab[1]	5.58a[1]	6.45ab
40	5.85 bc	4.85a	5.35 bc	6.18 bc	5.04a	5.61 bc
80	5.31 bc	4.66a	4.98 bc	5.53 c	4.79a	5.16 c
160	4.79 c	4.54a	4.66 c	5.56 c	4.68a	5.12 c
means	6.03[2]	5.03[2]	5.53	6.63[2]	5.19[2]	5.91

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.
2. Two means at each fertilizer rates had LSD(5%) = 1.770
3. Two average values at each barnyardgrass density ✳ fertilizer rates had LSD (1%) = 2.3626, LSD (5%) = 1.6707.

Mortality of rice. Rice's mortality were not significantly (P=0.05) between fertilizers. These differences were significantly different (P=0.05) between rice density and barnyardgrass density (Table 9), Increasing plants population increased mortality of plants.

Number of rice panicles. There were not significant differences (P=0.05) in number of rice panicles between fertilizers. These differences were significantly different (P=0.05) between rice density and barnyardgrass density (Table 10). Fertilization at 187.5 kg/ha, increasing rice density from 80 to 160 plants/m^2 increased panicles by about 64.57%; and 60.09% when fertilization at 350.0 kg/ha. Increasing barnyardgrass density from 0, 20, 40, 80 and 160 plants/m^2 reduced rice panicles by about 0, 20.4, 35.37, 54.84 and 72.87% respectively when fertilization at 87.5 kg/ha and 0, 18.55, 41.55, 54.59 and 74.88% when fertilization at 350.0 kg/ha.

Table 8 Effect of barnyardgrass density and fertilizer levels on tiller number of barnyardgrass (tiller/hill) at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
20	6.66a[1,3]	5.68a[1,3]	6.17a	6.78a[1,3]	5.63a[1,3]	6.21a
40	5.68ab[1]	4.49 b[1]	5.09 b	5.75ab[1]	5.12a[1]	5.44 b
80	5.37 b	4.23 b	4.80 b	5.74ab	4.93a	5.34 b
160	5.30 b	4.28 b	4.79 b	5.17 b	4.79 b	4.98 b
means	5.75[2]	4.67[2]	5.21	5.86[2]	5.12[2]	5.49

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.
2. Two means at each fertilizer rates had LSD(1%) = 0.5097, LSD(5%) = 0.3364.
3. Two average values at each barnyardgrass density ✳ fertilizer rates had LSD(5%) = 0.9385.

Table 9 Effect of barnyardgrass density and fertilizer levels on mortality of rice(%).

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
0	1.25c[1,2]	12.49d[1,2]	6.87e	0.62c[1,2]	14.06d[1,2]	7.34e
20	13.12c[1]	28.43c[1]	20.78d	9.06c[1]	25.46cd[1]	17.26d
40	35.94b	35.46c	35.70c	34.06b	37.65c	35.86c
80	56.56a	54.22b	55.39b	56.87a	52.50b	54.69b
160	68.12a	75.62a	71.87a	64.06a	75.45a	69.76a
means	35.00	41.25	38.12	32.94	41.03	36.98

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.
2. Two average values at each barnyardgrass density ✳ fertilizer rates had LSD(1%) = 0.5097, LSD(5%) = 0.3364.

Table 10 Effect of barnyardgrass density and fertilizer levels on number of panicles of rice (panicle/m^2) at 30 days after planted.

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
0	299.25a[1,3]	439.75a[1,3]	369.50a	327.50a[1,3]	468.50a[1,3]	398.00a
20	235.75a[1]	352.50 b[1]	294.12 b	266.75a[1]	382.00 b[1]	324.37 b
40	158.75 b	317.25 b	238.80 c	169.75 b	295.50 c	232.62 c
80	109.00 bc	224.75 c	166.87 d	107.75 bc	253.75 c	180.75 c
160	80.75 c	119.75 d	100.25 e	78.50 c	121.50 d	100.00 d
means	176.70[2]	290.80[2]	233.75	190.05[2]	304.25[2]	247.15[2]

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.
2. Two means at each fertilizer rates had LSD(1%) = 33.472, LSD(5%) = 22.093.
3. Two average values at each barnyardgrass density ✳ fertilizer rates had LSD(1%) = 93.873, LSD(5%) = 69.575.

Rice yields. There were not significant differences (P=0.05) in rice yields between fertilizers. These difference were significant (P=0.05) between rice density and barnyardgrass density (Table 11). Fertilization at 187.5 kg/ha, increasing rice density from 80 to 160 plants/m^2 increased rice yields by about 44.96% ; and 42.80 when fertilization at 350.0 kg/ha. Increasing barnyardgrass density from 0, 20, 40, 80 and 160 plants/m^2 reduced rice yields by about 0, 24.43, 44.51, 61.68, and 77.34% respectively when fertilization at 187.5 kg/ha ; and 0, 29.66, 48.44, 67.39 and 80.83% respectively when fertilization at 350.0 kg/ha.

Table 11 Effect of barnyardgrass density and fertilizer levels on yield of rice (g/m^2).

barnyardgrass	fertilizer 187.5kg/ha			fertilizer 375.0kg/ha		
	rice(plants/m^2)			rice(plants/m^2)		
(plants/m^2)	80	160	means	80	160	means
0	409.97a[1,3]	551.76a[1,3]	480.87a	458.76a[1,3]	605.01a[1,3]	531.89a
20	297.93 b[1]	428.83 b[1]	363.38 b	315.87 b[1]	432.45 b[1]	374.16b
40	204.64 c	327.06 c	265.85 c	209.95 c	338.54 c	274.23 c
80	134.34 cd	234.20 d	184.27 d	127.33 cd	219.59 d	173.46 d
160	98.87 d	119.04 e	108.96 e	87.20 d	116.73 e	101.97 e
	229.15[2]	332.18[2]	280.67	239.82[2]	342.47[2]	291.14

Remark

1. In a column under each fertilizer means follow by a common letter are not significantly different at the 5% level by DMRT.
2. Two means at each fertilizer rates had LSD(1%) = 39.609, LSD(5%) = 26.144.
3. Two average values at each barnyardgrass density ∗ fertilizer rates had LSD(1%) = 116.183, LSD(5%) = 86.169.

Discussion

In this experiment, increasing barnyardgrass density reduced transpiration rate of rice because the proportion of transpiration water was clearly correlated with plant density (Leopald and Kriedemann, 1975). Transpiration were reduced by shading of plants (Kramer, 1983). So that higher plant density or higher plant competition decreased transpiration. Plant growth were effected by transpiration, higher transpiration increased plant growth (Lang et al, 1976; Leopald and Kriedemann, 1975). Transpiration of rice reduced with high density of barnyardgrass ; resulted on the reduction of rice growth. Chlorophyll content, rice growth and rice were reduced by barnyardgrass density; High density more effected than lower density, because of competition for nutrients; Weeds usually absorb fertilizer faster and in relatively larger amounts than crops. (Zimdahl, 1980); So that in high density of barnyardgrass and high fertilizer rate, rice yield more decreased than rice yield in low fertilizer rate.

Reference

Anon, 1984. Progress Report : Integrated management of rice in Amphor Lumlukka, Pratoomtani Province. Dept. of Agriculture. Thailand. 91 p. (in Thai).

De Datla, S.K.,J.C. Moomaw, and R.T. Bantilon. 1966 Effects of varietal type, method of planting and nitrogen level on competition between rice and weeds. Pages 152-163 in Proceeding 2nd Asian - Pacific Weed Control Interchange, Los Banns, Philippines.

Hole, L. G., D.L. Pluckent,and J.V. Dancho 1977.The World's Worst Weeds. The University Press of Hawaii, Honolulu. 609p.

Kleining, C.R. and J.C. Noble. 1969. Competition between rice and barnyardgrass (Echinochloa) II. Response to nitrogen phosphorus and sulfur in pots. Aust. J. Exp. Agr. Anim. Husb.9, 105-112.

Kramer, P.J. 1983. Water relations of plants. Academic, Inc., San Diego. 499 p.

Lange, O.L., L. Kappen and E.D. Schulze. 1976. Water and Plant life Problems and Modern Approaches. Springer Verlag, Berlin. 535 p.

Leopard, A.C. and P.E. Kriedemann. 1975. Plant Growth and Development. 2nd ed., Mc Graw-Hill Book Company, New York. 543 p.

Li, H.H., M. Urashima, M. Amano, L.Lajide. H. Nishimura, K. Hasegawa and J. Mizutani. 1992. Allelopathy of Barnyardgrass (*Echinochloa crus-galli* L. Beauv. Var. *crus-galli*). Weed Research. Japan. 37(2) 146-152.

Noda, K., K Ozaowa. and K. Ibaraki. 1968. Studies on the damage to rice plants due to weed competition (effect of barnyardgrass competition on growth, yield and some eco-physiological aspect of rice plants). Kyushu Agr. Exp. Sta. Bull. 13: 345-367.
Smith, R.J.,Jr. 1968. weed competition in rice. Weed Sci. 16: 252-255.
Zimdahal, R.L. 1980. Weed Crop Competition. International plant Protection Center, Oregon State University, Oregon. 196p.

Exotic Weeds in Seeds and Crop Products Imported into Taiwan

T. Y. Ku[1] and M. Y. Chiang[2]

[1] Director, Food and Agriculture Department, Council of Agriculture, Executive Yuan
37, Nanhai Road, Taipei, Taiwan, Republic of China

[2] Taiwan Agricultural Chemicals and Toxic Substances Research Institute
11 Kung Ming Road, Wufeng, Taichung, Taiwan, Republic of China

Abstract. Introduced pests have caused tremendous damages to agricultural production and environmental quality in Taiwan. To support quarantine regulation of exotic pests, related research projects were initiated by the Council of Agriculture in 1991. In this study, a total of 538 samples of imported seeds- and processed-used plant products originating from 16 countries were examined for weed seed contamination. Sixty-five percent of the samples contained weed seeds. Identification of weed taxon was based on morphological characteristics of propagules by using photographs, drawings, keys, documented descriptions and measurements. One hundred and one weeds were identified to specific level. Noxious weeds such as *Agropyron repens* (L.) Beauv., *Amaranthus retroflexus* L., *Brassica Kaber* (DC.) L.C. Wheeler, *Cardaria draba* (L.) Desv., *Conium masculatum* L., *Convolvulus arvensis* L., *Plantago lanceolata* L. and *Thlaspil arvense* L. were among the 48 species not previously recorded in Taiwan.

Key words. Weeds, Seed, Grain, Noxious weed, Quarantine regulation.

Introduction

Taiwan has a highly developed small-farm agriculture. With very limited arable land, agricultural production had not only met domestic requirement but also produced valuable products for export. This contributed tremendously to the economic transformation and development of Taiwan in the 60-70s. With increasing population and changing food consumption patterns, Taiwan has increasingly relied on imported agricultural products in the last two decades (Fig 1) [8]. In 1993, crop products imported into Taiwan exceeded nine million tons (Table 1)[8].

Imported crop products pose some problems in plant quarantine in Taiwan. In quantity, most of the imported agricultural products are grains and other crop seeds (Table 2); these products are good carrier of weed seeds. Previously introduced alien species such as water hyacinth (*Eichornia crassipe* (Mart.) Solms), johnsongrass (*Sorghum halepense* (L.) Pers.), guineagrass (*Panicum maximum* Jacq.) and common ragweed (*Ambrosia artemisiifolia* L.) have spread widely in Taiwan and have had notable negative impacts on environment and crop production. Since a significant portion of the island is mountainous, plants originating from temperate regions or the tropics could establish readily in Taiwan.

Many countries have established quarantine regulations on exotic weeds [6]. The U.S. and Australia are two countries with the most stringent regulations against introduction and expansion of noxious weeds [10,13]. In the Asia-Pacific region, some countries also have also initiated some measures to regulate the invadion of noxious weeds [1,17]. In Taiwan, quarantine regulation of imported plant material focuses mainly on preventing entry of diseases and insect pests. Weeds and other animal pests of plants are to a lesser extent being considered in the Commodity Inspection regulation, last revised in 1976. The legislative body of the government is currently reviewing the draft of a newly proposed law on plant and animal quarantine. The new law, has a balanced coverage of all aspects of quarantine, is expected to be passed soon.

Since 1991, the Council of Agriculture has initiated programs to evaluate exotic weeds, diseases, and insect pests with potential to invade and establish in Taiwan. One of the major objectives of the program is to identify and document pests associated with imported agricultural products. Experts from different disciplines worked for various projects of this program. This paper reports the progress and findings of a three-year study on weed seeds associated with imported commodities.

Materials and Methods

All samples used in this study were collected from imported cereals and other crop seeds by quarantine officer of the Bureau of Commodity Inspection and Quarantine (BCIQ). Local quarantine offices also provided information on product name, quantity, source country, importing company and sampling date of the original cargo. The original quantity of imported cargo ranged from 100 kg or less for flower seeds to 50,000 tons plus of bulk shipment for grains. Sample size was 50 g for imported seeds used for planting purposes and 500 g for cereals and oil seeds used for food, animal feed or processing; for the latter group of products, contaminants sieved from 5-10 kg cargo from each shipment were used as samples in some cases.

Samples obtained from quarantine offices were cleaned and sorted for visual and microscopic examination to determine size, shape, color and other morphological characteristics of weed propagules. Identification was done by comparing these characteristics with photographs, drawings, keys, documented descriptions and measurements. Publications by Brouwer(5), Delorit(9), Gunn (11), Hanf(12), Kasahara (15) and Stucky(18) were used as major references. Identification to species level was done in cases where most characteristics match those in the literature documentation; If there was some inconsistency, identification was made up to the generic level. Weed seeds with the same morphological characteristics from a sample were designated as one weed seed unit; this term was used to express the ratio of weed seeds between examined and identified seeds.

Weed list and other relevant publications (2, 3, 4, 14, 15, 19) were used to match weeds to specific countries. The "Flora of Taiwan" (16) was used to determine exotic species for Taiwan; this comprehensive volume documents all endemic species in Taiwan reported till the 70s.

After examination, all weed seeds were properly stored under cool and dry conditions for future evaluation of viability and taxon confirmation.

Results and Discussion

Weed seeds from samples of different origin

Ninety percent of the samples originated from USA, Australia and Japan; the rest came from New Zealand, Netherlands, Thailand, Canada, mainland China, Denmark, Egypt, India, N. Korea, S. Korea, Pakistan, Philippines, and Singapore (Table 2).

Samples from U.S. products were associated with 39 crop species; of the total 323 samples, 69% contained weed seeds. Ninety-six different weeds were identified from these samples. Weeds that were identified from barley and oats from Canada were all found in US products. Inspected samples of Japan origin consisted of 44 plant species; most of these species were seeds of vegetables, ornamentals, and grasses used for planting purposes. Weed seeds were found in 47% of the 110 samples; 24 different weeds were identified. Most of the 52 samples from Australia were seeds of grasses and legumes; weed seeds were found in two-thirds of the samples and 34 weeds were identified. Only six weeds were identified from samples from two European countries-the Netherlands and Denmark, Crop products from these two countries were vegetables, grasses and flowers. Eleven weeds were identified from products from two south Asian countries-India and Pakistan. While six weeds were identified from samples from Thailand and other Southeast Asian countries.

In this study, we collected a sizable number of samples for the evaluation of weed seeds associated with products from USA, Japan and Australia. Samples from countries in other geographic regions such as Africa, South Asia, Southeast Asia and South America were either insufficient or completely lacking. A considerable amount of imported cereals and other crop seeds came from countries in these regions [8]. In future studies, more emphasis should be put on products from these sources.

Weed seeds associated with different types of crops

Corn, wheat, barley, sorghum, oats, soybean, mungbean, alfalfa, pea and sunflower were imported for use as food and animal feed directly or through processing. They were the largest group in quantity and represented more than 99% of tonnage of in all imported seeds (Table 1). We inspected 131 samples and identified 103 different weeds from this group of products (Table 3). There were at least 51 kinds of weed seeds associated with corn that originated from USA (data not shown).

Crop seeds imported for planting purposes were very little- some 3000 tons in 1993, they represented very diverse species. Our samples consisted of 78 different plants. We inspected 263, 100 and 44 samples of product group 2a, 2b and 2c, respectively (Table 3). The most frequently sampled grasses were bermuda grass (*Cynodon dactylon* (L.) Pers.), Bahiagrass (*Paspalum notatum* Fluegge), ryegrass (*Lolium* spp.) tall fescue (*Festuca arundinacea* Schreb.), centipedegrass (*Eremochloa ophiuroides* (Munro) Hack.), and carpetgrass (*Axonopus affinis* Chase). In all, 200 samples were inspected for these five grass species. Spinach (*Spinacia oleracea* L.), radish (*Raphanus sativus* L.), Chinese mustard (*Brassica juncea* (L.) Czerniak. et Coss.), common cabbage (*Brassica oleracea* var. *capitata* L.) and Chinese cabbage (*Brassica campestris* L. ssp. *pekinensis* (Lour.) Olsson) were the frequently sampled vegetable seeds. Seventy-six weeds were identified from crop seeds of group 2a. Weeds identified were 22 and 18 for group 2b and 2c, respectively.

For group 1 products, 67% of the 1528 seed units examined were identified. The ratio was much lower for group 2 of which less than 30% of the seed units examined were identified. The ratio of affirmative identification for all 2326 weed seed units was 55%. This indicated that weeds associated with imported crop products should be much higher than the 130 species identified.

Taxonomic presentation of weeds

More than 60% of all identified weeds belong to Gramineae, Compositae, Cruciferae, Polygonaceae and Leguminosae (Table 4). All 24 families associated with weed seeds are indigenous to Taiwan. Weeds of Cyperaceae, Euphorbiaceae, Scruphulariaceae, Verbenaceae and Commeliaceae are common in Taiwan [7,16]; however, weeds of these families were not found in our samples. Many of the exotic species found were from Cruciferae, Compositae, Amaranthaceae, Gramineae and Polygonaceae. Only 19 native species of Cruciferae were previously documented in Taiwan [16]; the abundance of exotic weeds of Cruciferae in the samples is worth looking into.

Many species found in our samples are serious weeds with widespread distribution. Of the 101 weeds that we identified, 32 species occurred in more than 30 countries according to Holm et al. [14]. Six of the identified species- *Ambrosia artemisiifolia, Argemone mexicana, Capsella bursa-pastoris, Rumex acetasella, Rumex crispus* and *Stellaria media* appear on the ASEAN A1/A2 list for noxious terrestrial weeds [17]. Noxious weeds such as *Agropyron repens, Amaranthus retroflexus, Brassica kaber, Cardaria draba, Conium masculatum, Convolvulus arvensis, Plantago lanceolata* and *Thlaspi arvense* were among the 48 species not previously recorded in Taiwan. Table 5 lists 50 weeds frequently found in our samples.

References

1. Anonymous. 1991. Weed quarantine. In "Encyclopedia of Chemical Weed Control on Farmland" (Chief ed. Zang DianJing). p 163-191. Shanghai Scientific and Technological Literature Publishing House, Shanghai, China.
2. Auld, B. A. and R. W. Medd. 1987. Weeds-an Illustrated Botanical Guide to the Weeds of Australia. 255 p. Inkata Press, Melbourne.

3. Bayer Ag. 1992. Important Crops of the World and their Weeds. 1682 p. Bayer AG, Leverkusen, Germany.

4. Bischof F. 1978. Common Weeds from Iran, Turkey, the Near East and North Africa. 212 p. German Agency for Technical Cooperation, Ltd.(GTZ). Eschborn, Germany.

5. Brouwer, W. and Stahlin A. 1975. Handbuch der Samenkunde fur Landwirtschaft, Gartenbau und Forstwirtschaft. 654 p. DLG-Verlag, Frankfurt.

6. Bureau of Commodity Inspection and Quarantine. 1991. Summary of National Plant Quaranting Regulations. Burea of Commodity Inspection and Quarantine, Ministry of Economic Affairs, ROC. 518 p.

7. Chiang, M. Y. 1982. List of weeds in Taiwan. Weed Science Bulletin (ROC) 3:130-180.

8. Council of Agriculture. 1995. Agricultural Trade Statistics of Republic of China- 1984. 377 p. Council of Agriculture, Taipei

9. Delorit, R. J. 1970. Illustrated Taxonomy Manual of Weed Seeds. 175 p. Agronomy Publications, Wisconsin.

10. Foy, C. L., D. R. Forney, and W. E. Cooley. 1983. History of weed introduction. in "Exotic Plant Pests and North American Agriculture" (Wilson, C.L. and C.L. Graham, eds.), page 65-89. Academic Press.

11. Gunn, C. R. and C. A. Ritchie. 1988. Identification of Disseminules Listed in the Federal Noxious Weed Act. 313 p. Agricultural Research Service, USDA.

12. Hanf, M. 1983. The Arable Weeds of Europe with Their Seedlings and Seeds. 494 p. BASF Aktiengesellschaft.

13. Hobbs, R. J. 1993. Dynamics of Weed Invasion: Implications for Control. Proceedings I, 10th Australian and 14th Asian-Pacific Weed Conference. p. 461-465.

14. Holm, L., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1979. A Geographical Atlas of World Weeds. 391 p. John Wiley & Sons.

15. Kasahara, Y. 1976. The Surface Structure of the Seeds and Fruits of Weeds in Japan Observed with the Scanning Electron Microscope. 130 p. Yokendo., Ltd. Tokyo.

16. Li, H.-L, T.-S. Liu, T.-C. Huang, T. Koyama, and C. E. Devol (eds.). 1979. Flora of Taiwan Vol. 6. 665 p. Epoch Publishing Co., Ltd. Taiwan .

17. Sastroutomo, S. S. 1985. Report of the ASEAN-PLANTI meeting on weeds of plant quarantine importance. 25 p. Southeast Asian Regional Center for Tropical Biology.

18. Stucky, J. M. 1981. Identifying Seedling and Mature Weeds Common in the Southeastern United States. 197 p. Agricultural Research Service, North Carolina State University, Raleigh.

19. Weed Science Society of America. 1989. Composite List of Weeds. 112 p. WSSA, Champaign, Illinois.

Table 1. Quantity and value of major imported cereals and other crop seeds of Taiwan in 1993.

Commodity	Quantity (1000 tons)	value $ (Million)
Cereals	6707	905.8
Corn	5466	685.5
Wheat	908	173.6
Barley	236	33.1
Sorghum	86	10.4
Others	11	3.2
Oil seeds	2478	634.8
Soybean	2436	618.7
Sesame	30	12.9
Others	12	3.2
Seeds for planting	3	16.6
sum	9188	1557.2

[1] Data source : Agricultural Trade Statistics of ROC 1993 (8).

Table 2. Cereals and other crop seeds sampled for weed seeds inspection during 1991-1993, samples organized by originating countries.

Sample origin	Crop species of sample	No of samples Total	W/ weeds	Ratio(%)	Weeds taxon identified
USA	39	323	223	69.0	96
Japan	44	111	52	46.8	24
Australia	16	52	34	65.4	34
New Zealand	4	10	9	90.0	13
Netherlands	8	10	6	60.0	5
Thailand	6	9	5	55.6	9
Canada	2	4	4	100.0	10
Others[1]	15	19	17	85.0	10
Total	88	538	350	65.1	130

[1] Other countries: China (PR), Denmark, Egypt, India, Korea, Pakistan, Philippine, Singapore.

Table 3. Imported crop products of Taiwan sampled for weed seeds inspection during 1991-1993, samples organized by usage and types of products.

Product group	No of sample: Total	No of sample: W/weeds	Weed seed unit [1]: Examined	Weed seed unit [1]: Identified
1. Seeds used for food, feed and processing	131(10)[2]	117	1528	1038
2. Seeds used for planting				
2a. Grasses and legumes for lawn, pasture, green mulch	263(28)	162	621	179
2b. Vegetables	100(22)	51	110	33
2c. Flowers and ornaments	44(28)	20	66	23
Total	538(88)	350	2326	1273

1 Weed seeds of same morphological characteristics of a sample were designated as one weed weed unit.

2 Figure in parenthesis indicates number of crop species of samples.

Table 4. Taxonomic presentation of weeds seeds sampled and identified from imported cereals and other crop seeds in Taiwan during 1991-1993 .

Family	Taxon identified: Generic	Taxon identified: Specific	No of exotic species[1]
Amaranthaceae	6	5	4
Boraginaceae	1	1	1
Capparidaceae	1	1	1
Caryophyllace	5	3	2
Chenopodiaceae	7	5	4
Compositae	17	12	7
Convolvulaceae	6	4	2
Cruciferae	15	12	9
Cucurbitaceae	1	0	0
Geraniaceae	1	1	1
Gramineae	22	21	4
Juncaceae	1	1	1
Labiatae	2	2	1
Leguminosae	13	10	3
Malvaceae	6	5	1
Molluginaceae	2	1	0
Onagaceae	1	0	0
Papaveraceae	1	1	0
Plantaginaceae	2	1	1
Polygonaceae	13	10	4
Ranunculaceae	1	1	1
Rubiaceae	3	2	0
Solanaceae	2	1	0
Umbelliferae	1	1	1
Sum	130	101	48

1 With reference to "Flora of Taiwan" (16).

Table 5. Weed seeds commonly found in cereals and other crop seeds imported into Taiwan during 1991-1993.

Weed species	Family	sampled frequency[1]	Exotic species[2]
Abutilon theophrasti	Malvaceae	44 (44)	
Acnidia altissima	Amaranthaceae	7 (5)	E
Agropyron repens	Gramineae	19 (12)	E
Amaranthus albus	Amaranthaceae	28 (26)	E
Amaranthus graecizans	Amaranthaceae	20 (20)	E
Amaranthus retroflexus	Amaranthaceae	39 (36)	E
Amaranthus sp.	Amaranthaceae	9 (0)	
Amaranthus spinosus	Amaranthaceae	16 (15)	
Ambrosia artemisiifolia	Compositae	36 (36)	
Ambrosia trifida	Compositae	8 (8)	E
Avena fatua	Gramineae	23 (19)	
Brassica kaber	Cruciferae	37 (34)	E
Bromus tectorum	Gramineae	9 (9)	E
Cassia obtusifolia	Leguminosae	14 (13)	
Chenopodium album	Chenopodiaceae	45 (41)	
Chenopodium hybridium	Chenopodiaceae	43 (42)	E
Cycloloma atriplicifolium	Chenopodiaceae	12 (11)	E
Datura stramonium	Solanaceae	9 (9)	
Digitaria sanguinalis	Gramineae	15 (9)	
Echinochloa crusgalli	Gramineae	9 (9)	
Echinochloa spp.	Gramineae	52 (45)	
Helianthus annuus	Compositae	39 (39)	
Hibiscus trionum	Malvaceae	6 (6)	
Ipomoea hederacea	Convolvulaceae	16 (15)	
Ipomoea lacunosa	Convolvulaceae	6 (6)	E
Iva xanthifolia	Compositae	7 (7)	E
Kochia scoparia	Chenopodiaceae	13 (13)	

(be continued)

Table 5. Weed seeds commonly found in cereals and other crop seeds imported into Taiwan during 1991-1993. *(continued)*

Weed species	Family	sampled frequency[1]	Exotic species[2]
Lithospermum arvense	Boraginaceae	11 (8)	E
Panicum capillare	Gramineae	13 (13)	E
Panicum dichotomiflorum	Gramineae	20 (20)	
Polygonum aviculare	Polygonaceae	30 (20)	
Polygonum convolvulus	Polygonaceae	42 (32)	
Polygonum lapathifolium	Polygonaceae	19 (18)	
Polygonum pensylvanicum	Polygonaceae	29 (29)	E
Polygonum persicaria	Polygonaceae	14 (13)	
Polygonum spp.	Polygonaceae	16 (8)	
Rumex obtusifolius	Polygonaceae	7 (6)	E
Salsola kali	Chenopodiaceae	8 (8)	E
Salvia reflexa	Labiatae	8 (8)	E
Saponaria vaccaria	Caryophyllace	15 (13)	
Sesbania exaltata	Leguminosae	15 (15)	E
Setaria faberi	Gramineae	30 (30)	
Setaria glauca	Gramineae	7 (6)	
Setaria lutescens	Gramineae	40 (37)	
Setaria verticillata	Gramineae	28 (25)	
Setaria viridis	Gramineae	43 (39)	
Sida spinosa	Malvaceae	36 (33)	E
Sorghum halepense	Gramineae	43 (42)	
Thlaspi arvense	Cruciferae	33 (26)	E
Trifolium repens	Leguminosae	8 (4)	

1 Out of the total 538 samples, figures in parenthesis indicates samples originating from USA

2 "E" indicating exotic species based on "Flora of Taiwan" (16).

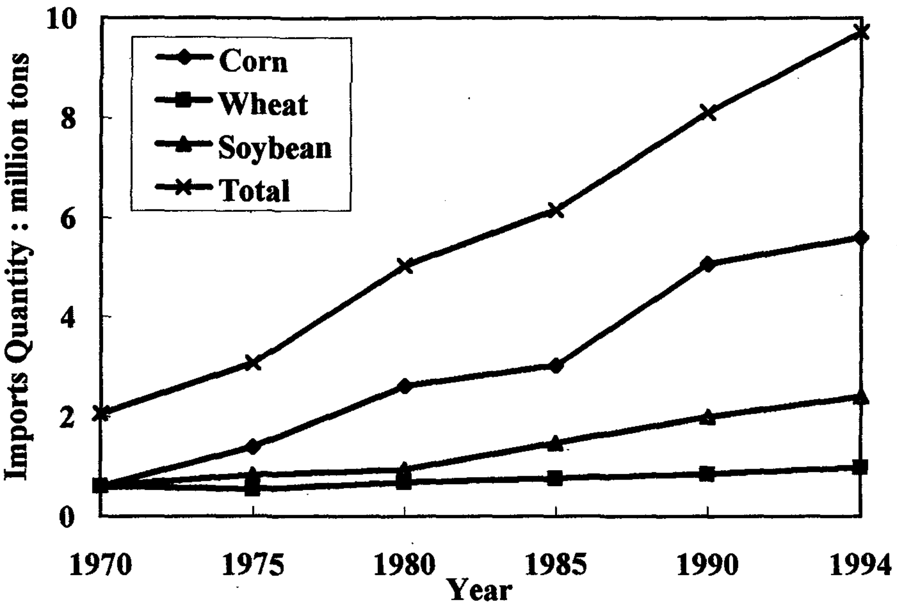

Fig 1. Grain imports of Taiwan during 1970~1994, data for "total" includes imports of barley and sorghum. (Data source : Agricultural Trade Statistics, COA, 1995[8])

DISTRIBUTION AND PROPAGATION OF THE INTRODUCED WEEDS, *BARBAREA VULGARIS* R. BR. AND *ANTHEMIS COTULA* L. IN THE TOHOKU AREA OF JAPAN

M. Tachibana*, K. Itoh and T. Sumiyoshi
Tohoku Natl. Agric. Expt. Stn., Omagari, Akita 014-01 Japan

__Abstract:__ The actual state of *Barbarea vulgaris* and *Anthemis cotula* in the Tohoku area were investigated. The distribution of *B. vulgaris* is not uniform in the Senboku area of Akita Prefecture. The greater part of this weed colonized on levees near canals. *B. vulgaris* is propagated by seeds in a wheat field, while on the levees, many individuals are propagated by vegetative organs, stocks and roots. Emergence of *A. cotula* is in the spring and the autumn. Flowering time of the weed is the same as heading time of winter wheat. When there is no rotary tilling of soil, after harvest the stubbles regrow, flower and produce many seeds in late July.

__Key words__: *Barbarea vulgaris*, *Anthemis cotula*, introduced weed, distribution, propagation

Introduction

Barbarea vulgaris R. Br., Yellow rocket , is an important weed of small-seeded grain, hay crops in Ontario, legume-grass meadows in NewYork State, and spring wheat in Russia[1].

Anthemis cotula L., Mayweed chamomile, is a Compositae winter annual and is troublesome in several crops grown in the Pacific Northwest, including wheat(*Triticum aestivum* L.), pea(*Pisum sativum* L.), and lentil(*Lens culinaris* L.)[2,3].

B. vulgaris and *A. cotula* are probably of Europe origin. The former is a serious weed of levees, bands and pastures in northern Japan. The latter has become troublesome for wheat, causing crop yield reduction, a stench and harm to human health in Aomori Prefecture.

This study revealed the actual state of *B. vulgaris* and *A. cotula* in the Tohoku area.

Materials and Methods

The distribution of *B. vulgaris* was surveyed in the Senboku area of Akita Prefecture in June 1993 and in May 1994. Plant population per 1 km was classified 5 levels and then mapped onto the Senboku area. I level indicate 0 per square meter, similarly II, III, IV and V indicate approximately 0.1, 1, 10 and 30 plants per square meter, respectively.

Seeds of *B. vulgaris* were collected from mature plants at expriment station's field on July 4, 1994 and stored at room temperature. The seeds were stored 50 cm deep in the reservoir on October 19, 1994 and then recovered on November 22, 1994 and July 5, 1995. Germination tests were conducted as follows. In 1994, 50 seeds were placed on two layers of wet filter paper in petri dishes, and were incubated at 15, 20, 25, 30, 35, 15/25, 20/30℃, under light(12hr) or dark condition. 200 Seeds were used per plot. Germination percentages were measured after 14 days. In 1995, 100 seeds were incubated at 15/25℃ under light(12hr) condition. 300 seeds were used, germination percentages were measured after 7 days.

Plants of *B. vulgaris* and *Erigeron philadelphicus* L. were collected in Omagari city on December 6, and 22, 1994, respectively. The roots of these species were cut to 5 cm fragments on December 22. Root fragments were placed on the soil surface and incubated at alternating temperature 20/30℃ in 12-h light. Performance of root bud sprouting was evaluated after 15 days. Root fragments of *B. vulgaris* in various diameter were also evaluated for performance of root bud sprouting at 20 days.

In 1993 and 1994, propagation of *B. vulgaris* was observed at wheat field and levees in Omagari city.

On April 4, 1994, the soil was sampled from wheat field in Ajigasawa town of Aomori Prefecture. Sampled soil was put in the concrete pots at experiment station on April 11 and emergences of *A. cotula* were observed seasonaly.

In November 1993, and in April, July 1994, emergences of *A. cotula* were observed at Ajigasawa town.

Results and Discussion

B. vulgaris has occured in 73 out of 143 surveyed points in the Senboku area. The number of V level were 24 points, similarly Ⅳ, Ⅲ, Ⅱ were 11, 9, 29 points. In this survey, almost all *B. vulgaris* occured on levees near canals and bands, and only two occured in meadows and one occured in orchard. Like this, the distribution of *B. vulgaris* is not uniform in the Senboku area of Akita Prefecture(Fig. 1).

The seeds of *B. vulgaris* were treated submergence in a depth of 50 cm for 34 days were still viable, germination percentage was more than 50 % in 12-h light at 15/25C, in spite of fungi contamination was occured during incubation periods. Further these seeds that were treated for 259 days germinated 60 %(Fig. 2).
These results show that *B. vulgaris* may spread by water and maintenance of irrigation channel.

Root bud growth of *B. vulgaris* was as vigorous as *E. philadelphicus* and even root fragments was less than 1 mm in diameter were able to sprout(Table 1, 2).

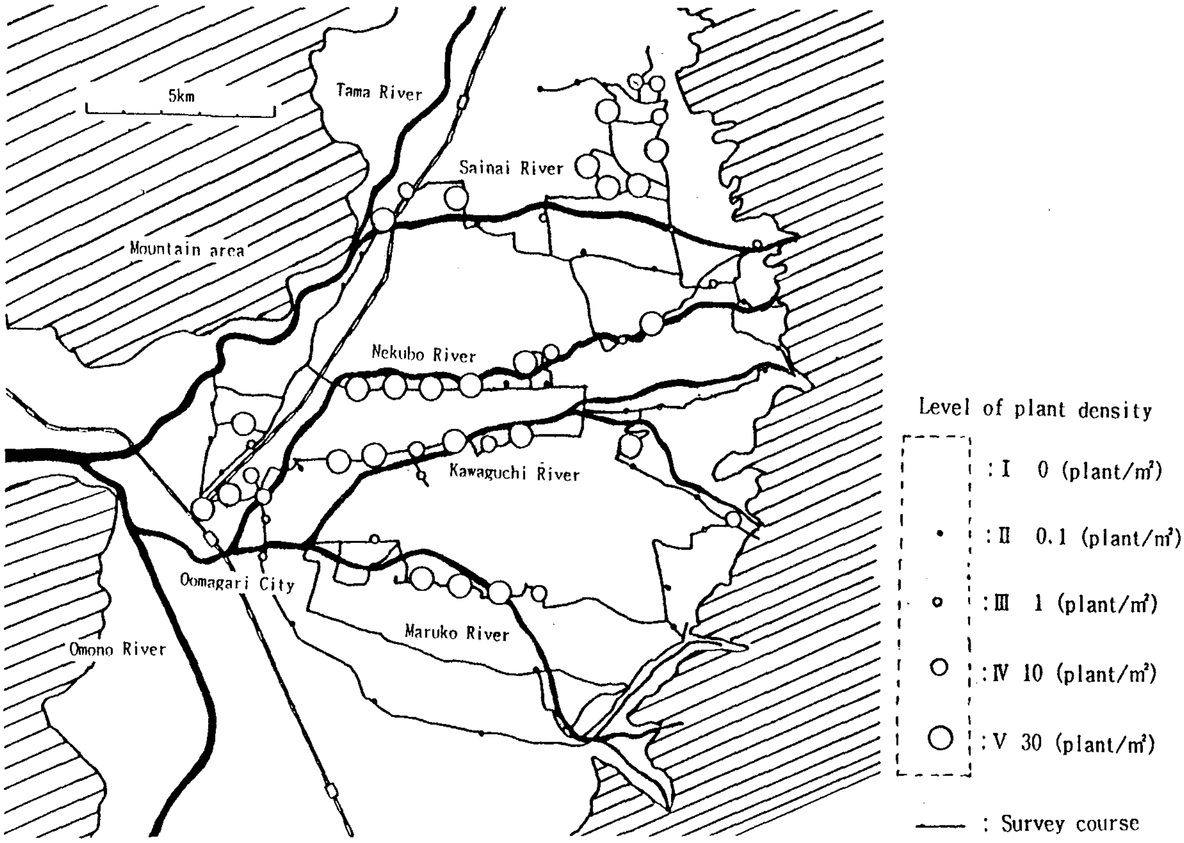

Fig. 1. Distribution of *B. vulgaris* in Senboku area of Akita Prefecture (1993)

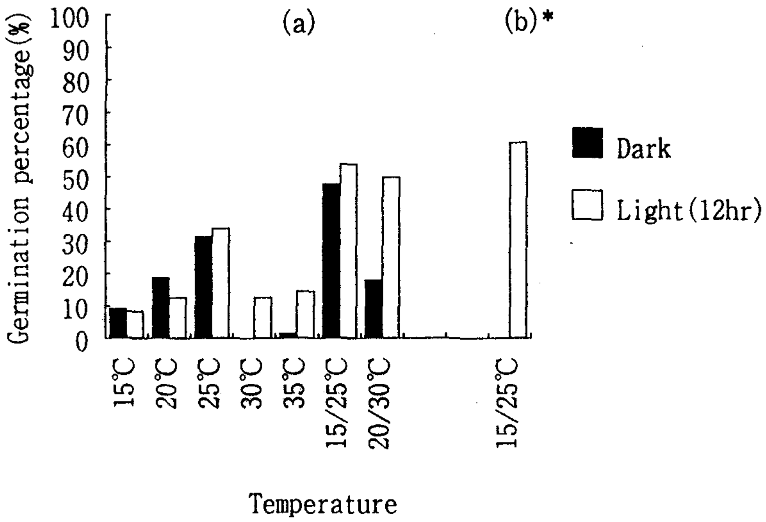

Fig. 2. Germination percentages of *B. vulgaris* seeds that were stored in deep water for (a) 34days and (b) 259days
*: Germination percentage was measured only under light condition

Table 1. Sprouting ability of root fragments **

Weed species	Sprouting rate (%)	Number of* sprouting buds	Number of * leaves	Leaf * length(longest) (cm)
Barbarea vulgaris R.Br.	95	5.5	13.1	3.2
Erigeron philadelphicus L.	100	2.4	5.2	1.0

*:Per fragment　　**:20/30℃. light(12hr). 15days after incubated.

Table 2. Sprouting abilyty of *Barbarea vulgaris* roots in various diameter**

Root diameter	Sprouting rate (%)	Number of* sprouting buds	Number of * leaves	Leaf * length(longest) (cm)
≧3.0mm	100	7.3	34.0	7.7
3.0~2.0	100	7.2	31.6	10.4
2.0~1.0	100	7.5	24.6	8.2
1.0~0.5	80	3.8	9.4	4.0
<0.5mm	50	1.6	2.4	0.8
Dwarf stem	100	3.0	10.7	4.7

*:Per fragment　　**:20/30℃. light(12hr). 20days after incubated.

On the levees in Omagari, *B. vulgaris* flowered vigorously in mid-May. In case that the flowering stalks were cut with brush cutter, those plants bolted new stalks and flowered again. And we confirmed that plant which flowered last year regenerated and developed new rosettes, thus *B. vulgaris* is considered to be perennial. It is typical that many individuals were vegetative propagation of stocks and roots on the levees, while almost all *B. vulgaris* reproduced by seeds in a wheat field. It is guessed that this difference is caused by mowing without plowing on the levees(Table 3).

Table 3. Proportion of seed and vegetative propagation of *B. vulgaris*

Site	Seedling		Vegetative propagation	
	Plants/m²	Rate(%)	Plants/m²	Rate(%)
Levee				
A	0	0.0	8	100.0
B	4	28.6	10	71.4
C	1	33.3	2	66.7
D	19	43.2	25	56.8
E	0	0.0	5	100.0
F	7	63.6	4	36.4
G	3	25.0	9	75.0
Wheat field				
H	29	96.7	1	3.3
I	76	100.0	0	0.0
J	150	96.8	5	3.2

A. cotula infested the upland crop area at ajigasawa town in Aomori Prefecture severely. There was a watermelon field that was given up the harvest. Emerging time of *A. cotula* is in the spring and the autumn(Fig. 3). Flowering time of the weed is the same as heading time of winter wheat. But Emergence and flowering time were varied by field husbandry. In july 1994, the stubble of *A. cotula* had regenerated, flowered and produced many seeds in the fields without rotary tilling of soil after harvest. Therefore the tillege of soil after harvest is very important for reducing *A. cotula* density and the intertillge may also be important, especially after end of emerging time in autumn.

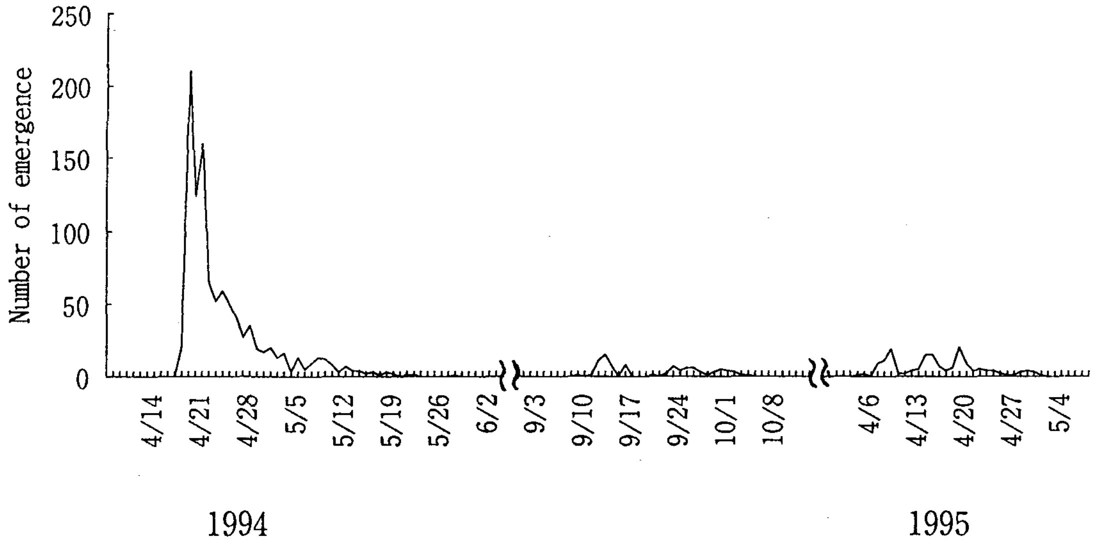

Fig. 3. Seasonal variation in emergence of *A. cotula*

References

1) Marilyn A. MacDonald and Paul B. Cavers (1991) The biology of Canadian weeds. 97. *Barbarea vulgaris* R. Br. Can. J. Plant Sci. 71, 149-166

2) David R. Gealy, Frank L. Young, and Larry A. Morrow (1985) Germination of Mayweed(*Anthemis cotula*) Achenes and Seed. Weed Sci. 33, 69-73

3) David R. Gealy, Sheila A. Squier, and Alex G. Ogg, Jr. (1991) Photosynthetic Productivity of Mayweed Chamomile. Weed Sci. 39, 18-26

The Influence of Row Spacing, Intra Row Spacing and Weeding on Growth and Yield of Cowpea (*Vigna unguiculata* L.) in Sri Lanka.

B. Meylemans, R.O. Thattil, U.R. Sangakkara and P. Van Damme*[1]
Weed Science Project, Dept. of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
[1]Laboratory for Tropical and Subtropical Crop Husbandry and Ethnobotany, Faculty of Agricultural Sciences, University Gent, Coupure Links 653, Gent, Belgium

Abstract In the tropics, small farmers' ability to purchase herbicides is often limited. Adaptation of cultural practices to minimize weed incidence is the most feasible solution for their weed problems. Higher plant densities and close spatial arrangements are a key tool to reduce weed-crop competition, and should be an important part of integrated weed control systems. A range of spacings were used to plant cowpea with different weeding regimes as another factor in an experiment with a specially modified 2-way systematic design. Based upon the results, four spatial arrangements were selected and tested during two seasons in a conventional factorial randomized block design against the spacing recommended by the Department of Agriculture (30x15 cm), weeding frequency being the second factor. Closer spacings give remarkably higher yields. Out of the broad range of spacings tested, that between 17.5 x 12 cm and 10x12 cm appeared to give an optimal yield. Over two seasons of conventional testing, a spacing of 15x10 cm gave the best yield Yield increase of close spacing compared to the recommended spacing varied from 2 to 242 %. Yield increase was highest in unweeded plots, comparable to once weeded plots (farmers' practice) at the recommended spacing. Unweeded plots had a higher number of established plants than season-long clean weeded plots , probably due to damage of crop plants through weeding in the flowering stage. Row spacings were more important than plant densities within the rows. Close spatial arrangements reduced the number of pods per plant, the number of branches per plant, and the number of plants that finally established, but had less influence on seed size.
Key words Integrated Weed Management, Systematic Design, Cultural Practices , Plant Densities

Introduction

In Sri Lanka, cowpea is an important leguminous crop, cultivated on 25000 to 30000 ha annually (Dept. of Census and Statistics, 1992), both as subsistence and as cash crop, and a major source of proteins in the diet. Weed infestations in small farmers' fields are generally severe, certainly in upland crops. Almost no small farmer uses herbicides in upland crops, because of financial constraints and a lack of knowledge (Van Damme et al., 1994). Cultural practices directly affect the extent to which weeds compete with a crop. This is certainly true for row spacings and plant densities within a row (Stoller et al., 1987). Information on the effect of these on weed-crop interference is needed for developing integrated weed management systems (Mc Whorter and Shaw, 1982). Plant densities and spacing patterns influence morphological characteristics of the crop, as the canopy development, plant height, root depth (Mayaki et al., 1976 for soya bean) and root distribution pattern (Mitchell and Russell, 1974 for soya bean). This morphological developments in turn influence to a great extent germination and emergence of weeds as well as the competitiveness of the crop with weeds, as shown by Wax and Pendleton (1968) for narrow-row spacing in soybean.

No data were found on the influence of cowpea spacings on weeds, but a lot of research was conducted on other leguminous crops, mainly on soya bean in the U.S.A. Narrow-row spacings in soya bean help to reduce weed interference. A yield increase and weed biomass decrease were found with mixed weed populations and this was attributed to an earlier competition of the crop with the weed through a better root distribution and more shading of the soil (Burnside and Colville, 1964 ; Felton, 1976 ; Legere and Schreiber, 1989 ; Walker et al., 1984 ; Wax and Pendleton, 1968 ; Williams et al., 1973). In some studies, weed biomass reduction was reported only from the beginning of the reproductive stages (Howe and Oliver, 1987 ; Mc Worther and Sciumbato, 1988 ; Murdock et al., 1986). With weed removal at various times, though, no significant differences were found between 38- and 76-cm rows in soya bean (Burnside and Colville, 1964). Narrow rows in these experiment were generally between 0.25 and 0.5 m, wide rows between 0.5 en 1m. Similar results were obtained for soya bean densities intra-row spacings with yellow foxtail (*Pennisetum glaucum*) and Pennsylvania smartweed (*Polygonum pensylvanicum*) (Weber and Staniforth, 1957) and for common cocklebur (*Xanthium strumarum*) (Mc Whorter and Barrentine, 1975). Typical values for high densities were 30 to 50 plants/m and 10 plants/m for low

densities. Another study by Malik et al. (1993) states that increased seeding densities intra-row (from 25 to 37.5 /m^2) did not reduce weed biomass and weed density for white beans (*Phaseolus vulgarus*).
Objective of this study was in the first place to optimize cowpea spacing patterns and plant densities under different weeding conditions for small farmers, and secondly to study the effects of spacing and weeding on yield components and plant parameters. Thirdly, we wanted to test a modified 2-way systematic statistical design for use in spacing experiments with different weeding conditions.

Materials and Methods

All experiments were conducted at the University Farm, Dodangolla, situated in the Intermediate Mid-Country Zone of Sri Lanka, with an average yearly rainfall of 1675 mm in two seasons in atropical climate. The cowpea (*Vigna unguiculata* L. *subsp. unguiculata)* variety used was MI-35, an erect, determinate, short duration, high yielding variety. For all cultural practices, except weeding and spacing, the recommendations of the Department of Agriculture (1990) were followed. Land preparation existed of one disc ploughing and one harrowing. Insecticide was sprayed if necessary. Fertilizer applications were : 30 kg N/ ha, 65 kg P_2O_5/ha and 45 kg K_2O/ha as basal application and 25 kg N/ha as a top dressing at the onset of flowering.
Experiments were conducted during three consecutive seasons, *Maha* '92/'93, *Yala* '93 and *Maha* '93/94, *Maha* being the long rainy season and *Yala* the short one.
In the first experiment, a large range of spacings was screened under different weeding conditions in an experiment with a specially modified 2-way systematic statistical design. Based upon the results, four spacings were selected and compared to the recommended spacing (D.O.A., Sri Lanka) under different weeding conditions in a conventional factorial experiment in the two following seasons.
The statistical design used in the first season, was based on a 2-way systematic parallel design given as an example for intercropping trials by Mead and Stern (1980). In this design, both row spacing and intra-row spacing are gradually increased to create a large range of spacing patterns. The trial is then divided in subplots with a minimum number of plants, in which the spacing is averaged. The modification which was introduced here to make it possible to look at weeds also was to repeat the smaller spacings, both row spacings and intra-row spacings, to increase the area of each subplot, so each subplot has not only a minimum number of plants but also minimum area. This was done because subplots with very close spacings, will be very small if the only condition was a minimum number of plants. This poses no problem in analysing crops in clean weeded fields, but it would cause too much variation in unweeded treatments. On the other hand, if the subplots have a bigger area, the range of spacings which has to be averaged will be too large, therefore the smaller spacings were repeated. To bring in weeding treatments, a split plot experiment with 4 replicates was set up, with the main factor being weeding, and the subfactor spacing, organized in the modified 2-way systematic design as in fig. 1. Row spacings varied from 10 to 45 cm, intra-row spacings from 3 to 30 cm. Weeding treatments were no weeding, one weeding three weeks after planting (farmers' practice) and clean weeding. In the second experiment, a randomized complete block design was used with spacings 10x4, 10x7, 15x4, 15x7 cm selected after the first trial, and D.O.A. recommended spacing 30x15 cm as a control, and the same weeding treatments as in the previous trial. In the third experiment, the closest spacings were dropped, and spacings used were 10x7, 10x10, 15x7, 15x10 and 30x15 cm. In these two experiments, plot size was 3x1.5 m. Parameters measured at harvest from each subplot were plant establishment (percentage harvested plants compared to planted sites), plant height averaged from 3 randomly selected plants, total number of pods, total seed yield and hundred seed weight. Per plant parameters were calculated from these. Number of branches per plant was averaged from three plants per subplot in the last two seasons, weed biomass at harvest was measured in the first and the third season only. Leaf area was measured from three plants per subplot at the flowering stage in the last season, and L.A.I was calculated.
Analysis was done using ANOVA and General Linear Models procedures from the SAS package, for complete randomized block design and split plot design experiments. Whenever replicates were significant, data were plotted by replicate. In all cases, trends were similar, after which the data were pooled for analysis. Significance was analyzed at the Pr>0.05 level, the Duncan test was used for mean separation.

Results and Discussion

Systematic design experiment No interactions were found between weeding and spacing treatments in this experiment, thus the effects will be discussed separately. Yields were rather low, maximum 529 kg/ha.

Table 1 Effects of cowpea spacing in 2-way systematic design spacing experiment, Maha 1992/1993

Spacing	*Yield (kg/ha)*	*Establishment(%)*	*Pods/ plant*	*100 Seed Wt. (g)*
40x24	217 c	91 ab	3.18 a	6.29 a
26.7x24	319bc	95 a	2.71ab	6.30 a
26.7x12	420 ab	87 abc	2.11 bcd	6.38 a
24x12	322bc	51 ef	2.51ab	5.86 ab
17.5x12	529 a	75 cd	2.25 bcd	6.28 a
40x11.3	304 bc	66 de	2.48 abc	5.86 ab
24x10.3	324 bc	66 de	1.93 bcde	6.36 a
12x10.3	492 a	66 de	1.35 def	6.32 a
42.5x4	257 c	48 f	1.49 def	5.18 b
32.5x4	424 ab	49 f	1.60 cdef	5.84 ab
22.5x4	402 ab	49 f	1.04 ef	6.11 a
12x4	427 ab	47 f	0.81 f	5.92 ab

Spacing Results averaged over the weeding treatments are given in Table 1. Table 1 is actually a field map of the spacing subplots, with smaller subplots for the higher plant densities, and larger plots for the lower plant densities, each plot having a minimum number of plants and a minimum area as explained above. Average spacings in a subplot are indicated in the upper left corner. There is a clear gradient in yields, both in row spacings and intra-row spacings, the biggest spacings having the lowest yields. The closest spacing, however, seems to be suboptimal, optimal spacings were 12x10 cm and 17x12 cm. Yields in this treatments are 135 % higher than with a 40x24 cm spacing, indicating the importance of optimal spacings in field crops. The D.O.A. spacing of 30x15 cm can clearly be improved for small farmers who don't practice mechanical weeding. Plant establishment is seriously decreasing at closer spacings, particularly with the closest intra-row spacings (4 cm), where more than 50% of the plants die off due to intraspecific competition. In the same way, yield per plant (data not given) and number of pods per plant decrease when the spacings become closer. The effect of a lower plant establishment and less pods per plant are compensated by the higher plant densities to a certain extent, explaining an optimum at a close spacing, but not at too close spacings, where intraspecific competition becomes too strong. Differences in 100 seed weight measurements were sometimes significant, but didn't show a very consistent pattern.

Weeding Results averaged over the spacing treatments are given in Table 2. Yield and pod number were highest at the unweeded treatments. This surprising result was caused by a higher plant establishment. In our group, this trend was found in several experiments conducted by different people and maintained by different groups of labourers. In a recent trial, we showed that weeding with the traditional large bladed hoe ("mammoty") as practised by farmers damages the plants and causes 10 to 20 % reduction in harvested plants. Hundred seed weight was significantly reduced by weed competition. Weed biomass measurements (data not given) did not show a very consistent pattern.

Table 2 : Effects of Weeding on Cowpea parameters, Maha 1992/1993

Weeding Treatment	% Establishment	Yield (kg/ha)	Pods/m²	Pods/plant	100 Seed Weight (g)
No weeding	77 a	429 a	61 a	2.01	5.94 b
1 weeding	58 b	279 b	41 b	1.76	5.88 b
Clean Weeding	64 b	338 b	44 b	2.11	6.32 a
R^2	0.66	0.65	0.64	n.s.	0.49
C.V.	25.8	40.9	35.1		14.1

ab Duncan classification for mean separation (Pr>0.05)

Follow-up experiments The second season had a drought period during the vegetative growth phase, maximum yields where 762 and 1084 kg/ha in the second and third season respectively. Data are given in table 3 and 4. Weeding-spacing interactions were present, thus they will not be discussed separately here. If there were no interactions, data were averaged over all weeding treatments and over all spacing treatments whenever they were significant.

The recommended spacing has almost always the lowest yield, though not always significant, indicating that it certainly can be improved by closer spacing. In both seasons, the effect of closer spacings was the clearest in the unweeded treatments, no significant effects were found in the once weeded treatments. The closest intra-row spacings (4 cm) appeared to be suboptimal in weeded treatments, indicating that a 7 cm intra-row spacing is close enough. Unweeded close spacings yielded as least as much as once or clean weeded wider spacings. Plant establishments in the last season were very low at the closer spacings. The cost of extra seeds for close spacings has to be kept in mind, making again the very close spacings, specially close intra-row spacings, less attractive. Yield per plant and in a similar way number of pods per plant were reduced by closer spacings, as in the first experiment, strongest by close intra-row spacings. This is similar to the findings of Malik et al. (1993). Buttery (1969) also states that the number of pods per plant is the first yield parameter affected by stress in soya bean. This stress is in the case of close spacings intraspecific competition. Another indication for this is the increased plant height at close spacings, pointing to light competition. L.A.I. was higher, mostly significant, at all close spacings compared to the recommended spacing, reflecting the earlier and better canopy closure of the close-spacing crops. The number of branches per plant was only affected at very close spacings in one season. Like in the first season, hundred seed weights did not show a consistent pattern in relation to spacing, though some differences were significant. Malik et al. (1993) did report that in soya bean, hundred seed weight was not affected by close spacings. It was affected by weed competition during the second season as in the first. Weed biomass measurements were again not clearly affected by the different spacings in the last season. Probably this occurred because all the crop canopies closed early this season due to high rainfall in the vegetative phase.

Conclusions

Under the conditions in Sri Lanka, cowpea spacings closer than the recommended spacing (30x15 cm) are better in terms of yield in unweeded fields, and most of the time in weeded fields. Unweeded fields with close spacings yielded at least the same as once weeded fields at the recommend spacing, which confirms that adapted spacings are a good base for integrated weed management systems. Deciding on an optimal spacing for cowpea MI-35, mechanical problems in very narrow rows and low plant establishment at very close spacings (high loss of extra seeds) have to be taken into consideration. 15x7 cm or 15x10 cm spacings are recommendable. Using very close spacings strongly reduces the number of pods/plant, leaf area/plant and increases plant height and plant mortality. However, this effect is compensated by the higher total number of plants present, and finally closer spacings develop a higher L.A.I. . Branches/plant are only reduced at very close spacings, the effect on 100 seed weight is less clear. Furhetr, a modified 2-way systematic design is a useful tool for screening large ranges of plant spacings, with or without weeding treatments. Almost all the trends found in the trial were confirmed during two seasons of conventional testing afterwards. The finally recommended spacings are close to the best spacings of

Table 3 : Conventional Spacing Experiment, Yala 1993.

	Yield (kg/ha)			Pods /m²			100 Seed Weight (g)			Plant Height	Branches
Weeding	No	1	Clean	No	1	Clean	No	1	Clean	(cm)	/ Plant
10x4	693w	561	563	116r	78	96ab		7.67ab		46a	8.4b
10x7	598	631	762	96r	77	87ab		7.78a		45a	9.0ab
15x4	762w	756	476	88	135r	77b		7.68ab		45a	8.9ab
15x7	416	679	701	67	120	94ab		7.24bc		45a	9.3a
30x15	223	626	752	53	76	113a		7.17c		36b	9.3a
Weeding							7.28b	7.52ab	7.72a		
R^2	n.s.	n.s.	n.s.	n.s.	n.s.	0.53		0.47		0.65	0.17
C.V.						40.3		7.7		11.1	8.17

Table 4 : Conventional Spacing Experiment, Maha 1993/1994

	Establ. Plants %	Yield (kg/ha)			Yield / plant(g)	Pods / m²	Pods / Plant	100 Seed Weight (g)			Plant Height	Branch / Plant	LAI (m²/m²)			L.A./ plant	Weed (kg/ha)	Biomass
Weeding		no	1	clean				no	1	clean	(cm)		no	1	clean	(cm²)	no	1
10x7	23c	1084a	754	739b	1.58b	102	2.0b	6.42	6.86	7.69a	51	6.5	3.04a	1.96a	2.52a	428r	398	84
10x10	33bc	532d	929	812a	2.49b	102	4.0ab	6.92	6.42	6.39b	48	6.3	1.53bc	2.56a	1.91ab	407r	452	75
15x7	26c	720bc	836	833a	2.07b	100	2.5b	6.72	6.46	5.83b	45	6.8	1.63bc	1.96a	2.16a	443	432	75
15x10	47b	649cd	914	705b	1.82b	101	2.5b	6.76	6.36	6.51b	45	7.0	2.55ab	1.92a	1.79ab	464	279	91
30x15	103a	837b	737	709b	3.97a	103	5.7a	6.98	7.19	7.70a	44	7.2	1.33c	0.96b	1.17b	481	580	89
R^2	0.79	0.78	n.s.	0.67	0.51	n.s.	0.41	n.s.	n.s.	0.70	n.s.	n.s.	0.76	0.82	0.68	n.s.	n.s.	n.s.
C.V.	36.9	15.1		5.7	56.2		86.7			9.5			33.2	20.6	28.6			

ab Duncan classification to separate significant categories(Pr>0.05 level).
r Significantly different from control if analyzed by rows.
w Significantly different from control if analyzed by intra-row spacing.

12x10 cm and 17.5x10 cm in the systematic design trial. The fact that plants are sometimes damaged through weeding practices points to a need of adapting weeding tools in future research.

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References

Burnside, O.C. and W.L. Colville (1964). *Soybean and Weed Yields as affected by Irrigation, Row Spacing, Tillage and Amiben.* Weeds, 12:109-112.

Buttery, B.R. (1969). *Effects of Plant Population and Fertilizer on the Growth and Yield of Soybeans.* Can.J.Plant Sci. 49:659-673.

Dept. of Agriculture (1990). *Crop Recommendations Technoguide*, Peradeniya, Sri Lanka, p.9-32.

Dept. of Census & Statistics (1992). *A Statistical Perspective of Cereals and Pulses in Sri Lanka, Colombo, Sri Lanka*, 152pp.

Felton, W.L. (1976). *The Influence of Row Spacing and Plant Population on the Effect of Weed Competition in Soybeans (Glycine max).* Aust. J. Exp. Agric. Anim. Husb. 16:926-931.

Howe, O.W. and L.R. Oliver (1987). *Influence of Soybean (Glycine max) Row Spacing on Pitted Morningglory (Ipomoea lacunosa) Interferences.* Weed Sci. 35:185-193.

Legere, A. and M.M. Schreiber (1989). *Competition and Canopy Architecture as Affected by Soybean (Glycine max) Row Width and Density of Redroot Pigweed (Amaranthus retroflexus). Weed Sci. 37:84-92.*

Malik, V.S., C.J. Swanton and T.E. Michaels (1993). *Interaction of White Bean (Phaseolus vulgaris L.) Cultivars, Row Spacing, and Seeding Density with Annual Weeds.* Weed Sci. 41:62-68.

Mayaki, W.C., I.D. Teare and L.R. Stone *(1976). Top and Root Growth of Irrigated and Nonirrigated Soybeans.* Crop Sci. 16:92-94.

Mc Whorter, C.G. and W.L. Barrentine (1975). *Cocklebur Control in Soybeans as Affected by Cultivar, Seeding Rates, and Methods of Weed Control.* Weed Sci. 23:386-390.

Mc Whorter, C.G. and W.C. Shaw (1982). *Research Needs for Integrated Weed Management Systems.* Weed Sci. 30:40-45 (Suppl. 1).

Mc Worther, C.G. and G.L. Sciumbato (1988). *Effect of Row Spacing, Benomyl, and Duration of Sicklepod (Cassia obtusifolia) Interference on Soybean (Glycine max) Yields.* Weed Sci. 36:254-259.

Mead, R. and Stern, R.D. (1980). *Statistical Aspects of Intercropping Research. Proc. Int. Workshop on Intercropping*, ICRISAT, Hyderabad, India.

Mitchell, R.L. and W.J. Russell (1974). *Root Development and Rooting Patterns of Soybean [Glycine max (L.) Merill] evaluated under Field Conditions.* Agron.J. 63:313-316.

Murdock, E.C., P.A. Banks, and J.E. Toler (1986). *Shade Development Effects on Pitted Morningglory (Ipomoea lacunosa) Interference with Soybeans (Glycine max).* Weed Sci. 34:711-717.

Stoller, E.W., S.K. Harrison, L.M. Wax, E.E. Regnier, and E.D Nafziger (1987). *Weed Interference in Soybeans (Glycine max).* Rev. Weed Sci. 3:155-181.

Van Damme, V., B. Meylemans and P. Van Damme (1994). *A Survey on Weed Management Practices in Upland Crops in the Dry Zone of Sri Lanka.* Mededl. Landbouwfac. 59 : 1345-1350.

Walker, R.H., M.G. Paterson, E. Hauser, D.J. Isenhour, J.W. Todd and G.A. Buchanan (1984). *Effects of Insecticide, Weed-free Period, and Row Spacing on Soybean (Glycine max) and sicklepod (Cassia obtusifolia) Growth.* Weed Sci. 32:702-706.

Wax, L.M. and J.W. Pendleton (1968). *Effect of Row Spacing on Weed Control in Soybeans.* Weed Sci. 16:462-465.

Weber, C.R. and D.W. Staniforth (1957). *Competitive Relationships in Variable Weed and Soybean Stands.* Agron.J. 49:440-444

Williams, C.F., G. Crabtree, H.J. Mack and W.D. Laws (1973). *Effect of Spacing on Weed Competition in Sweet Corn, Snap Beans and Onions.* J.Am.Soc.Hortic.Sci. 98:526-529.

THE DEVELOPMENT OF ALANG-ALANG CONTROL IN INDONESIA

Soepadiyo Mangoensoekarjo *

Indonesian Planters Association for Research and Development
(IPARD)
B O G O R 16151 Indonesia

Abstract

Alang-alang (*Imperata cylindrica* (L) Raeuschel) is one of the most troublesome weeds in plantation crops, upland food crops and deforested areas. Alang-alang control in 1960 was done by the use of dalapon 8,0 kg a.i./ha followed four weeks later by another equal application, early in 1970 glyphosate was applied at 2,0 kg a.i./ha, followed four weeks later by another similar application, and from 1980 up to now glyphosate alone or glyphosate mixed with urea or imazapyr at a dose of 16.8 kg/ha, or 1.0 kg a.e./ha respectively, has been used. Although the conventional kanpsack sprayer continues to be the main equipment for weed control, there has been more extensive use of alternative techniques such as a power sprayer and controlled droplet application (CDA) during the last decade. Water carrier rate is from 800 - 1000 l/ha to 100 - 200 l/ha, by this latter method.

Key Words : *Imperata cylindrica*. Alang-alang, Origen and extent, chemical control aromatic oil, dalapon, glyphosate, imazapyr, metsulfuron.

INTRODUCTION

Alang-alang (*Imperata cylindrica* (L.) Raeuschel is widely recognized as one of the most troublesome perennial grass weeds in the tropics. Holm (1969) listed alang-alang among the world's ten worst weeds in major agricultural areas in warmer regions. The grass is found in arable land, deforested and reforested areas, in shifting cultivation, upland food crops and plantations especially in rubber, oil palms, coconut, coffee, tea, and cocoa.

The climax vegetation of much of equatorial South East Asia is tropical rain forest, large areas of which are now under continuous sheet alang-alang. It colonises areas cleared of forest by commercial enterprises or for new settlements before cultivation takes place (Anwar and Bacon, 1986), or by shifting cultivators who abandon the land after fertility decilines to the point where crops do not give adequete returns for labour expanded. Alang-alang is well adapted for colonisation by means of airborne seeds or by rhizomes if there are plants nearby. Sheet alang-alang is a fire climex community, its rhizomes rapidly sprouting after burning, maintaining its dominenance in the ecosystem.

The grass appeas of particular importance in Southeast Asia, and in parts of Africa. In Southeast Asia it is known as lalang in Malaysia, cogon in the Philippines, illuk in Ceylon, contranh in Vietnam, sbauv in Khmer, Ya-ka in Laos and Thailand, and alang-alang in Indonesia. In Indonesia it has been regarded as a weed since 1930. In the first half of the 20th century biological and ecological studies were carried out or observations on alang-alang were made in connection with agriculture. Intensive and experimental ecological studies however only started about 1960. In that time it was realized that in the process of managing areas infested with weeds one has to know about many different aspects of the weed concerned. During the last few years increasing attention has been paid to alang-alang because of serious and steadily increasing economical problems it represents in large areas in Indonesia and in all of tropical countries. In Indonesia the area covered with this grass is estimated at 15-20 milion ha, with an annual increase of 150..000 ha (Soerjani, 1970). These areas constitute an economical problem in Indonesia as they have to be used for agricultural purposes, especially in transmigration projects.

CROPS LOSSES DUE TO ALANG-ALANG

In perenial estate crops, weeds are particularly troublesome during the first three years planting, before the young trees shade out the established vegetation. In young estate crops the magnitude of the weed problems is closely connected with planting distances, crop varieties and type of maintenance.

Because of its high growth rate alang-alang forms a strong competitor with other plants for common resources such as water and nutrients. It decreases soil nutrient status. Alang-alang causes retardation or complet stagnation of crop growth. In an extreme situation yellowing of the foliage will occur, and retardation of stem development will prolong the immature period. A severe retarding effect on growth of young mature rubber, and as much as a 40-50% retardation in growth in immature trees has been recorded over a 5 years period, such a retardation would mean a delay of 3 years in opening tapping.

In oil palm plantations, alang-alang decreases yield, and improverishes fertile soils of tea plantation, sometimes causing dieback of the bushes. In coffee plantations alang-alang has a definitely bad effect, and is a dangerous weed in cinchona nurseries. Alang-alang caused retardation of coconut growth, almost all palms showing yellowing of the fronds, the productions of surface feeding roots was reduced, whish tends to limit the nitrogen uptake. These phenomena indicate the effect of competition for nutrients and water or of the allelopathic effect of alang-alang upon other crops. The possible existence of an allelopathic mechanism in the harmfull effect of alang-alang upon coconut.

METHOD OF CONTROL

Considering the great regreneration capacity of alang-alang by way of rhizomes it is essential in the control of this grass to eradicate all viable buds or at least prevent them from forming new aerial shoots. Hand weeding is which all plants parts are removed from the field, may therefore be an effective control method however is very costly.

Chemical control of alang-alang is mostly practised by estates which have a paid labour force that can be assigned to the task, and generally it is impractical for smallholder farmers with limited incomes. The advantages of chemical over mechancial control are that it is often cheaper, quicker and involves less soil disturbance. There is less risk of erosion than if the land is cleared by cultivation, especially on sloping land. Disadvantages of chemical control are that large volumes of water and skilled labour may be needed, it may be prohibitively expensive and there is the possibility of toxicity to non-target plants.

The first herbicides used to control alang-alang were Na arsenite and aromatic oils, in the 1930s (Mangoensoekarjo, 1980). Both required numerous applications, and Na arsenite is very toxic. Organic herbicides were developed later, including the halogenated aliphatic acids in the 1960 (e.g. dalapon, tetrapion), substituted phenols (e.g. PCP), bipyridyls (paraquat), and others in the 1970 (e.g. glyphosate, imazapyr).

Aromatic Oil

Aromatic oils such as Sovacide and Shell alang-alang oil (mineral oil + PCP) are commonly used as contact herbicides. They can be used only for interrow crop areas or non-agricultural land. Rates of 1,000 to 1,200 l/ha pure oil are required followed by a further three or four lesser applications with a 3 to 4-week interval (Simanjuntak 1963, Mangoensoekarjo and Kadnan 1972, Anon 1974).

Sodium Arsenite

Sodium arsenite has been used for alang-alang in Indonesia. The everage dose used successfully is 15.0 kg/ha, followed by either the same dose or 8.0 kg/ha, four times or more as needed, with an interval of 8 to 30 days between applications. The oral LD_{50} is 10-50 mg/kg, and Riepma (1968) reported that skin contact causes dermatitis; therefore there is an appreciable danger of toxicity to man and animals, which forced the Indonesia Gevernment to ban the chemical completely as of September 1974.

Dalapon

Dalapon (2,2-dichloropropionic acid). This herbicide was first introduced in the later 1940s. Usually formulated as the Na or Mg salt in a 74% in 85% solution, it is a slow acting systemic herbicide which is absorbed by both leaves and roots. It is translocated to the meristems where it percipitates proteins and disrupts enzyme production; therefore is most effective when applied to rapidly growing shoots. It takes 6-20 weeks for maximum effect to be achieved. The best solution concentration appears to be 1.0-1.5%. Higher concentrations kill leaf tissues on contact, preventing translocation.

Dose required depends on the stage of growth, found that 10.0 kg a.i./ha applied to vigirously growing shoots that had been cut a month earlier gave more than 90% control for longer than 4 months, with little subsequent regrowth. On older, 1 m long shoots which were still growing, 15.0 kg a.i./ha was necessary for a similar level of control. On mature shoots in dry conditions, only temporary control was achieved. Treatment early in the rainy season gave better control than later, but it was ineffective if applied too soon after slashing when shoots were small.

Recommended doses and number of applications vary, but total quantity is usually in the region of 8.0-15.0 kg a.i./ha (Mangoensoekarjo, 1980). Low doses have some effect (Soedarsan *et al.* 1978) found that 5.0 or 10.0 kg/ha reduced numbers and weights of shoots and rhizomes. However, the most effective rates are between the 15.0 and 20.0 kg a.i./ha. Most workers recommend two applications a month apart, the second usually being about 60-70% of the first dose. Some recommend a third low dose, and even spot wiping thereafter. Wetting agents are sometimes recommended .

Other adjuncts ti dalapon tested include tetrapion, aminotriazole (Mangoensoekarjo, 1980), and urea (Mangoensoekarjo and Nurdin 1978), to a great improvement if 8.0 kg a.i./ha dalapon with 8.0 kg/ha urea is used (Mangoensoekarjo and Nurdin 1978).

Paraquat

Paraquat has been investigated for use a second spray after dalapon (Mangoensoekarjo, 1980). Application of dalapon is reduced to 5.0-8.0 kg a.i./ha, and is followed between 1 and 4 weeks later by paraquat at 0.3-1.0 kg a.i./ha. This procedure is estimated to be as effective as dalapon applied at the standard rate of if 20.0 kg a.i./ha, giving control for up to 4 months.

Glyphosate

Glyphosate (N(phosphono-methyl) glycine). This translocated herbicide was first introduced in the early 1970a, and has proved to be a most effective agent for controlling alang-alang. The manufacturers claimed that at 1.44 kg a.e/ha it would kill shoots and suppress rhizomes of alang-alang for 10 weeks after treatment (Monsanto, 1971), maximum destruction occuring 40-50 days after treatment. Efficacy is not dependent upon volume of carrier, thus it can be applied using weed wipers or in low volume as well as high volume sprays. However, it does suffer from a number of disadvantages. It is very expensive and not rain fast so, if rain falls within 6 hours of treatment, it may need to be repeated.

Glyphosate is more effective under shade, requiring approximately half the dose needed for open field conditions for the same level of control. Also, effective dose may need to be doubled if soil moisture content is high, maintained that shade had a greater influence upon efficacy than wet or dry season applications.

Some workers have recommended split applications, usually with one or 2 months between them at the rate of 1.50-2.88 kg a.e/ha on each occasion (Mangoensoekarjo, 1979).

Tests upon the volume of carrier seem to give contradictory results, but these may be due to differing conditions at time of application, the application of glyphosate through very low volume nozzles in a volume of 200-250 litres/ha. Arif *et al.* (1986) found that 1.8 kg a.e/ha applied using a Micron Herbi spinning disc applicator (CDA) gave as good control as glyphosate applied with a conventional knapsack sprayer. However, there have been a number of reports that glyphosate at 1.8 kg a.e/ha 20 litres water/ha has not given as good control of alang-alang as a knapsack sprayer.

Bacon and Kusnanto (1964) tested two models of weed wiper for clearance of alang-alang stands. Glyphosate was applied diluted 1 : 2 with water, and one model used 3 litres/ha whilst the other. of local manufacture, used 15 litres/ha. A Moderate level of control was obtained, and follow up application was necessary. Treatment of swards which had been slashed first and allowed to regrowth to 50 cm was more successful than treatment of full height swards.

A number of fertilizer leave been tested to determine if they would improve the efficacy of glyphosate, i.e. that addition of 16,8 kg/ha urea to 2,2 kg a.e./ha glyphosate was effective against alang-alang (Mangoensoekarjo and Kadnan, 1979)

Imazapyr

Imazapyr (RS)-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl) nicotine acid). This new herbicide is very effective against alang-alang. It is translocated, but the period to total sward necrosis is often 3-4 months (Boonsirat *et al.*, 1985). The dose required for complete control of alang-alang appears to be from 0.5 to 1.0 kg a.e/ha, the higher figure giving more consistent action. Complete destruction did not occur until ten weeks after treatment. Kill was sustained for up to 250 days after treatment, and no secondary weed infestation occurred up to 270 days after treatment. Boonsirat *et al.* (1985) observed less than 10% regrowth 305 days after treatment with a dose rate 0.75 kg a.e./ha in Thailand. Initial work by Bacon (1985) suggested that imazapyr was equally effective whether applied by conventional knapsack sprayer or spinning disc applicator, although because of its viscosity the latter did have to be calibrated carefully. As imazapyr is so slow in action against alang-alang, combination with glufosinate ammonium has been tested to determine if response can be quickened, that addition of 1.2 kg a.e./ha glufosinate ammonium to 1.0 kg a.e/ha imazapyr was effective, necrosis occurring within a week of application.

REFERENCES

Anon 1974. Cara-cara pemberantasan alang-alang. Lembaran Teknis Karet Seri Karet 1,6,2. Balai Penelitian Perkebunan Medan 8 pp.

Anwar A,T. Sutono and W. Harahap 1986. Lalang grass control with low spray volume of glyphosate herbicide. Symposium in Weed Science, Biotrop Special Publication no. 24 Indonesia. pp 317 - 339.

Anwar A and P.S. Bacon 1986. Comparison of Imperata-control by manual, chemical and mechanical methods for smallholder rubber farming systems. Symposium in Weed Science. Biotrop Special Publication no. 24 Indonesia. pp 307 - 316.

Bacon, P.S. and U. Kusnanto. 1984 Use of direct contact herbicide applicatiors for controlling *Imperata cylindrica* (L) Beauw, Proceedings of the 7th Indonesia Weed Science Conferences. pp 189 - 197.

Bacon, P.S. 1985. New developments in herbicide control of *Imperata cylindrica* (L) Beauw Proceeding of the first Tropical Weed Science Conference. Vol. II. Hat hai Thailand. pp 447 - 462.

Boonsirat C, K.S. Chee dan S.C. Lee. 1985. AC. 252, 925, A new herbicide for use in rubber plantations. Proceeding of the 10th. Asian-Pacific Weed Science Society Conference Chiangmai, Thailand. pp 99 - 106.

Holm, L.R. 1969. Weed problems in developing countries. Weed Science 17. pp 113 - 118.

Mangoensoekarjo S. dan N. Kadnan. 1972. Pemakaian herbisida secara bergantian terhadap sheet alang-alang. Bull. BPP Medan III (1) pp 107 - 116.

Mangoensoekarjo S. and Nurdin. 1978. Preliminary trial on the control of alang-alang (*Imperata cylindrica* (L) Beauw) the influence of mixing urea with dalapon. Bull. BPP Medan 9. pp 103 - 108.

Mangoensoekarjo, S. 1979. Glyphosate trials on plantation crops in North Sumatera. Symposium herbicide Round Up 3, Medan, Indonesia.

Mangoensoekarjo, S. an N. Kadnan 1979. Control *Imperata cylindrica* in immature rubber: the influence of mixing urea with herbicide. Proceeding of the 7th. Asian-Pacific Weed Science Conference Sydney, Australia. pp 111 - 113.

Mangoensoekarjo, S. 1980. Alang-alang problems and their control in Estate crops. Proceeding of Biotrop workshop on alang-alang. Biotrop Special Publication No. 5 Indonesia. pp 79 - 87.

Monsanto Europe. S.A. 1971. Mon - 1139. Post emergence herbicide. Weed Abstract 1972 no. 1061.

Riepma, K.P. 1968. Pans. 14, pp 43 - 60.

Simanjuntak, M.T. 1963. Pemberantasan alang-alang khususnya penelitian metoda kimia. Menara Perkebunan 32 (5) pp 83 - 87.

Soerjani, M. 1970. Alang-alang (*Imperata cylindrica* (L) Beauw); Pattern of growth as related to its problem of control. Biotrop Bull no. 1 88 pp.

Soedarsan, A, K. Wargadalem and E. Suhendar. 1978. Dalapon-Mg (Dowpon M) and buthidiazole (Ravage) as lalang eradicants. Menara Perkebunan 46. pp 81 - 86.

EFFECTS OF GLYPHOSATE, TRICLOPYR, FLUROXYPYR ON FEVER VINE *(PAEDERIA SP.)* CONTROL IN UPLAND FIELD

T. Sangtong and S. Kanjanajirawongs
Botany and Weed Science Division, Department of Agriculture
Bangkok 10900, Thailand.

Abstract Two years of repeated use of glyphosate 1350,1800, 2250 g.(ai)/ha., triclopyr 200, 300, 400 g (ai)/ha.,fluroxypyr 200, 300, 400 g.(ai)/ha., for controlling fever vine *(Pederia sp.)* were undertaken in central Thailand. Herbicides were sprayed on young fever vine stems in January of 1991,1992. Fluroxypyr and triclopyr at all rates gave very good control on weeds with higher rate providing better control than lower; fluroxpyr was more active than triclopyr and prolonged efficacy up to 16 weeks after treatment.Gly phosate provided satisfactory control of weeds although weeds were not completely killed by the herbicide, they remained severely stunted more than 16 weeks, Statistical differences from untrated fields were obtained in weed dry weights and weed number per unit area by the herbicide treatments.

Introduction

Fever vine (*Paederia sp.*) a broadleaf, perennial herbaceous plant belongs to Rubiaceae family has been found to be a very serious weed in upland crop fields,waste places and roadsides (Noda,1985). In crop fields it can be problems since land preparation until crop harvesting and the difficulties to control this weed neither by manual or mechcanical due to its capabilities of repreducing of new shoots after cutting or ploughing as well as the propragation either by vegetative or reproductive means. Further more with the long deep root, fever vine can nomally grow or reproduce even in the dry season under severe drought condition. To control this specific weed specie, two years repeatedly use of herbicides glyphosate,triclopyr, and fluroxypyr were investigated in farmers upland fields.

Materials and Methods

The experiments were conducted in farmer's upland fields in Lopburi Province, central part of Thailand where farmers usually grow soybean corn or tobacco during the rainy season. Usually after crop harvesting (January) farmers would plough the land to kill and incorporate the existing weeds in to the soil and then fallow the land until rainy season for cropping period(May-November). The experiments were started in January 1991 after land ploughing and the new shoots of fever vines were about 50-70 cm. long, glyphosate at 1350, 1500. 2250 g a.i./ha., triclopyr at 200, 300, 400 g a.i./ha. and fluroxypyr at 200, 300 g. a.i./ha. was sprayed on weeds by knapsack sprayer with the volume spray about 375 l/ha. The experiment was repeated in the same experimental plot in January 1992. Assesments of phytotoxicity, weed control, weed cover, weed dry weights as well as weed number/area were done to investigate the efficacy of herbicide treatments comparing with the untreated treatment. The experiments were designed in RCB with 4 replications. The plot side measured 7x8 square meters.

Results and Dicussion

Fever vines showed the same reponse to each of rate of herbicides of the two year repeated application (Table 1,2).Fluroxypyr and triclopyr provided excellent control of weeds with the higher rate showed faster and more effects on weed than lower rate and fluroxypyr were more, of the same rate, effective than triclopyr. The weeds showed the symptoms of yellowing and wilting of the whole plant within 1-2 weeks and turned black, twisted stem and drying completely about 4-5 weeks after herbicide applications and prolonged efficacy up to more than 16 weeks. A.B. Baba et al.1985 reported that generally fluroxypyr was more active than triclopyr at all treated weed species and C.O.Love 1993 introduced that fluroxypyr was a readily translocated herbicide and exhibited a high degree of activity with post emergence foliar application of broad-leaved weed. The rapidly and effective control of fluroxypyr and triclopyr caused lower in weed area cover and were statistical difference in weed dry weight from untreated treatment of both years of herbicide application.The weed dry weights collected at 16 weeks from treatments treated with fluroxypyr or triclopyr were from fever vines which emerged late after herbicide application and very few from recovering of treated weeds.Glyphosate caused slowly effect on fever vines. The abnormal growth of wilting and stunting of the weeds were visible about 10-15 days after herbicide treatment. The peak of satisfactory control by glyphosate, especially the highest rate ,were about 8-16 weeks although the weeds were not killed by the herbicide they remained wilted stunting for more than 16 weeks and the weed dry weights were also significant different from the untreated treatment. After the second year application the weeds were more affected by glyphosate especially at the higher rate in which the treated weeds were much stunted and some weeds could not emerge to the soil surface causing lower weed area cover and dry weed weights than in the first year application. The results also indicated, at 24 weeks after herbicide treatment and after one plough before cropping in rainy season, the plant number per area of fever vine in every herbicide treatment was highly significant different from the untreated control (table 3). After the first year application and because of the rapid ,higher and longer effective control the number per area of fever vine treated with fluroxypyr were less than treatment treated with triclopyr or glyphosate ,but at the same duration after the second year herbicide application and because of the severe stunted and unemerged of the weeds caused the number of weedy plant treated with glyphosate were much less than treatments treated with fluroxypyr or triclopyr.

References

A.B. Baba et. al 1985. Fluroxypyr, picloram, triclopyr and chlopyralid for braodleaf weed control in Malaysia plantation.Proc. 2 10th APWSS Conference, Bangkok p. 601-607.

C.O. Love 1993. The use of fluroxypyr for broadleaf weed control in soybean in Southern Queensland and Northern New South Wales, Proc. 1 10th Australian and 14 th APWSS Conference, Brisbane, Australia p.133-136

Noda. K., C.Prakongvongs and L. Chaiwiratunkul.1986. Major weeds in Thailand 164 p.

Table 1 Effects of herbicide on fever vine control at Ta-Luang, Lopburi dry season 1991.

Treatment	rate g. ai/ha.	phytotoxicity (0-10)[1] WAA[2]			control (%) WAA			weed cover (%) WAA		dry wt. g/$28m^2$
		4	8	16	4	8	16	0	16	16WAA
1. triclopyr	200	6.5	7.0	6.7	83	83	63	80	22	252 b
2. triclopyr	300	6.8	7.3	7.1	88	93	70	70	16	572 b
3. triclopyr	400	7.2	7.5	7.1	95	97	85	71	9	315 b
4. fluroxypyr	200	8.5	9.2	8.1	97	97	84	84	7	354 b
5. fluroxypyr	300	8.8	9.5	8.2	98	98	87	71	6	271 b
6. fluroxypyr	400	9.8	9.8	9.3	100	100	90	78	5	262 b
7. glyphosate	1350	3.2	5.2	5.3	15	20	40	63	50	1827 b
8. glyphosate	1800	3.6	5.6	5.7	17	31	43	70	51	1231 b
9. glyphosate	2250	4.0	5.8	5.9	18	32	47	74	50	1589 b
10.check	-	0	0	0	0	0	0	75	98	3789 a
								N.S.		**
cv								**13.7**		**89.0**

1.(0-10) : 0 = no effect 10= complete kill
2.WAA : week after herbicide application

Table 2 Effects of herbicide on fever vine control at Ta-Luang, Lopburi dry season 1992.

Treatment	rate g. ai./ha	phytotoxicity (0-10)[2] WAA[2]			control (%) WAA			weed cover (%) WAA		dry wt. g/$28m^2$
		4	8	16	4	8	16	0	16	16WAA
1. triclopyr	200	8.1	8.5	7.2	95	95	81	88	26	512 b
2. triclopyr	300	8.2	8.5	7.8	96	95	88	56	12	364 b
3. triclopyr	400	9.2	8.8	8.3	100	94	92	51	10	266 b
4. fluroxypyr	200	9.5	9.2	8.8	98	95	90	43	16	248 b
5. fluroxypyr	300	9.8	9.5	8.9	100	97	96	21	3	144 b
6. fluroxypyr	400	9.9	9.6	9.1	100	97	94	43	8	133 b
7. glyphosate	1350	4.8	5.6	5.8	37	73	78	65	31	1248 b
8. glyphosate	1800	5.0	6.0	5.9	50	82	81	75	25	517 b
9. glyphosate	2250	5.1	6.2	6.3	50	85	82	63	26	577 b
10.check	-	0	0	0	0	0	0	88	98	3105 a
								N.S.		**
cv								**24.7**		**38.9**

1.(0-10) : 0 = no effect 10= complete kill
2.WAA : week after herbicide application

Table 3 Effects of herbicides on plant number and dry weights of fever vine during rainy season in 1991 and 1992.

Treatment	rate	Plant number/$28m^2$			
		July 1991 (24 WAA)		July 1992 (24 WAA)	
	g.(ai)/ha	number	%	number	%
1. triclopyr	200	15 bc	43	37 b	46
2. triclopyr	300	10 bc	29	20 bc	25
3. triclopyr	400	6 c	17	24 bc	30
4. fluroxypyr	200	6 c	17	15 c	19
5. fluroxypyr	300	7 c	20	13 c	16
6. fluroxypyr	400	5 c	14	7 c	9
7. glyphosate	1350	18 b	51	8 c	10
8. glyphosate	1800	18 b	51	6 c	7
9. glyphosate	2250	10 bc	28	7 c	9
10.check	-	35 a	100	81a	100
		**		**	
cv		89.0		38.4	

WAA:week after herbicide application

CONSERVATION TILLAGE IN SUGARCANE

K. Tanphiphat [1] and P. Prammanee [2]

ABSTRACT A conservation tillage program has been proposed as an alternative practice to reduce loss of soil productivity in the Thailand sugarcane industry. Ploughing was replaced by Roundup at 2.16 kg ae/ha sprayed to destroy an old sugarcane crop and natural vegetation. The herbicide was sprayed with a knapsack sprayer on regrowing ratoon cane, after harvesting a final crop when average height was 0.5 - 1.0 m. New sugarcane was planted between old rows using combination of either fertilizer applicator or trash shredder and regular sugarcane planter. Early sprouting of sugarcane in no-till plots was better than that in conventional plots. Growth and tillering of stalks/hill at 3 and 6 months after planting did not differ between no-till and conventional till practice. Soil analysis results indicated that no-till plots contained higher organic matter and total nitrogen than conventional till plots, while available P, exchangeable K, electro-conductivity and pH remained the same.

Key words Notillage, glyphosate, sugarcane, no-till planter

INTRODUCTION

Sugarcane is an important economic crop of Thailand which comprises the total planted area of 1 M hectares. Sugarcane field in Thailand has long suffered from the excessive mechanical cultivation. The process for land preparation including leveling and cultivation in preparation for planting have all been done using heavy mechanical equipment. The effect of these repeated working on soil characteristics has been serious. The soil losts its structure, becomes compact. The hard pan which occurs under the top soil retards growth and development of cane roots. In addition, the soil decreases its water holding capacity and causes run off and erosion.

Fundamental reasons for ploughing is to control weeds and preparing seedbed for establishing a new crop. It was not until 1970's when new concept on conservation tillage was developed. The benefits of the new system are so obvious that more than one million hectares of crop in the U.S.A. are now planted annually with little or no land preparation. In sugarcane, it was not until the advent of the herbicide glyphosate that minimum and notillage farming became feasible. In South Africa, Iggo and Moberly 1976 developed a technique in which, at planting, old, regenerating sugarcane was killed using glyphosate at 2.8-3.5 kg/ha and then new cane setts were planted between old rows.

Results of notillage in sugarcane are rather controversy. It has been demonstrated on the lighter soils of South Africa that the minimum tillage technique gave yield advantage of ten percent in the plant crop and five percent in the first ratoon crop compared with normal cultivation (Moberly and Turner 1978). This fact, together with other advantages, has led to rapid commercial acceptance of the system, and the method is now becoming standard practice in South Africa. On the contrary, McMahon and Teske 1989 found that notillage never produced significantly higher yields than the conventional tillage. Three out of their six trials were subject to yield loss from notillage treatment which corresponded to a financial loss of approximately $ 325 per hectare.

1.) Monsanto Thailand Limited, Bangkok, Thailand

2.) Supanburi Field Crops Research Center, Supanburi, Thailand

The information on notillage in Thailand sugar industry is limited. The objectives of this study were to evaluate the possibility of notillage practice in sugarcane in Thailand and to develop planting equipment for planting new cane under the heavy trash, unburnt field situation.

MATERIALS AND METHODS

Rate and timing of glyphosate for old ratoon control

Rate and application timing of glyphosate were evaluate for ratoon cane control. After second ratoon crop was harvested, the field was irrigated to stimulate regrowth of the old ratoon. Glyphosate at 1.08, 1.62 and 2.16 kg ae/ha was applied, to regrowing ratoon cane when the average height was 0.5 and 1.0 m. Equipment use was knapsack sprayer which delivered spray volume of 200 L/ha. Sugarcane control was visually evaluated at 7, 15 days and monthly after application. Shoot dryweight was measured at 90 days after application. Experimental design was split plot with three replications.

Effect of different land preparation practices on sugarcane establishment and yield

Experiment was conducted in Supanburi province in unburnt field. Soil type was hydromorphic, non-calcic brown soil (Kampangsaen series). Experimental design was five replicates strip trial with the following treatments:

1.) Conventional planting treatment. The old ratoon was removed by cultivation consisting of one round of disk plough and two rounds of harrow plough.

2.) No-till planting treatment using fertilizer applicator to manage residue prior to planting. After the third ratoon was harvested, glyphosate at 2.16 kg ae/ha was sprayed by using knapsack sprayer, at the spray volume of 200 L/ha on regrowing ratoon cane when average shoot height was 1.0 m. Ten days after application new cane was planted between the old rows. Because of a heavily trashed situation. A fertilizer applicator, equipped with coulter was used to cut leaf residue prior to planting by regular sugarcane planter.

3.) No-till planting treatment using trash shredder to manage residue prior to planting. Methods were similar to that of treatment 2 except that trash shredder was used instead of fertilizer applicator, for residue management prior to planting.

Sugarcane in all treatments was planted on May 6, 1994. Three and six months after planting, sugarcane growth such as plant height and number of stalks/hill were recorded. Soil analysis was done at 6 months after planting.

RESULTS AND DISCUSSION

Rate and timing of glyphosate for old ratoon control

Glyphosate at 1.62 - 2.16 kg ae/ha demonstrated good efficacy for ratoon cane control (Figure 1, 2). At lower rate the herbicide was less effective. Application of glyphosate on 1m tall cane provided better control than that did on 0.5m tall. Dryweight of treated shoot was significantly reduced when glyphosate at 2.16 kg ae/ha was applied to sugarcane when average shoot height was 1m (Table 1). Little regrowth occured at 90 days after application. The regrowing shoots exhibited a witches boom symptom and was not able to survive.

Effect of land preparation on sugarcane establishment and yield

Fertilizer applicator used as residue managing equipment performed better than trash shredder. Coulter on fertilizer applicator cut trash effectively and enable planter to plant into the cut tract more precisely than that did by trash shredder.

Notillage demonstrated good potential as an alternative practice to mechanical cultivation in sugarcane. Growth of sugarcane in no-till treatments was not significantly different from that in conventional planting treatment. Shoot height and number of stalks/hill at 3 and 6 months after planting remained the same among different treatments (Table 2, 3). It was observed that early sprouting of sugarcane in no-till plots was better than that in the conventional plot. Large amount of leaf residue in no-till plots might help conserve soil moisture and resulted in better initial growth. Soil analysis results showed that percent organic matter and total soil nitrogen, expressed as percent of dryweight, from no-till plots were significantly higher than those in conventional plot. Available phosphorus and exchangeable potassium also showed increasing trend although it was not statistically different. Other soil characteristics such as electrical conductivity and pH remained unchanged. Sugarcane yield, collected as bulk sample of five replications, was higher in no-till than that in conventional till plot.

Use of glyphosate in combination with no-till planter could be an alternative for farmers to improve soil productivity in sugarcane industry in Thailand. It was clearly demonstrated that notillage practice increased soil organic matter and soil nutrients especially nitrogen. Leaf residue that covered soil surface might help conserve soil moisture. All of these factors might have contribute to higher yield in no-till practice.

A planter equipped with coulter was designed and tested by Department of Farm Mechanics, Kasetsart University. When tested under heavy trashed conditions, the planter worked effectively with working speed of 0.42 ha/h with operating cost of 7 USD/ha. When compared with traditional labor planting and conventional planter, no-till practice helped farmer save 92 USD/ha and 61.5 USD/ha, respectively.

Although notillage practice demonstrated good potential for success in plant cane, farmers have raised concerns on the reduction in yield of ratoon cane. Growth and yield of ratoon cane needed to be further monitored.

LITERATE CITED

1. Gebhardt, M. R. and K. J. Fornstrom. 1985. Weed Control in Limited-Tillage Systems In R. H. Hodgson. Limited-Tillage System. Monog. Ser. Weed Sci. Soc. No.2:242-254

2. Iggo, G. A. and P. K. Moberley. 1976. The concept of minimum tillage in sugarcane. Proc. South African Sugar Technol. Assoc. 50:141-143

3. McMahon G. G. and L. H. Teske 1989. Minimum Tillage Planting. Proc. of Australian Society of Sugarcane Technologists. 1989. pp. 85-87

4. Moberly, P. K. and P. E. T. Turner. 1978. The Minimum Tillage System for Re-establishing sugarcane fields. Proc. 16th Congress ISSCT, 9-25 Sept., 1977. Sao Paulo, Brazil. Pages 1377-1382

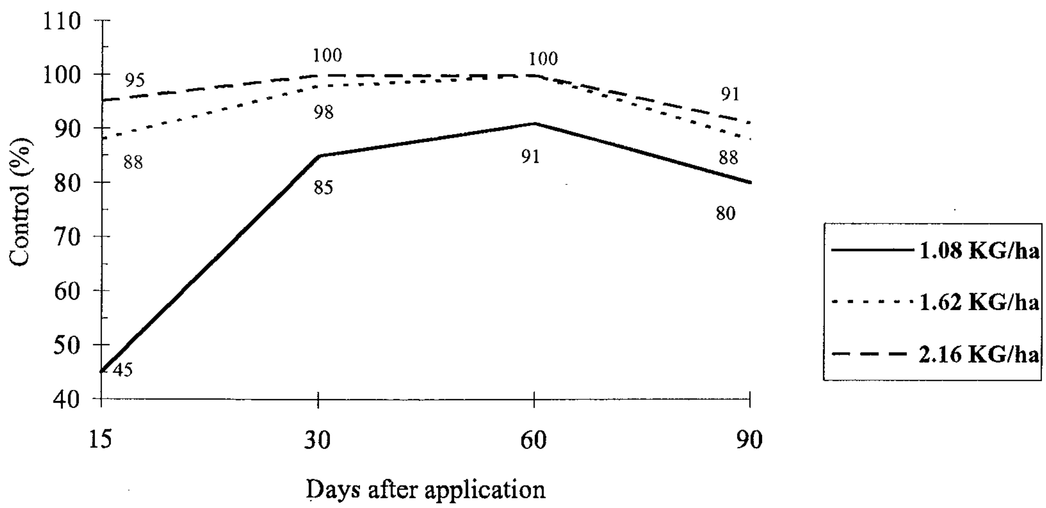

Fig. 1. Effect of glyphosate on ratoon cane control.
Application was made when shoot height was 0.5m.

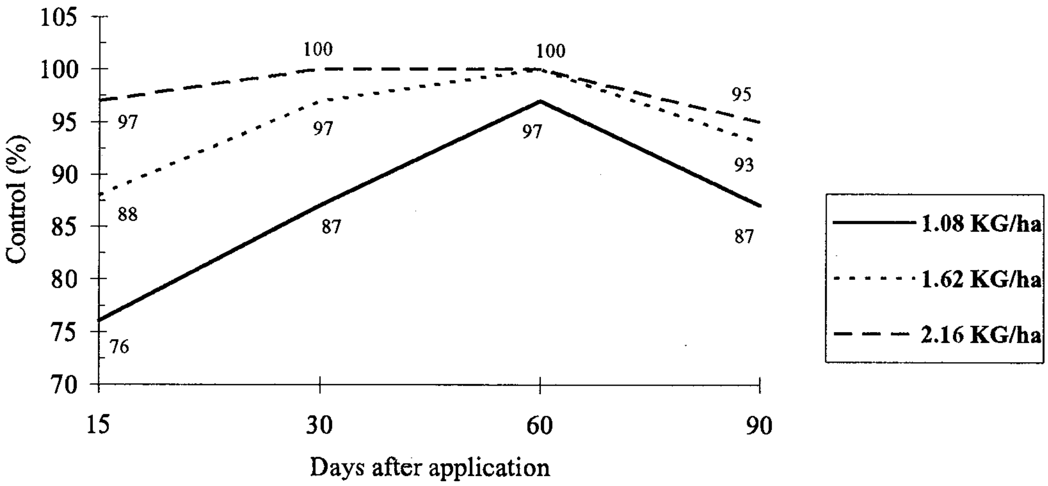

Fig. 2. Effect of glyphosate on ratoon cane control.
Application was made when shoot height was 1m.

Table 1 Shoot dryweight of sugarcane at 90 days after application of glyphosate. The herbicide was sprayed when average shoot height was 0.5 and 1.0 m.

Treatment (Kg ae/ha)	shoot dryweight (gm)	
	0.5 m	1.0 m
Control	3483[a]	1811[a]
glyphosate 1.08	470[b]	298[b]
glyphosate 1.62	166[b]	240[b]
glyphosate 2.16	126[b]	68[c]

Table 2 Shoot height, Number of stalks/hill and yield of plant cane from different plant methods

Treatment	Shoot height (m)		Number of stalks/hill		Yield [3)]
	3 months	6 months	3 months	6 months	Tons/ha
1) Conventional Tillage	0.35	1.62	4.9	4	50
2) Notillage [1)]	0.34	1.69	5.4	4.2	75
3) Notillage [2)]	0.33	1.63	5.1	4.5	62.5
F-test	NS	NS	NS	NS	-
LSD	0.03	0.13	0.5	0.6	-
CV	6.1	5.3	6.1	0.9	-

1) No-till planting using fertilizer applicator to manage leaf residue prior to planting by regular planter

2) No-till planting using trash shredder to manage leaf residue prior to planting by regular planter

3) Bulk sample of five replications

Table 3 Soil chemical properties under 3 different tillage systems in the farmer's field in Supanburi. Organic matter (OM) and total nitrogen (Total N) are expressed as percent of dry weight. Available Phosphorus, exchangeable potassium and electrical conductivity are expressed in ppm and m mho, respectively.

Treatments	OM (% OD wt)	Total N (% OD wt)	avai P (ppm)	exch K (ppm)	EC (m mho)	pH
1. Conventional Tillage	1.83	0.081	74	167	0.8	6
2. Notillage [1]	2.14	0.09	79	145	1.2	4.6
3. Notillage [2]	2.07	0.094	102	192	1.2	5.7
F-test	**	**	NS	NS	NS	NS
LSD 0.5	0.17	0.006	47.6	88	0.37	1.6
CV	5.6	4.6000	38.3	36.2	23.6	19.8

1) Notillage planting using fertilizer applicator to manage leaf residue prior to planting by regular planter

2) Notillage planting using trash shredder to manage leaf residue prior to planting by regular planter

Table 4 Cost comparison between conventional and no-till planting

Operation	Cost (USD/ha)		
	Conventional		
	Labor	Planter	Notill
Land Preparation			
Primary tillage	37.5	37.5	-
Secondary tillage	50.0	50.0	-
Planting Cost			
Herbicide [1]	-	-	51
Seedbed	25	25	-
Labor cost [2]	-	37.5	-
Operation cost [3]	7	-	7
TOTAL	119.5	150	58

1) Herbicide + spray cost

2) Twenty persons/ha/day

3) USD/ha

Effect Of MON 12000 On The Germination Of Turfgrasses

J. D. Ranjit & G. E. Coats
Agronomy Division, Khumaltar, Nepal & Mississippi State Uni., USA

Abstract: Two separate experiments were initiated at Mississippi State University in the greenhouse on 4/5/1994 and 5/24/1994 to determine the effect of MON 12000 on the germination of common bermudagrass, perennial ryegrass, annual bluegrass, roughstalk bluegrass, dallisgrass, centipedegrass, tall fescue and creeping bentgrass. The design of the experiment was a split plot replicated four times with plot size 0.30 by 0.46 m. The herbicide MON 12000 was applied as pre emergence at the rate of 0.018, 0.035, 0.070, 0.140, 0.280, & 0.56 kg ai/ha. The highest rate, 0.56 kg ai/ha, of MON 12000 significantly suppressed germination of bermudagrass, roughstalk bluegrass, tall fescue, and creeping bentgrass by 40 to 80% but not perennial ryegrass, annual bluegrass, dallisgrass, or centipedegrass. Germination response to MON 12000 was mainly a quadratic type in all turfgrasses, except in creeping bentgrass. The percent fresh and dry weight of turfgrasses differed significantly with check by 10 to 80 percent except in centipedegrass with a quadratic and cubic trend, respectively.

Key word: MON 12000, Fresh wt., Dry wt., Stand count, Turfgrass

INTRODUCTION

Many herbicides have been tested for use in warm and cool season turfgrasses. Bermudagrass tolerates dichlofop {(#)-2-[4-(2,4-dichloro phenoxy) phenoxy]propanoic acid } very well (7). However, rate response was evident with higher rates resulting in increased phytotoxicity. But the turf recovered within 3-14 days after application. Ac 263,222 {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-methyl-3-pyridinecarboxylic acid} at 0.06 kg ai/ha, alone or in combination with imazaquin {2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-quinoline-carboxylic acid} (0.21 kg ai/ha) significantly effected height of bermudagrass more than imazaquin (0.42 kg ai/ha) applied alone (4). However, metribuzin [4-amino-6-(1,1 dimethyl-ethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one] applied alone or in combination with dichlofop damaged the turf at unacceptable levels (7). Red fescue (*Festuca rubra* L.), tall fescue was injured with dichlofop, but dry weight and color of bentgrass was not changed by dichlofop rates of 0.6 - 1.1 kg ai/ha (8, 3). Sulfometuron {2[[[[(4,6-dimethyl-2-pyrimidinyl)amino] carbonyl]amino]sulfonyl]benzoic acid} at 105 g ai/ha killed bahiagrass (*Paspalum notatum* Fluege) seedling in newly planted centipedegrass and Tifway bermudagrass (*Cynodon dactylon* (L) Pers. x *C. transvaalensis* Burtt-Davy)turf . However, mefluidide {N-[2,4-dimethyl-5-[[(trifluoromethyl) sulfonyl] amino]phenyl] acetamide}, the activity of MON 4620 N-{[(acitylamino)-methyl]-2-chloro-N-2,5-(diethylphenyl) acetamide} plus paclobutrazol [(2RS,3RD)-1-(-4-chloro-phenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)pentan-3-ol}, paclobutrazol plus mefluidide and flurprimidol [α-(-methylethyll)-αr-(4-trifluoromethoxy) phenyl-5-pyrimidinemethanol] plus mefluidide was minimal on bahiagrass (5, 6). Fenoxaprop (#)-2-[4-[(6-chloro-2-benzaxazolyl)oxy}phenoxy]propanoic acid} applied between late-winter and mid-spring selectively controlled roughstalk bluegrass in perennial ryegrass grown for seed (11).

MON 12000 is a new sulfonylurea herbicide of Monsanto Company which selectively controls yellow nutsedge (*Cyperus esculentus* L.) and purple nudsedge (*Cyperus rotundus L.*) in most turfgrasses including Kentucky bluegrass (Poa pratensis L), perennial ryegrass, creeping bentgrass, tall fescue, bermudagrass and zosiagrass (*Zoysia japonica* Steud.)(14, 2, 13, 1). Perennial kyllinga (*Cyperus brevifolia* Rottb.) and purple nutsedge were controlled 80 -89% by two application of MON 12000, chlorimuron {2-[[[[4-chloro-6-methoxy-2-pyrimidinyl)amino]carbonyl]amino] sulfonyl]benzoic acid}, and imazaquin in centipedegrass and St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Ktze.) (9). MON 12000 controlled yellow nutsedge and rice flatsedge (*Cyperus iria L.*) in sweet potato (12).

This experiment was conducted to find out the effect of MON 12000 herbicide on the germination of eight turfgrasses.

MATERIALS AND METHODS

Two separate experiments were initiated at Mississippi State University in the greenhouse on 4/5/1994 and 5/24/1994. The design of the experiment was a split plot replicated four times with plot size 0.30 by 0.46 m. The soil used for this experiment was sandy loam : sand, 2:1 by volume, with pH of 8.2. The turfgrasses used for this experiment were common bermudagrass, perennial ryegrass, annual bluegrass, roughstalk bluegrass, dallisgrass, creeping bentgrass, centipedegrass, and tall fescue. Seed of each turfgrass were mixed with the soil and then put in 10 by 12.7 cm cups, separately. There were seven treatments including the check. The herbicide MON 12000 50 WP was applied as a preemergence treatment with the increasing rates from 0.018 to 0.56 kg ai/ha. The herbicide was applied with spray chamber. The nozzle type and size was a flat fan & 8002E, respectively, with one nozzle. The boom height was 30 cm with 3.21 km/h at 234 l/ha. Moisture was maintained at the field capacity. Weeds were removed by hand.

Stand count was done 2 and 4 weeks after treatment (WAT). counts were converted to percent of the untreated. Shoot fresh and dry weight were taken 4 WAT and were also converted to percent of the untreated fresh weight (PERFRSWT) and dry weight (PERDRYWT), respectively.

RESULT AND DISCUSSION

With all the variables, there was a significant interaction between treatments and species. Hence the analysis of variance and trend analysis with general linear model was done for all the individual turfgrasses.

Turfgrasses responded differently to MON 12000. Perennial ryegrass, tall fescue, and annual bluegrass turned yellowish brown in color following treatment. However, there was no drastic change in the plant height up to 0.070 kg ai/ha. But plant height was slightly reduced at the higher rates. Roughstalk bluegrass and creeping bentgrass was highly retarded and the color of the plants changed into dark purplish brown. A slight reduction in plant height was noted without drastic color change when dallisgrass was treated with MON 12000.

a) Effect of herbicide rates on stand count on 2 and 4 WAT

Germination on 2 and 4 WAT was significantly reduced (quadratic trend) at 2 and 4 WAT. At both times, germination decreased with the higher rates of MON 12000 (0.24 to 0.56 kg ai/ha). Although there was no significant differences among the rates 0.14 - 0.56 kg ai/ha, germination of perennial ryegrass was reduced compared to lower rates. All rates reduced annual bluegrass and dallisgrass germination compared to the untreated but no difference due to MON rates of 0.018 to 0.56 kg ai/ha at 2 WAT, with a cubic and quadratic trend, respectively (Table 1). However, there were significant differences at 4 WAT with a quadratic trend in annual bluegrass. The trend analysis in roughstalk bluegrass showed a cubic response due to herbicide rates. The highest rate 0.56 kg ai/ha significantly decreased the germination compared to other rates, except 0.14 kg ai/ha at 2 WAT. At 4 WAT, germination decreased at rates of 0.070 to 0.56 kg ai/ha however, no difference were observed within this rate range. In centipedegrass, there was a rate response from 0.14 - 0.56 kg ai/ha, but were not significantly differ among those rates. The rate response was quadratic and linear trend at 2 WAT & 4 WAT, respectively. The response of tall fescue was a quadratic at 2 and 4 WAT. At higher rates of 0.28 - 0.56 kg ai/ha, response was obvious in tall fescue at 2 and 4 WAT but were not significantly different with each other.

With creeping bentgrass the rate (0.14 - 0.56 kg ai/ha) response was noted in 2 and 4 WAT showed a linear trend (Tables 1 & 2). The tolerance of turfgrasses to MON 12000 at 2 WAT was annual, bluegrass & tall fescue less than 0.018 kg ai/ha; bermudagrass, dallisgrass, & roughstalk bluegrass 0.018 kg ai/ha; centipedegrass 0.035 kg ai/ha; and perennial ryegrass & creeping bentgrass 0.070 kg ai/ha (Table 1).

b) Effect of herbicide rates on fresh and dry shoot weight

There were no significant differences in percent fresh weight of bermudagrass among rates however, there was a significant difference in percent dry weight at 0.28 kg ai/ha. For perennial ryegrass there was a significant difference among the herbicide rates on both percent fresh and dry weight. A significant decrease in percent fresh and dry weight was noted in 0.14 - 0.56 kg ai/ha with a cubic and quadratic trends, respectively. There was no significant difference among the herbicide rates on percent fresh and dry weight of annual bluegrass, except on 0.28 kg ai/ha which differd significantly from 0.018 - 0.070 kg ai/ha. The trend of percent fresh and dry weight was a quadratic and cubic, respectively. The trend on percent fresh and dry weight was a linear and quadratic respectively, for dallisgrass. However, there was no significant difference among the herbicide rates in both percent fresh and dry weight.

Roughstalk bluegrass showed a highest rate (0.56 kg ai/ha) response in percent fresh weight but not in percent dry weight with a cubic trend. With centipedegrass, 0.14 and 0.28 kg/ha showed a significant difference than in the rest rates with a quadratic trend in both percent fresh and dry weight. Although there were no significant differences among rates, a prominent rate response was observed in fresh and dry weight with a cubic trend for tall fescue. The percent fresh and dry weight was not significantly different among the herbicide rates with cubic trend in creeping bentgrass (Table 3 & 4).

From the above result, it can be concluded that the response of all turfgrasses except creeping bentgrass to MON 12000 was a quadratic at 2 & 4 WAT. At 0.56 kg ai/ha, MON 12000 significantly suppressed the germination of bermudagrass, roughstalk bluegrass, tall fescue, and creeping bentgrass by 40 to 80 percent. Germination of perennial ryegrass, annual bluegrass, dallisgrass, and centipedegrass was not significantly reduced.

The percent fresh and dry weight of turfgrasses differed significantly with check by 10 to 80 percent, except centipedegrass with a quadratic and cubic trend, respectively.

The results from this study are different with other findings reported by other researchers under field conditions with perennial ryegrass, tall fescue, bermudagrass, centipedegrass and St. Augustinegrass (9, 14). The tolerance of turfgrasses varied 2 WAT in the greenhouse. Hence, this research work needs to be repeated under field conditions.

LITERATURE CITED

1. Boyd, J. W. 1993. Nutsedge suppression in bermudagrass turf. Proceedings SWSS 47:75.
2. Cuarezma, J. A., L. Smith, and N. E. Jackson 1993. MON 12000 for nutsedge (*Kyllinga brevifolia* Rottb.) control on Florida golf course. WSSA Abstracts 33:26.
3. Dernoeden, P. H. 1990. Comparison of three herbicides for selective tall fescue control in Kentucky bluegrass. Agron. J. 82:278-282.
4. Goatly, J. M. Jr., V. L. Maddox, and R. M. Watkins 1993. Growth regulation of common bermudagrass [*Cynodon dactylon*(L) Pers.] with imazaquin and AC 263222. Weed Technol. 7:746-750.
5. Hanna, W. W., C. W. Swann, J. Schroeder, and P. L. Utley 1989. Sulfometuron for eliminating bahiagrass (*Paspalum notatum* Fluege) from centipedegrass [*Eremochloa ophiuroides* (Munro) Hack.] and bermudagrass [*Cynodon dactylon* (L) Pers.]. Weed Technol. 3:509-512.
6. Johnson, B. J. 1990. Response of bahiagrass (*Paspalum notatum* Fluege) to plant growth regulators. Weed Technol. 4:895-899.
7. McCathy, L. M., L. C. Miller, and D.L. Colvin 1991. Bermudagrass (*Cynodon* spp.) cultivar response to dichlofop, MSMA and metribuzin. Weed Technol. 5:27-32.
8. McCarty, L. B. 1989. Bentgrass tolerance to postemergence grass herbicides. Agron. Abstr. 81:161.
9. McCarty, L. B., and D. L. Colvin 1993. Postemergence purple nutsedge [*Cyperus rotundus* (L) Pers.] and perennial kyllinga (*Cyperus brevifolia* Rottb.) Hassk.) control in Centipedegrass and St. Augustinegrass sod. WSSA Abstracts. 33:26.
10. Murphy, G. P., and W. W. Wilt 1993. Efficacy and corn response of MON 12000 in three tillage. WSSA Abstracts 33:105.
11. Mueller-Warrant, G. W. 1990. Control of roughstalk bluegrass (*Poa trivialis* L.) with fenoxaprop in perennial ryegrass (*Lolium perenne* L.) grown for seed. Weed Technol. 4:250-257.
12. Porter W. C. 1994. Sedge (*Cyperus* spp.) control in sweet potatoes. Proceedings SWSS 47:79.
13. Sherrick, S. L., A. P. Burkhalter, J. A. Cuarezma, and J. F. Mason 1993. MON 12000 - A new herbicide for control of purple nutsedge (*Cyperus rotundus* L.) and yellow nutsedge (*Cyperus esculentus* L.) in turfgrass. Proceeding SWSS 46:99.14. Travers, J. N., M. B. Spaur, R. O. Radke, D. R. Williamson, and C. R. Schulze 1993. Effect of spray volume, simulated rainfall and mowing on yellow nutsedge (*Cyperus esculentus* L.) control with MON 12000. WSSA Abstracts 33:25.

Table 1. Effect of MON 12000 on germination of turfgrasses 2 WAT.

Treatments	Rate	CYNDA	LOLPE	POAAN	PASDI	POATR	ERLOP	FESAR	AGSST
	Kg ai ha^{-1}	% of check							
MON 12000	0.018	94ab	92a	82b	76abc	86a	85abc	83b	88ab
MON 12000	0.035	83c	96a	81b	71bc	53b	87ab	83b	87ab
MON 12000	0.070	84c	85a	84b	71bc	37bc	80bcd	73b	84ab
MON 12000	0.140	86bc	61b	79b	58c	32cd	69cd	69b	76bc
MON 12000	0.280	64d	57b	85b	71bc	37bc	67d	40c	79bc
MON 12000	0.560	57d	49b	83b	90ab	17d	70cd	37c	62c
CV		10	23	17	36	35	21	21	22
LSD(.05)		8	18	ns	ns	18	17	15	19
Linear		-	-	-	-	-	-	-	s
Quadratic		s	s	-	s	-	s	s	-
Cubic		-	-	s	-	s	-	-	-

Means within a species followed by the same letter do not differ significantly at the 0.05 level of probability according to Fisher's protected LSD.

Table 2. Effect of MON 12000 on germination of turfgrasses 4 WAT.

Treatments	Rate	CYNDA	LOLPE	POAAN	PASDI	POATR	ERLOP	FESAR	AGSST
	Kg ai ha^{-1}	% of check							
MON 12000	0.018	80b	74bc	85bc	73b	71b	89ab	69b	89ab
MON 12000	0.035	74b	89ab	87abc	78ab	58b	88ab	67b	86ab
MON 12000	0.070	74b	92ab	93ab	76b	41c	85b	66b	79ab
MON 12000	0.140	65bc	65cd	77c	74b	32cd	82b	60bc	71bc
MON 12000	0.280	47d	68cd	76c	61b	23d	78b	43c	72bc
MON 12000	0.560	53cd	51d	86bc	81ab	21d	76b	43c	56c
CV		23	23	16	28	33	15	29	25
LSD(.05)		17	18	14	ns	17	13	19	20
Linear		-	s	-	-	-	s	-	s
Quadratic		s	-	s	s	-	-	s	-
Cubic		-	-	-	-	s	-	-	-

Means within the species followed by the same letter do not differ significantly at the 0.05 level of probability according to Fisher's protected LSD.

Table 3. Effect of MON 12000 on fresh weight of turfgrasses 4 WAT.

Treatments	Rate	CYNDA	LOLPE	POAAN	PASDI	POATR	ERLOP	FESAR	AGSST
	Kg ai ha^{-1}	% of check							
MON 12000	0.018	63b	82b	63b	71b	42b	86ab	61b	34b
MON 12000	0.035	69b	74bc	58b	70b	38b	91ab	57b	19b
MON 12000	0.070	64b	64cd	62b	63b	37bc	76bc	42c	23b
MON 12000	0.140	65b	54de	49bc	66b	41b	60cd	33c	22b
MON 12000	0.280	55b	50de	39c	59b	24bc	57d	35c	19b
MON 12000	0.560	54b	46e	54bc	53b	14c	74bc	35c	27b
CV		28	21	30	36	55	21	26	52
LSD(.05)		19	14	18	26	24	17	14	18
Linear		-	-	-	s	-	-	-	-
Quadratic		s	-	s	-	-	s	-	-
Cubic		-	s	-	-	s	-	s	s

Means within the species followed by the same letter do not differ significantly at the 0.05 level of probability according to Fisher's protected LSD.

Table 4. Effect of MON 12000 on dry weight of turfgrasses 4 WAT.

Treatments	Rate	CYNDA	LOLPE	POAAN	PASDI	POATR	ERLOP	FESAR	AGSST
	Kg ai ha^{-1}	% of check							
MON 12000	0.018	74b	93ab	66b	74b	45b	93a	70b	25bc
MON 12000	0.035	72	84bc	62b	67b	41b	92a	57c	18c
MON 12000	0.070	70b	72cd	64b	67b	29b	86ab	45d	21bc
MON 12000	0.140	72b	58de	53b	58b	41b	76bc	37de	17c
MON 12000	0.280	47c	50e	52b	54b	33b	69c	24f	16c
MON 12000	0.560	61bc	45e	61b	55b	26b	85ab	26ef	30b
CV		23	22	26	35	60	17	22	30
LSD(.05)		17	16	17	24	28	15	12	10
Linear		-	-	-	-	-	-	-	-
Quadratic		s	s	-	s	-	s	-	-
Cubic		-	-	s	-	s	-	s	s

Means within the species followed by the same letter do not differ significantly at the 0.05 level of probability according to Fisher's protected LSD.

Development of Samurai CDA for General Weed Control in Plantation and Orchard Crops

Y.T. Teng and T.J. Chang
Monsanto Malaysia Sendirian Berhad,
Kuala Lumpur, Malaysia.

Abstract.

The hand operated knapsack sprayer is the most commonly used spray equipment for application of herbicide to control weeds in plantation and orchard crops in Malaysia. Such knapsack sprayers are fitted with various hydraulic nozzles but this method of applying herbicides has been recognised to be highly inefficient. A wide range of droplets produced, small ones being prone to drift while large droplets are likely to run off leaf surfaces. This results in considerable wastage of chemicals and has potentially harmful environmental impact. This method of applying herbicides is also labour demanding. Malaysia is rapidly progressing towards its objectives of achieving an industrialised national status. This has further aggravated the actual shortage and rising cost of labour in the agricultural sector because of competition for labour from the industrial, manufacturing and construction sectors. Monsanto, being a leading herbicide company, embarked on a massive development program in 1990 to develop new spray techniques with glyphosate aimed at improving labour and spraying efficiency, and applying more cost-effective weed control in plantation and orchard crops. Evaluations were made on several controlled droplet applicator (CDA) models for weed control with glyphosate. By further modifying the CDA to suit local conditions, the Samurai CDA was developed. This technique of weed control has reduced the dependency on a large volume of water and size of the workforce. Moreover, it has resulted in greater efficiency of the workers and reduced weeding costs.

Key words: Samurai CDA, Glyphosate, Plantation crops, Orchard crops, Weed control.

INTRODUCTION

The hand operated knapsack sprayer is the most commonly used spray equipment for application of herbicide to control weeds in plantation and orchard crops in Malaysia. Such knapsack sprayer are fitted with various hydraulic nozzles but this method of applying herbicides has been recognised to be highly inefficient. Malaysia is rapidly progressing towards its objectives of achieving an industrialised nation status. This has further aggravated the acute shortage and rising cost of labour in the agricultural sector. There is clearly a need to change traditional labour intensive application techniques to methods that are labour saving, more efficient and most cost-effective in weed control.

OBJECTIVE

Monsanto, being a leading herbicide company, embarked on a massive development program in 1990 to develop new spray techniques with glyphosate aimed at improving labour and spraying efficiency, and applying more cost-effective weed control in plantation and orchard crops.

MATERIALS AND METHODS

Evaluations were made on several controlled droplet applicator (CDA) models for weed control with glyphosate. Further modifications and improvement of the selected CDA model to suit the local conditions was carried out in the development. The selected CDA model was further evaluated in users reliability trials in plantation and orchard corps to determine its reliability, ease-of-operation, efficiency, cost-effectiveness and suitability for local conditions.

1) Evaluation of Samurai CDA using Roundup for General Weed Control in Mature Rubber and Oil Palm.

Ten trials were carried out in mature rubber and oil palm plantations to evaluate the performance of Samurai CDA using 8% Roundup solution for general weed control. The spray volume was 25 liters for hectare. The main weeds in the trial areas were *Ottochloa nodosa, Paspalum conjugatum, Axonopus compressus, Eleusine indica, Digitaria adscendens, Asystasia Gangetica, Borreria latifolia, Cyperus spp.*, and legume cover crops. Comparison was made with the conventional knapsack sprayer (CKS) fitted with floodjet fan nozzle 2.0 mm orifice diameter using Roundup at 2.0 liters per hectare and (Paraquat+Diuron) at 2.8 liters per hectare. A spray volume of 450 liters per hectare was used.

For rubber, only the planting strips were sprayed. For oil palm, both the harvesting paths and the palm circles were sprayed. For each treatment, the plot size was 0.1 hectare and there was no replication. General weed control based on weed desiccation was evaluated at 7, 15, 30, 60 and 90 days after treatment (DAT).

2) Evaluation of Samurai CDA Using Spark for General Weed Control in Orchard Crops.

Three trials each were established in mature orchard crops of guava, starfruit, mango, durian, and jackfruit respectively where the main weeds were *Eleusine indica, Digitaria adscendens, Paspalum conjugatum, Cleome rutidosperma, Cyperus spp., Borreria latifolia, Asystasia Gangetica, Ageratum conyzoides*, and *Erigeron sumatrensis*. There were three treatments in each trials.

24.0% Spark solution was used with Samurai CDA for spraying the weeds at a spray volume of 25 liters per hectare. As a comparison, Spark and paraquat was used to treat weeds at a rate of 6.0 liters and 2.8 liters per hectare respectively and using the CKS fitted with the floodjet fan nozzle 2.00 mm orifice diameter.

For orchard crops, the whole trial area was treated (blanket spraying). For all these trials, the plot size for each treatment was 0.05 hectare and there was no replication. General weed control was evaluated based on the method used in the plantation crops trials.

RESULTS

The Samurai CDA when used for application of glyphosate for weed control offers significant advantages and benefits over conventional knapsack systems.

The advantages and benefits include:

1) Water required for spraying very much reduced. Reduced water needs and cost by 94% (Table 1).

2) Extremely labour efficient. One worker covered three times the area sprayed when compared with knapsack system (Table 2).

3) Reduced application costs by 60% over knapsack system (Table 3).

4) More effective and broader spectrum of weed control because of its uniform droplet size, even droplet distribution and retention of spray droplets (Tables 4 and 5).

Table 1. Comparison on water requirement using knapsack and Samurai CDA for treating one hectare of weeds.

Spray technique	Spray volume	
	Blanket hectare	Spray hectare
Knapsack	450 liters	126 liters
Samurai CDA	25 liters	7 liters
Water saving by Samurai CDA	425 liters (94%)	119 liters (94%)

Table 2. Comparison of labour efficiency between knapsack system and Samurai CDA for spraying weeds.

Spray technique	Area sprayed (hectares/day)		
	Mature oil palm	Mature rubber	Orchard crops
Knapsack	1.3	1.7	0.5
Samurai CDA	3.8	5.0	1.5
Labour efficiency of Samurai CDA : Knapsack	3:1	3:1	3:1

Table 3. Comparison of application cost between knapsack vs Samurai CDA

Spray technique	Cost per field hectare/round (US$)			Total cost (ha/round)
	Labour	Equipment	Battery	
Knapsack	2.80	*	-	US$2.80
Samurai CDA	0.93	0.13**	0.06	US$1.12
Samurai CDA saves (60%)				US$1.68

* Assumes zero cost for CKS equipment.

** Cost of Samurai CDA equipment + One Spare Motor is US$160.00 and can last 1,200 spray hours minimum.

Table 4. General weed control in plantation crops

Treatment	Rate/ha	Equipment	Percent control (DAT)				
			7	15	30	60	90
Roundup	2.0L	Samurai CDA	65	85	95	90	85
Roundup	2.0L	CKS	50	75	90	85	80
Paraquat + diuron	2.8L	CKS	90	80	65	50	35

(Average of ten trials)

Table 5. General weed control in orchard crops

Treatment	Rate/ha	Equipment	Percent control (DAT)				
			7	15	30	60	90
Spark	6.0L	Samurai CDA	80	90	98	85	70
Spark	6.0L	CKS	70	80	95	75	50
Paraquat	2.8L	CKS	95	70	50	30	10

(Average of 15 trials)

CONCLUSION

This technique of using the Samurai CDA with glyphosate for weed control in plantation and orchard crops had reduced the dependency on a large volume of water and size of the labour force. Moreover, it has resulted in greater efficiency of the workers and reduced weeding costs.

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References

1 TENG, Y.T., Teh, K.H. and Chang, T.J. (1991). Monsanto PD Annual Report, 150: 45-60.

2 TENG, Y.T., Teh, K.H. and Chang, T.J. (1992). Monsanto PD Annual Report, 187:83-94.

3. TENG, Y.T. and Lim, A.H. (1993). Samurai CDA Sprayer, 2nd Ed., 24 pages.

4. TENG, Y.T., Teh, K.H. and Chang, T.J. (1993). The use of Samurai CDA for general weed control (including *Hedyotis verticilatta*) in plantation and orchard crops. Seminar, on management of selected weeds in Malaysia, Feb. 1993, Kuala Lumpur.

5. TEOH, C.H. (1985) Recent Developments in Pesticide Application Technology.

6. TEOH, C.H., Wong, P.W. and Sabudin, M.A. (1983). Herbicide Application Technology in Malaysia. Pesticide Application Technology, MAPPS.

RESIDUE OF FLUROXYPYR IN SOIL AFTER APPLICATION FOR KNOCKDOWN OF PINEAPPLE PLANTS

O. Wongkasem*, P. Krasaesindhu and U. Suwunnamek

Department of Agriculture, Kasertsart University, Bangkok 10900, Thailand

Abstract. A study on the residue of fluroxypyr in Phangnga soil series at varying depths and times after its application was carried out in a greenhouse of the NWSRI project and in pineapple fields in Rayong Province, Thailand. The amounts of fluroxypyr were analyzed by GC with an ECD detector. The results in the greenhouse showed that fluroxypyr in soil decreased with depth and time after application. At normal rate, the greatest fluroxypyr residue of 400 ppb was found at 0-5 cm depth at 0 time after application. At 10-20 cm depth and 6-12 weeks after application less than 10 ppb residue was found. Under field conditions fluroxypyr residue also decreased with time and depth. In a bioassay test, tomato plants grown for 12 weeks in soil treated with fluroxypyr in which about 5 ppb residue was found had a dry weight just 77% that of untreated control, whereas cucumber plants grown similarly showed no effects on growth and dry weight.

Key words : soil residue, fluroxypyr, pineapple

Introduction

According to the previous reports, it was found that fluroxypyr can be used for killing old pineapple plants before the new planting will be made. (Lertwatanakiat and Suwunnamek, 1988) By this method, new crop can be planted at least 2 to 3 months earlier than the normal practice. In order to avoid the harmful effects of fluroxypyr on new pineapple crops, it is necessary to deternime the residue of fluroxypyr in soil at varying depths and times after application. The experiments were carried out in the greenhouse and the field. The soil samples were taken at 0-12 week after application with 0-5, 5-10, 10-15 and 15-20 cm depths. The amounts of fluroxypyr were analysed by Gas Chromatography with ECD detector.

Materials and Methods

1. The residue of fluroxypyr in Phangnga soil series in the greenhouse. The experiment was designed as 4 x 5 factorial in CRD with 4 replications. Fluroxypyr was applied at the rate of 2.25 kg a.i./ha. The soil samples were taken at 0, 4, 6, 8, and 12 weeks after application with 4 depths : 0-5, 5-10, 10-15 and 15-20 cm. The amounts of fluroxypyr in soil were analysed by Gas Chromatography.

2. The residue of fluroxypyr in soil after application for knockdown of pineapple plants. The experiment was designed as 3 x 4 factorial in CRD with 4 replications. Fluroxypyr was applied to the old pineapple plants at the rate of 2.25 kg a.i./ha and the soil samples were taken at 0, 6 and 12 weeks after application with 4 depths.

3. For bioassay test, tomato and cucumber plants grown in soil treated with fluroxypyr for 0-12 weeks compared with untreated. The dry weight of shoots was determined for 2 weeks after planting.

Results and discussion

1. The amounts of fluroxypyr at varying depths and times after application were significant. (Table 1). Fluroxypyr residue was found the most 113.49 ppb at 0 week and the least 0.74 ppb at 12 weeks. The amount of fluroxypyr decreased after application and depth. At 0-5 cm depth the residue was 118.32 ppb. It was found that there was no fluroxypyr residue at 12 weeks with 5-20 cm. Lehmann et.al. (1990) reported that fluroxypyr was found to degrade readily in soil before it moved to soil profile.

2. Fluroxypyr residue in soil under field condition was significant. (Table 2). The amount of fluroxypyr decreased at various depth and time after application. It was found that fluroxypyr residue at 0-5 cm depth with 0 week was 27.70 ppb. There was fluroxypyr residue at the depth of 15-20 cm because the pineapple plants treated fluroxypyr were ploughed into the soil.

3. For bioassay test, the dry weight of shoot of cucumber and tomato plants were determined for 2 weeks after planting. (Table 3). It was found that fluroxypyr caused injury to tomato in soil treated with fluroxypyr for 12 weeks. The dry weight of shoot was 0.450 g or

77.28% of control. The dry weight of cucumber shoot in soil treated with fluroxypyr 0 and 6 weeks were 0.754 and 1.166 g or 52.12 and 88.33% of control respectively. However, cucumber plant was not injury in soil treated with fluroxypyr for 12 weeks in which about 5 ppb residue was found.

Conclusion

The fluroxypyr residue decreased at various depth and time after application. Cucumber plant was not injury in soil treated with fluroxypyr for 12 weeks. It might be concluded that fluroxypyr was not harmful for the new pineapple plants.

References

Lehmann, R.G., J.R. Miller and D.A. Laskowski. 1990. Fate of fluroxypyr in soil : II Desorption as a function of incubation time. Weed Res. 30 : 383-388

Lertwatanakiat, S. and U. Suwunnamek. 1988. Application of certain pyridinyl herbicides for intercycle knockdown of pineapple. Proc. Trop. Weed Sci. Conf. 2 (1) : 73-80

Table 1 Residue of fluroxypyr in Phangnga soil series in the greenhouse

times (weeks)	depths (cm) 0-5	5-10	10-15	15-20	Ave.
(after application)	ppb				(time)
0	427.79	18.80	7.37	0	113.49
4	110.60	18.47	4.18	0	33.31
6	37.90	18.98	0.73	0	14.40
8	12.34	0.88	0.59	0.80	3.65
12	2.97	0	0	0	0.74
Ave. (depth)	118.32	11.43	2.57	0.16	

LSD (0.05) time = 13.04, depth = 11.66, time x depth = 26.07

Table 2 Residue of fluroxypyr in soil after application for knockdown of pineapple plants

times (weeks)	depths (cm) 0-5	5-10	10-15	15-20	Ave.
(after application)	ppb				(time)
0	27.70	14.23	9.96	0	12.97
6	18.50	10.70	6.63	5.14	10.24
12	10.19	5.79	2.79	1.86	5.16
Ave. (depth)	18.79	10.24	6.46	2.33	

LSD (0.05) time = 5.36, depth = 6.19, time x depth = 10.72

Table 3 Dry weight of tomato and cucumber plants from soil treated with fluroxypyr

Treatments	tomato		cucumber	
	dry weight	% of control	dry weight	% of control
	—— g ——		—— g ——	
control	0.590	100	1.320	100
0 WAA*	0.142	26.06	0.754	52.12
6 WAA*	0.346	58.64	1.166	88.33
12 WAA*	0.456	77.26	1.376	104.24
LSD (0.05)	0.138		0.295	

* WAA = Weeks after application

Weed Control Efficiency of New Herbicides in Direct Seeded and Transplanted Riec

B.C.Ghosh and B.N.Mittra
Department of Agricultural and Food Engineering,
IIT,Kharagpur, India

Abstract : Metsulfuron methyl (Ally) at 3g and 4 g a.i./ha and Chlorimuron ethyl (Classic) at 3g and 4 g a.i./ha were tested along with butachlor and anilophos at sub-optiomal doses in direct seeded and transplanted rice during kharif (warm, wet) season. Butachlor at 1500 g a.i./ha and anilophos at 400 g a.i./ha were used as standard herbicides along with hand weeded and unweeded control for comparison. The predominant weeds were Digitaria sanguinalis (L) Scop. Paspalum conjugatum Berg., Echinochloa crusgalli (L.) Beauv. Ludwigia perennis L.in direct seeded rice and that of Cyperus sp. Fimbristylis miliacea (L) Vahl and Ludwigia perennis L. in transplanted rice. Crop weed competition was much higher in direct seeded than transplanted paddy and reduced the grain yield by 88% and 22% respectively under weedy check treatment. In transplanted paddy field different herbicide treatments kept the plot weed free till harvest. In direct seeded rice combined application of ally and classic each of 4 g/ha was effective in controlling the grassy weeds and thereby increased grain yield (1370 kg/ha) more significantly than their individual applications. Weed control efficiency was further increased when butachlor or anilophos was combined with ally and classic at sub-optimal doses. Of the total N removed the weeds in direct seeded and transplanted rice account for 80% and 18%, respectively.

Key words: Herbicides, Direct seeded rice, Transplanted rice, Nutrient uptake, Weed density

Introduction

Rice is the most important cereal crop in India occupying about 40 million hectares of area with a total production of 72 million tonnes (FAI, 1992). In the traditional rice belt of eastern India, this crop is grown either by direct seeding or transplanting depending upon land situation and rainfall distribution pattern. Direct seeded rice faces severe weed problem than transplanted rice and the average losses of yield in case of former is estimated as 10-50% (Manna, 1983), while in latter as 11-20% (DeDatta, 1981;Mukhopadhyay, 1983). The low weed infestation in transplanted field was mainly due to manipulation of soil for puddling and submerged condition prevailed in the field . Under intensive cropping with rice, some weed flora that have

(L) Scop., Ludwigia perennis L.

For last few years, a number of herbicides have been used to control weeds in paddy field with different degree of success. Butachlor and anilophos have been the most effective and widely accepted rice herbicides. In this investigation two new herbicides were tested alone or in combination with standard herbicides at sub-optimal doses to findout their nature and extent of weed control and their effect on growth and yield of both transplanted and direct seeded rice.

Materials and Methods

Two field experiments were conducted at Agrciultural and Food Engineering Department Farm, Indian Institute of Technology, Kharagpur, West Bengal, India on direct seeded and transplanted rice during kharif (Wet,worm) seasons of 1994. The area is situated $22^{0}19'$N and $87^{0}19'$E at an altitude of 48 m above mean sea level in a sub-humid climate with an average rainfall of 1200-1500 mm, most of which is received during June to September. The soil of the experimental site is laterite, light textured and acidic in nature (pH 5.2).

The experiments were carried out in Randomized Block Design with 16 treatments (Table 1 and 2) replicated three times. The rice cultivar was IR 36. The new herbicides metsulfuron methyl (Ally) chlorimuron ethyl (Classic) and standard herbicides butachlor (Machete 50% EC) anilophos (Arozin 30 EC) were tested alone as well as in their conbination at different doses (sub-optimal dose in case of butachlor and anilophos). A treatment of weed free and unweeded check were included for comparison. Ally and classic are available as 20% and 25% W.P. respectively. The herbicides were dissolved in water, mixed with sand and applied evenly over each plot. In case of combined application, they were mixed in desired proportion and applied in the field in same way. Butachlor and anilophos were applied at 2 days after sowing (DAS) in direct seeded rice and 3 days after transplanting (DAT) in transplanted rice while ally and classic at 7 DAS/DAT in both the experiments. A common dose of 80 Kg N, 60 Kg P_2O_5 and 40 Kg K_2O /ha was applied in all the treatments. A water regime of 5 $\pm$ 2 cm submergence was maintained in transplanted rice, while a moist soil condition (field capacity to saturation) mostly prevailed in case of direct seed rice.

Observations were taken on weed density and dry weight of weeds 40 days after herbicide application and at harvest and grain yield/ha and N- uptake by crops and weeds.

Results and Discussion

Weed Flora : The weed flora in the experimental field consisted of grasses, sedges and broad leaf weeds. The common weed species of both the experiments were Digitaria sanguinalis (L.)Scop., Paspalum distichum L, Ludwigia perennis L. Cyperus rotundus L. However, other weed species Echinochloa crusgalli (L.)Beauv. and Cynodon dactylon (L.) Pers. were observed in direct seeded and Fimbristylis miliacea (L.) Vahl. in transplanted rice field.

Effects on Weeds: In direct seeded rice, different herbicide treatments controlled the weeds and reduced their density as well as dry matter (Table 1). Ally and classic both were found effective in controlling grassy weeds. The weed control effciency was further increased when these two herbicides were combined along with butachlor or anilophos at sub-optimal doses. At 40 DAS maximum dry matter of weeds of 4730 kg/ha obtained in unweeded control treatment and it was recorded less by 27.5 to 77.3 % under different herbicide treatments. At initial growth stage of rice though the grassy weeds Paspalum distichum, Digitaria sanguinalis were controlled but subsequently Ludwigia parennis, Panicum repers and Lendernia sp. were emerged and competed with the crop. This resulted higher drymatter of weeds at harvest producing 6200 kg/ha under unweeded control treatment.

In transplanted rice field as expected, the weed density was sparse in all treatments (Table 2) particularly under combined herbicidal treatments of ally , classic and butachlor or ally, classic and anilophos. The drymatter of weeds at 40 DAT was 810 kg/ha and it was reduced by 62% to 91% under different herbicide treatments.The weed population at harvest was further declined due to loss of annual weeds. The data on dry matter of weeds at havest is threrefore not reported. No phytotoxicity was observed at any growth stage of rice plant with ally or classic.

Grain Yield: In direct seeded rice all four herbicides alone and in combination resulted in significant increase in grain yield as compare to the unweeded check (Table 1). The increase in yield was 111% and 172% under ally and classic treatments respectively as compared to unweeded check. The new herbicides at low doses thus proved to be efficient in achieving effective weed control in rice. The grain yield of rice was further increased by 347% to 533% when ally and classic was combined with butachlor or anilophos at suboptimal doses. However, these herbicidal treatment combinations were at par with butachlor or anilophos at their recommonded dose of application.

In transplanted rice, the difference in grain yield between different treatments is non- significant. This was due to adequate control of weeds by use of herbicides . The increase in grain yield under different weed control treatments were estimated to be as high as 26% as compared to unweeded control (2720 kg/ha).

N-uptake by Crops and Weeds: Nitrogen uptake by crops and weeds also differed between two methods of rice cultivation. Weed shared 88% uptake of N in direct seeded as against 22 % in transplanted rice in unweeded control treatment. In the former method of rice cultivation, the N uptake by weeds was reduced by 26% to 68% when different herbicide treatments were used. In case of transplated rice the large share of N-uptake was enjoyed by rice crop as is apparent from Fig.1.

The findings indicate that problem of weed infestation is more acute in direct seeded than transplanted rice field. The new herbicide ally and classic applied alone would be beneficial in controlling weeds in transplanted paddy field. But in direct seeded rice where crop weed competition is severe and continuous throughout the crop growth period use of sub-optimal doses of butachlor (0.5 to 0.75 kg ai/ha) and anilophos (0.1 to 0.3 kg ai/ha) along with ally and classic would be a feasible proposition. Such practice would also be advantageous in reducing the N-loss by weeds.

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References

1. De Datta, S.K. 1981. Principles and practices of Rice Production. John Wiley and Sons, New York. P. 460-507.
2. Manna, G.B. 1983. Weed Control in rice under different situations.Paper presented at Annual Workshop of all India Co-ordinated Rice Improvement project, 1983. Hyderabad, India.
3. Mukhopadhyay, S.K. 1983. Weed Control Technology in Rainfed wet land Rice. In: "Weed Control in Rice," IRRI and IWSS Conf. Proc. 1981. International Rice Research Institute, Los Banos, Philippines. p. 109-118.
4. Fertilizer Association of India, 1992, New Delhi.

Table 1 : Effect of herbicides on weed count, dry weight of weeds and grain yield of direct seeded rice

Treatments	Weed number/m^2		Dry weight of weeds (kg/ha)		Grain yield (kg/ha)
	40DAS	At harvest	40 DAS	At harvest	
C_4	62	284	3430	4570	980
A_4	80	222	2990	3400	760
A_4C_4	70	234	1860	2840	1370
$A_3C_3B_{0.5}$	48	164	1750	2070	1660
$A_3C_3B_{0.75}$	30	144	1070	1620	1820
$A_4C_4B_{0.5}$	48	194	2380	2240	1610
$A_4C_4B_{0.75}$	46	114	1170	1790	1900
$A_3C_3AP_{0.1}$	52	214	2040	2390	1790
$A_3C_3AP_{0.2}$	32	120	1190	1810	1900
$A_3C_3AP_{0.3}$	52	174	1130	1640	2280
$A_4C_4AP_{0.1}$	54	164	1070	2030	1800
$A_4C_4AP_{0.2}$	38	83	1200	1460	2260
$B_{1.5}$	52	112	1560	2780	1730
$AP_{0.4}$	38	82	1170	1690	2230
Weed free check	-	-	-	-	3040
Unweeded check	156	364	4730	6200	360
CD at 5%	-	-	-	-	311

A - Ally, C- Classic, B- Butachlor, AP - Anilophos
DAS-Days after sowing
Subscripts of A and C indicate herbicide doses in g ai/ha and that of B and AP in Kg ai/ha.

Table 2 : Effect of herbicides on weed count, dry weight of weeds and grain yield of transplanted rice

Treatments	Weed number/m^2 at 40 DAT	Dry weight of weeds (kg/ha) at 40 DAT	Grain yield (kg/ha)
C_4	27	161	2550
A_4	49	301	2320
A_4C_4	38	210	2210
$A_3C_3B_{0.5}$	25	156	2240
$A_3C_3B_{0.75}$	19	125	2570
$A_4C_4B_{0.5}$	16	86	2090
$A_4C_4B_{0.75}$	10	54	2210
$A_3C_3AP_{0.1}$	21	141	2500
$A_3C_3AP_{0.2}$	19	135	2530
$A_3C_3AP_{0.3}$	15	105	2190
$A_4C_4AP_{0.1}$	26	161	2280
$A_4C_4AP_{0.2}$	15	91	2480
$B_{1.5}$	12	75	2520
$AP_{0.4}$	10	70	2800
Weed free check	95	610	2530
Unweeded check	100	810	2220
CD at 5%	-	-	NS

A - Ally, C - Classic, B - Butachlor , AP - Anilophos
DAT - Days after transplanting
Subscripts of A and C indicate herbicide doses in g ai/ha and that of B and AP in Kg ai/ha.

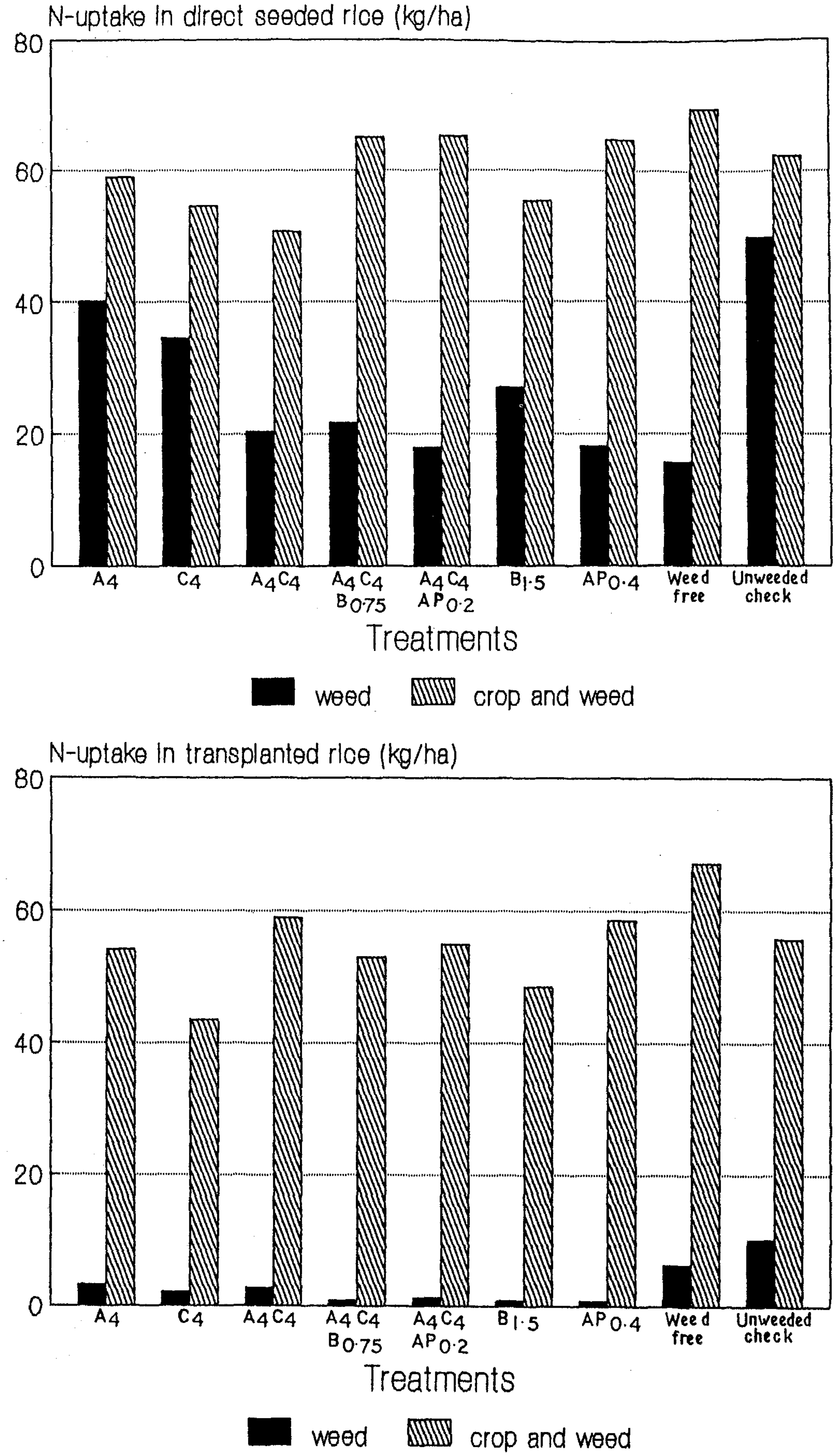

Fig. 1: N-uptake by crops and weeds in direct seeded and transplanted rice as influenced by herbicides application.

Manuscripts submitted but not registered

EFFECTS OF MOISTURE STRESS AND TEMPERATURE ON GERMINATION STUDIES OF BOERHAAVIA VERTICILLATA POIR.

Aradhana Bajpai*, D.S. Tripathi, Anamika Tripathi and H.R. Sant
Laboratory of Terrestrial Ecology, Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi 221005, India.

The investigation concerned the influences of simulated drought conditions and temperature on germinability and early seedling growth of Boerhaavia verticillata (weed), a widely used herbal medicine for renal and urinary tract diseases. Polythene glycol 4000 and sucrose were used as osmotic substrates to prepare aqueous solutions having 0 to 15 atmospheres of osmotic pressure (O.P.), corresponding to different moisture stress conditions. Seed germination and subsequent seedling growth progressively decreased with increasing O.P. levels. Trends were noted indicating more adverse effects of high osmotic pressure on shoot than on root growth. On the other hand low and high temperature adversely affected the germination percentage. Optimum temperature for seed germination was 25°C. Average time taken in radicle emergence increased on either side of this value.

INTRODUCTION

Studies concerning the influences of drought and temperature on seed germination and early seedling growth have been commonly restricted to field conditions that lacked precise experimental control. Because of difficulties in maintaining satisfactory control of soil moisture, the use of osmotic substrates to provide controlled water potential around the roots offer oppertunities of bypassing many uncertainties in field studies (Wiggans and Gardener 1959).

Effects of water stress on seed germination have been studied by several workers (Harris and Pittman 1919; Lagerwerff et al. 1961; Taylor 1965; Parmar and Moore 1968; Varshney and Baijal 1977; Stuart and William 1990). Parmar and Moore (1966) reported that most suitable O.P. level for evaluation of seed vigour, will be a function of many variables, such as, type and age of seed, nature of solute used, temperature, light intensity and humidity.

Studies concerning the effect of thermal variations on seed germination showed that germination and dormancy of seeds vary with temperature and light regime (McIntyre 1990; Willis et al. 1991). Kumar (1984) documented that seed germination decreased on either side of the optimum value.

The objective of the current study was to evaluate the potential usefulness of polythene glycol and sucrose for simulating the influence of drought conditions and effect of thermal variations upon germination and early seedling growth of Boerhaavia verticillata

MATERIALS AND METHODS

Mature seeds of Boerhaavia verticillata were collected from Ayurvedic Garden, Banaras Hindu University. They were dry stored at ambient laboratory temperature. Polythene glycol 4000 and sucrose in aqueous form were used to induce moisture stress of varying osmotic potentials (O.P.) i.e. from 3 atm to 15 atm. Aqueous solutions of Polythene glycol 4000 and sucrose were prepared by the methods of Parmar and Moore (1968).

The experiment was set up in triplicate parallel of 50 seeds at 25°C temperature. Seeds were allowed to imbibe in the respective solutions for a period of 24 hrs followed by removing the excess solution. The filter papers were kept moist using the respective solution over the entire period of experimentation. Double distilled water was used for control. Temperature treatments were conducted in seed germinator where the temperature varied between 10°C to 40°C. Protrusion of radicle through the seed coat was considered as criterion of germination. Other characters, viz., shoot length and root length were estimated when the seedlings were 10 days old.

RESULTS AND DISCUSSION

The effect of factors viz. induced moisture stress and temperature on germination and early seedling growth was studied and results are summarized in Table 1, 2, 3 and 4. Germination of seeds reflected different behaviour in various osmotic substrates. Increased O.P. levels progressively delayed and reduced germination.

Germination was more retarded by Polythene glycol than by sucrose. At similar O.P. levels germination percentage vary with osmotic subtrate used, presumably mainly due to specific effects of substrate other than the osmotic effects (Parmar and Moore 1968). Average time taken in radicle emergence also increased with increasing O.P. levels. At higher O.P. levels germination showed a statistically significant ($P < 0.001$) decrease as compared to the control (Table 1). The inhibitory effect on germination probably was due to a higher osmotic effect than calculated by formula which causes a marked departure from an ideal solution with this particular solute solvent combination (Wiggans and Gardener 1959).

Values of early seeding development (root and shoot growth) and shoot/root ratio follow a similar pattern of response as for germination (Table 2). Increasing O.P. levels decreased the seedling growth significantly ($P<0.001$) which was likewise more evident on shoot than on root growth. Also the seedling growth was more retarded by poly-thene glycol than by sucrose as osmotic substrate. Decreasing shoot to root ratio with increasing O.P. levels emphasizes this differential response of plant organs to external conditions. Less adverse effects in case of root than in shoot are explained on the basis of the greater dependence of root on the seed reserve food and less dependence on water uptake during the early non-photosynthetic stage of seedling growth (Parmar and Moore 1968).

Effects of thermal variations on germination were studied and observations indicate that low and high temperatures significantly affected germination percentage (Table 3). Analysis of variance showed significant effect of temperature on percentage seed germination (Table 4). The most suitable temperature was 25°C. Activity of enzyme appears to be at its maximum at a certain optimum temperature (Mayer et al. 1960). Higher the germination percentage shorter exposure became sufficient to render the seeds to germinate. An increase in germination with an increase in temperature between 10°-25°C was noticed. This may be due to increase in metabolic process involved in seed germination (Kumar 1984). Subsequent decrease is indicative of high temperature injury to the living cells and enzyme activity. Higher and lower values other than the suitable range, the enzymes are inactivated (Devlin 1966).

It can be concluded that for determining drought resistance by

using osmotic solutions varying in O.P. levels on germinating seeds and seedlings is at best a test of physiological drought resistance and perhaps then only in the seedling stage.

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REFERENCES

Devlin, R.M. (1966). Plant Physiology. Reinold Publishing Company, New York.

Harris, F.S. and Pittman, D.W. (1919). Relative resistance of variour crops to alkali. U.S. Utah Agr. Exp. Stn. Bull. 32: 202-211.

Kumar, L. (1984). Ecological studies of Carthamus tinctorius L. Ph.D. Thesis, Banaras Hindu University, Varanasi. India.

Lagerwerff, J.V., Ogata, G. and Eagle, H.E. (1961). Control of osmotic pressure of culture solutions by means of polythene glycol. Science, 133: 1486-1487.

Mayer, B.S., Anderson, D.B. and Bohning, R.H. (1960). Introduction to plant physiology. D. Ven Nos. Trand Company, INC, New York.

McIntyre, S. (1990). Germination in eight native species of herbaceous dicots and implications for their use in revegetation. Victorian Naturalist, 107: 154-158.

Parmar, M.T. and Moore, R.P. (1966). Effects of simulated drought by polythene glycol solutions on corn (Zea mays L.) germination and seedling development. Agron. J., 58: 391-392.

Parmar, M.T. and Moore, R.P. (1968). Carbowax 6000, mannitol and sodium chloride for simulating drought conditions in germination studies of corn of strong and weak vigour. Agron. J., 60: 192-195.

Stuart, P.H. and William, E.E. (1990). Partitioning water potential and specific salt effects on seed germination of four grasses. Ann. Bot., 66: 587-595.

Taylor, R.M. (1965). Germination of seeds and growth of plants as affected by different moisture tensions. Diss. Abst., 25(11): 6144.

Varshney, K.A. and Bajpai, B.D. (1977). Effect of salt stress on seed germination of some pasture grasses. Comp. Physiol. Ecol., 2: 104-106.

Wiggans, S.C. and Gardener, E.P. (1959). Effectiveness of various solutions for simulating drought conditions as measured by germination and seedling growth. Agron. J., 51: 315-318.

Willis, A.J. and Groves, R.H. (1991). Temperature and light effects on germination of seven native forbs. Aust. J. Bot., 39: 219-228.

TABLE 1. Effect of osmotic substrates of different O.P. concentrat- tions on germination percentage of B. verticillata.

O.P. Levels	Germination (%)		Average time taken in radicle emergence	
	Sucrose	Polythene glycol	Sucrose	Polythene glycol
0	91.61 ±0.66	91.80 ±0.59	3.67 ±0.29	3.70 ±0.26
3	85.32* ±0.87	82.11* ±0.99	4.69 ±0.53	4.84 ±0.38
6	75.59** ±1.20	64.42** ±1.44	5.34 ±0.42	5.63 ±0.50
9	53.12** ±1.50	46.31** ±0.95	6.00 ±0.61	7.16 ±0.48
12	36.11** ±0.91	24.58** ±0.57	8.32 ±0.50	8.66 ±0.71
15	17.19** ±0.78	11.23** ±0.28	8.76 ±0.53	8.94 ±0.69

± = standard error; * significant at 0.5 % P level,

**significant at 0.1 % P level.

TABLE 2. Influence of osmotic substrates of different O.P. concentrations during germination upon the development of seedling of *B. verticillata*.

O.P.	Sucrose		Polythene glycol		Shoot/Root ratio	
levels	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Sucrose	Polythene glycol
0	4.10 ± 0.27	4.31 ± 0.66	4.15 ± 0.36	4.34 ± 0.44	0.95	0.94
3	3.72 ± 0.58	4.00 ± 0.87	3.69 ± 0.61	4.02 ± 1.09	0.93	0.91
6	$3.11^{a} \pm 0.20$	3.76 ± 1.02	$3.02^{a} \pm 0.15$	3.69 ± 0.20	0.82	0.81
9	$2.29^{a} \pm 0.49$	3.04 ± 0.40	$2.00^{a} \pm 0.57$	$2.95^{a} \pm 0.24$	0.75	0.67
12	$1.14^{b} \pm 0.30$	$2.21^{a} \pm 0.29$	$0.98^{b} \pm 0.28$	$2.16^{a} \pm 0.51$	0.51	0.45
15	$0.79^{c} \pm 0.12$	$1.39^{a} \pm 0.24$	$0.51^{c} \pm 0.02$	$1.18^{b} \pm 0.27$	0.56	0.43

$\pm$ = Standard error; a, b & c indicates level of significance at 5 %, 0.5 % and 0.1 % of P levels respectively.

TABLE 3. Germination percentage at different temperatures.

Temperature (°C)	Percentage Germination	Average time taken in radicle emergence
10	6.56 ±0.05	8.50 ±0.15
15	15.50 ±0.44	8.33 ±0.28
20	63.33 ±1.03	5.66 ±0.38
25	91.81 ±0.58	3.55 ±0.27
30	79.32 ±1.02	4.60 ±0.21
35	60.00 ±1.15	6.02 ±0.50
40	11.16 ±0.25	6.83 ±0.59

± = standard error.

TABLE 4. Analysis of variance of seed germination of *B. verticillata* under different temperatures.

Sources of Variations	Sum of Squares	D.F.	Mean Squares	F Ratio	Probability
Temperature	21894.86	6	3649.14	1366.72	<0.001
Replicates	5.64	2	2.82	1.06	$>0.05^*$
Error	31.91	12	2.66		
Total	21932.41	20			

DF = Degree of Freedom; *Non-significant.

STUDIES ON COMPETITION BETWEEN WHEAT AND/OR BARLEY CULTIVARS WITH WILD OATS IN POT EXPERIMENTS UNDER NATURAL CONDITIONS

A. Farahbakhsh and K.J. Murphy
Fars Agricultural Research Center, Shiraz, Iran and Department of Botany, University of Glasgow, Glasgow,UK.

Abstract. Pot experiments were conducted under field conditions by embedding pots in soil to compare a) the competition of Avena fatua L. with spring wheat and/or barley cultivars (Semi-dwarf and conventional height); b) the competition of Avena sterillis subsp. ludoviciana (Dur.) Nyman with winter wheat cultivars (erect and horizontal leaf posture). A split plot experiment in randomized complete block design with four replications was used for both crops. The grain yield of weed-free pots of either cultivar (spring wheat and spring barley or winter wheat cultivars) was not very different from the output of these cereals under normal field conditions. The grain yield of both taller cultivars (spring wheat and spring barley) was more than the shorter cultivars. There was no yield difference between the two winter wheat cultivars, although it tended to be larger than spring cultivars. Both taller spring wheat and spring barley cultivars seemed to be slightly more competitive with A. fatua than semi-dwarf ones at the lower weed density (4 plants/pot) than the higher one (8 plants/pot). However, there was no significant difference between grain yield losses of cereal cultivars at the high weed density (8 palnts/pot).
Key words. Competition, pot experiments, barley, wheat, wild oats (Avena fatua; Avena ludoviciana).

Introduction

Although pot experiments under controlled conditions are vital for weed research studies, relying too much on the results could be misleading. Root temperature is one of the main factors controlling yield (Davidson, 1978). By using pots on benches under glasshouse conditions, a soil temperature problem does exist. This problem may have little or no effect on yield when pots are used for a short-time experiment but when plants remain for a longer period the general validity of the results would be less. However, managing large field experiments, especially when several factors are involved, is very difficult and sometimes impractical. Attempts have been made to overcome root temperature problem by inserting pots in the ground (Hanson and Juska, 1961). Previous work however, have not employed a systematic weed-crop competition study in pots under natural conditions.

This study involves a comparison of the effect of Avena fatua or A. ludoviciana competition on the growth and yield of cereal cultivars (wheat and barley) with different height and leaf arrangement. Data are also presented on the potential yield of two Iranian cereal cultivars in pots under field conditions.

Materials and Methods

Additive experiments were carried out at Glasgow University (Garscube estate) by embedding 25 cm diameter plastic pots almost at 2 cm above soil level under natural conditions. A sandy-loam soil:peat moss (80:20) mixture was used in all experiments. A split plot experiment in randomized block design with 4 replications was employed for each trial. Three uniformly pre-germinated seeds of the crop or weed were sown in each position, in pre-set regular pattern, in the pots. Seedlings were thinned to required number one week after emergence. A constant density of 8 crop plants per pot was used in all pots. Pots were embedded in the soil as described above at two weeks after emergence. Standard fertilizers were applied at rates equivalent to 80 and 60 $kg.ha^{-1}$ phosphorus and potassium one week before sowing. Nitrogen was applied at rates equivalent to 150 and 180 $kg.ha^{-1}$ respectively for spring and winter cereals.

An additional pot experiment was conducted under Iranian conditions in Shiraz (Zarghan estate) to compare the performance of monocultures of two cereal cultivars (wheat and barley) under field conditions. The pots were embedded in soil or left on the soil surface.

Plants were harvested as they reached maturity. Plant height, number of ear, dry weights of ears and shoots were determined. The ears were threshed: number of grain per ear and dry weights of chaff and grain were recorded. Data were subjected to analysis of variance. The details of experiments are given below:

Expt. 1. Competition of A. fatua with spring wheat. A split plot experiment (2 X 3) with wheat cultivar as main factor (a_1= cv. Wembley= semi-dwarf; a_2= cv. CSW= conventional height) and weed density as sub-factor (b_1= 0; b_2= 4; b_3= 8 plants per pot) was used. Nitrogen was applied in two splits (75% one week before sowing and 25% at the end of March. Plants were transferred outdoors in early April and harvested late September.

Expt. 2. Competition of A. fatua with spring barley. A split plot experiment (2 x 3) with barley cultivar as main factor (a_1= cv. Corgi= semi-dwarf; a_2= cv. CSB= conventional height) and weed density as sub-factor (b_1= 0; b_2= 4; b_3= 8 plants per pot) was used. Nitrogen applications and harvest time were as in Experiment 1.

Expt. 3. Competition of *A. ludoviciana* with winter wheat. A split plot experiment (2 x 6) with wheat cultivar as main factor (a_1= cv. Hornet= erect leaf posture; a_2= cv. Rendezvous= horizontal leaf posture) and weed density as sub-factor (b_1= 0; b_2= 1; b_3= 2; b_4= 4; b_5= 6; b_6= 8 plants per pot) was used. Nitrogen was applied in three splits (25% one week before sowing, 50% in early April and 25% at the end of March. Plants were transferred outdoors in October and harvested late September.

Expt. 4. Performance of cereal monocultures in pots. A split plot experiment (2 x 2) in 8 replications with growing conditions of pots as main factor (a_1= embedded in soil; a_2= non-embedded in soil) and cereal cultivar as sub-factor (b_1= winter wheat cv. Falat; b_2= winter barley cv. Walfajr) was used. Nitrogen was applied in two splits (75% one week before sowing and 25% at the end February). Plants were transferred outdoors in early November and harvested early July.

Results

The effects of increasing density of wild oat species on wheat grain yield and its components of spring wheat, spring barley and winter wheat cultivars are shown in tables 1 and 2. Data on the performance of two Iranian cereal cultivars are also presented in table 3.

The potential yield of all 8 cereal cultivars (British and Iranian) in weed-free pots in terms of tonne per ha was not very different from their recorded yield under field conditions. When the pots were not embedded in soil, the grain yield and number of ear per plant of both wheat (cv. Falat) and barley (cv. Walfajr) decreased significantly compared to the embedded pots (table 3).

Grain yield and biomass production of either crop cultivar was reduced by increasing weed density. However, no significant difference was observed in total biomass production (crop + weed) as the density of *A. fatua* or *A. ludoviciana* increased (data not shown). The loss of grain yield was mainly due to a reduction in fertile tiller number. Number of grain per ear and kernel weight were also reduced by the presence of weeds, although the effect was less pronounced. Both tall spring wheat (cv. CSW) and tall spring barley (cv. CSB) cultivars produced more grain yield in weed-free pots when compared to the relevant semi-dwarf cultivar (spring wheat: cv. Wembley and spring barley: cv. Corgi). There was no difference between competitiveness of either spring wheat of barley cultivars with *A. fatua* at the highest weed density (8 plants per pot). However, at the lower weed density both tall cultivars (cv. CSW and cv. CSB) appeared to be slightly more competitive than the semi-dwarf ones (cv. Wembley and cv. Corgi).

There was no difference between grain yield of both weed-free winter wheat cultivars with different leaf posture (cv. Hornet and cv. Rendezvous). There was no significant difference between grain yield of weed-free pots and A. ludoviciana infested pots at the lowest weed density (1 plant per pot). No difference was detected in competitiveness of winter wheat cultivars with A. ludoviciana at the highest weed density (8 plants per pot). However, at the lower weed densities cv.Rendezvous seemed to be slightly more competitive than cv. Hornet.

Table 1. Effect of Avena fatua competition on spring wheat and spring barley cultivars with different heights, plants grown in 25 cm diameter pots (mean of 4 repls.).

Crop cultivar	Weed density per pot	Grain yield g/pot	% yield loss	Number of ear per plant	Yield in terms of $tonne.ha^{-1}$
WHEAT:					
Wembley	0	44.3b*	---	3.35a	9.03b
	4	26.8d	39.5	2.08bc	5.46d
	8	21.3e	51.9	1.52d	4.34e
CSW	0	53.1a	---	3.33a	10.82a
	4	35.5c	33.1	2.35b	7.24c
	8	26.1de	50.8	1.58cd	5.31de
	SED	2.209	---	0.232	0.450
BARLEY:					
Corgi	0	34.6b	---	3.33a	7.06b
	4	24.6d	28.9	2.45b	5.01d
	8	19.0e	45.1	1.55c	3.88e
CSB	0	40.3a	---	3.35a	8.20a
	4	29.8c	26.0	2.32b	6.07c
	8	21.8de	49.9	1.48c	4.45de
	SED	1.661	---	0.203	0.338

Wembley and Corgi = semi-dwarf
CSW and CSB = conventional height
* Values followed by the same letters within the same column are not significant according to DMR test (p=0.05)

Table 2. Effect of *Avena ludoviciana* competition on winter wheat cultivars with different leaf postures, plants grown in 25 cm diameter pots (mean of 4 repls.).

Crop cultivar	Weed density per pot	Grain yield g/pot	% yield loss	Number of ear per plant	Yield in terms of $tonne.ha^{-1}$
Hornet	0	52.8a*	---	3.07bc	10.80a
	1	48.1ab	9.0	2.72a	9.79ab
	2	44.0bc	16.7	2.51ef	8.96bc
	4	39.9c	24.5	2.22g	8.13c
	6	29.2d	43.4	1.58i	5.95d
	8	21.0e	60.2	1.19j	4.29e
Rendezvous	0	53.1a	---	3.12b	10.82a
	1	50.1a	5.6	2.88cd	10.21a
	2	47.7ab	10.2	2.69de	9.73ab
	4	41.5c	21.8	2.35fg	8.46c
	6	34.2d	35.6	1.85h	6.97d
	8	22.3e	58.0	1.29j	4.54e
	SED	2.509	---	0.114	0.511

Hornet = erect leaf posture
Rendezvous = horizontal leaf posture
* Values followed by the same letters within the same column are not significant according to DMR test (p=0.05)

Table 3. The performance of two Iranian cereal cultivars grown in pots (embedded and non-embedded in soil) under field conditions (mean of 8 repls.).

Growing conditions	Cereal cultivar	Grain yield g/pot	Number of ear per plant	Yield in terms of $tonne.ha^{-1}$
Embedded	Falat	28.15a*	3.51b	5.74a
	Walfajr	20.34b	3.80a	4.15b
Non-embedded	Falat	15.69c	2.47d	3.20c
	Walfajr	13.38d	2.78c	2.73d
	SED	0.740	0.085	0.151

Falat= Conventional height spring wheat
Walfajr= Conventional height spring barley
* Values followed by the same letters within the same column are not significant according to DMR test (p=0.05)

Discussion

Since the grain yield of each cereal cultivar used in the pot experiments was not very different from its actual yield recorded elsewhere, the evaluation of weed-crop competition studies in pots under field conditions found to be quite realistic. In previous work (Farahbakhsh et. al., 1987), the maximum grain yield we gained for winter wheat cv. Norman in 25 cm diameter weed-free pots under glasshouse conditions was 2.18 tonne.ha^{-1} which is almost 1/4th of the recorded yield under field conditions. In the present study it appears that embedding pots in soil is a means by which the adverse effect of possibly high root temperature would be minimized and this allows better interpretation of data. While both wild oats species are troublesome in spring and winter cereals, the results suggest that they may cause greater crop yield reductions in semi-dwarf cultivars than conventional height cultivars. It may be more likely that wild oats population to increase in density and distribution more in semi-dwarf and erect leaf posture cultivars compared to conventional height and horizontal leaf posture cultivars. Barnes et. al. (1990) and Cudney et. al. (1991) stated that the ability of a plant to place foliage in the upper, better lit portions of, or above, the canopy is an important structural trait in determining the plant performance and competition outcome.

References

1. Barnes, P. W., W. Beyschlag, R. Ryel, S. D. Flint and M. M. Caldwell. 1990. Plant competition for light analyzed with a multispecies canopy model. III. Influence of canopy structures in mixtures and monocultures of wheat and wild oat. Oecologia 82:560-566.
2. Cudney, D. W., L. S. Jordan and A. E. Hall. 1991. Effect of wild oat (Avena fatua) infestations on light interception and growth rate of wheat (Triticum aestivum). Weed Science 39:175-179.
3. Davidson, R. L. 1978. Root system-the forgotten component of pastures. In Plant Relations in Pasture, ed. J. R. Wilson. CSIRO, Melborne, Australia, pp. 86-94.
4. Farahbakhsh, A., K. J. Murphy and A. D. Madden. 1987. The effect of weed interference on the growth and yield of wheat. British Crop Protection Conference-Weeds Vol.3. pp. 955-961.
5. Hanson, A. A. and F. V. Juska. 1961. Winter root activity in Kentucky bluegrass (Poa pratensis L.). Agronomy Journal 53: 372-374.

Critical Period of Weed Competition in Soybean (*Glycine max* (L.) Merrill).

K. Ponnuswamy, R. Jagannathan ,O.S. Kandasamy and N.Balasubramaniam,Department of Agronomy,Tamil Nadu Agricultural University,Coimbatore-641003,India.

Abstract : Field experiments were conducted during summer and rabi, 1992 at Tamil Nadu Agricultural University, Coimbatore to assess the critical period of weed competition in soybean. The crop was maintained weed-free and weed infested for the first 15,30,45,60 days and till harvest. Though the soybean crop maintained in a weed-free condition till harvest recorded the maximum yield (1479 kg ha^{-1}), the competition offered by weeds 45 days after sowing did not significantly reduce the yield. Similarly, the weed infested condition upto 15 days after sowing did not reduce the yield significantly. Weed index was lower (3.3) where the weed free condition was maintained for the first 60 days of sowing. Hence the first 15 to 60 days of crop growth was found to be the critical period of weed competition for soybean.

Keywords : Critical period, weed competition, weed-free, weed-infested condition.

Introduction

Among the pulses, soybean is known for high oil and protein content. Since the crop growth is slow in the initial stage, severe weed infestation reduces the yield drastically. The critical period of crop-weed competition is the period from the time of sowing upto which the crop is to be maintained in a weed-free environment to get the highest possible yield. The weed competition in a crop is invariably severe in early stages than at later stages. Generally in a crop of 100 days duration, the first 35 days after sowing should be maintained in a weed-free condition. There is no need to attempt for a weed-free condition throughout the life period of the crop, as it will entail unnecessary additional expenditure without proportionate return in yield.. So an attempt was made to assess the crucial period of weed competition in soybean, during rabi and summer seasons at Coimbatore.

Materials and Methods

Field trials were carried out during summer and rabi seasons of 1992 at Tamil Nadu Agricultural University, Coimbatore to assess the crucial period of weed competition in soybean. Weed free sitiuations were maintained for the first 15,30,45 and 60 days of crop growth and till harvest. Likewise weed infested conditions were also maintained for various periods. Weed index was calculated for various treatments. In soybean, number of pods per plant and grin yield were recorded.

Results and Discussion

Assessment of critical period of crop-weed competition is very important to decide the suitable weed management practices. The results showed that keeping the soybean crop under weed - free condition till harvest recorded the maximum yield of 1479 kg ha^{-1}. The competition offered by weed after 45 days of sowing did not significantly reduced the yield of soybean (Table). Similarly the weed infested condition upto 15 days of sowing did not reduce the yield significantly. Muniyappan et al., (1982) during the first 60 days of growth. Patterson et al., (1983) reported that the highest yield was obtained in four weeks weed-free condition. Weed index was lower (3.3) where weed-free Durigan et al., (1983) reported that the critical period varied from one season to another season for different soil and climate ie., 10 to 50 days after emergence of soybean crop. it could be concluded that for soybean the first 15 to 60 days was the critical period for weed competition.

References

Durigan, J.C., R. Victoria Filho., T. Matuo and R.A. Pitelli. 1983. Periods of weed competition in the soybean (*Glycine max* (L.) Merr.). Crop cultivars Senta Rosa and IAC-2.II. Effects on morphological characteristics and seed composition. Planta Danninha 6(2) : 86-100 (Weed Abstr., 34 : 3053, 1985).

Muniyappan, T.V., T.V.R. Prasad, and K.Krishnamoorthy. 1982. Critical stages of crop weed competition and chemical stages of crop weed competition and chemical weed control in soybean. Abstracts of papers. Annual Conf. ISWS/UAC. Bangalore. India pp. 15-16.

Patterson, M.G., R.H. Walker, D.J. Isenhour, E.N. Hauser and J. Slaughter. 1983. Effect of row pattern and weed interference periods on soybean-sickle pod competition. Abstracts of papers, 36th Annual meeting, Sothern Weed Sci., Soc., U.S.A. pp. 419. (Soybean Abstr., 8.2118, 1985).

Table . Effect of different periods of weed interference on weed index and grain yield of soybean

Treatments	Summer 1992		Rabi 1992	
	Weed index (%)	Grain yield (kg ha^{-1})	Weed index (%)	Grain yield (kg ha^{-1})
WF for 15 DAS	40.8	876	48.4	600
WF for 15 DAS	20.3	1179	23.6	889
WF for 15 DAS	3.4	1428	6.4	1089
WF for 15 DAS	2.2	1446	4.5	1111
WF for 15 DAS	5.1	1403	7.1	1081
WF for 15 DAS	44.9	815	52.9	548
WF for 15 DAS	51.3	721	63.0	430
WF for 15 DAS	57.9	623	73.3	311
WFH	0.0	1479	0.0	1163
UWC	60.5	584	76.4	274
SEd	-	39	-	42
CD (P=0.05)	-	81	-	89

Biosuppression of Salvinia (*Salvinia molesta*) in Kerala, India

P.J. Joy, D. Joseph, N.V. Satheesan and K.R. Lyla
Kerala Agricultural University
Vellanikkara 680 654, Trichur, India

Abstract: *Salvinia molesta* Mitchell, the haunting nightmare of farmers of Kuttanad and kole lands in Kerala, has finally succumbed to a tiny beetle, *Cyrtobagous salviniae* Calder & Sands, introduced from Australia. This phenomenal biological suppression has been accomplished over a wide area of 1000 km^2 in the comparatively short period of two years. Fortunately, the weevil has remained strictly host-specific to the target plant. The weed suppression obtained is above ninety per cent in Kuttanad. Occasionally weed regrowth has been noticed; but it has perished in 8 to 12 months. The farmers of Kuttanad and kole lands have benefited immensely by the weed-kill. From the 29,000 hectares of paddy fields in Kuttanad alone, the reduction of weed damage has saved Rs 6.8 million per year. The once chocked navigation canals have been cleared for transportation. An hourly cut of about 25 per cent in time and one litre in diesel is now experienced by motorboats in the weed-free canals. Thus, Kuttanad and kole lands, the granaries of Kerala, have been cured of a grave cancer gnawing into the economy of the State.

Key words: Biocontrol, *Salvinia molesta*, *Cyrtobagous salviniae,* impact.

Introduction

Salvinia molesta Mitchell (Fam. Salviniaceae), the haunting nightmare of the farmers of Kuttanad in Kerala has finally succumbed to a tiny beetle, *Cyrtobagous salviniae* Calder & Sands (Curculionidae: Coleoptera), a foreigner introduced from Australia. The lion's share of this menacing weed in Kuttanad and other parts of Kerala has already disappeared and the farmers did have a sigh of relief at the throttling of this giant foe which seemed really formidable. The fact that this phenomenal biological suppression has been accomplished over a very wide area of more than 1000 km^2 in a comparatively short duration of two years adds one more feather to the glorious victory. Joy *et al.* (1984 & 1985) reported the establishment of *C. salviniae* and the initial field level success of biosuppression of salvinia at selected spots in Kerala. Almost ten years have already passed after this legendary success. It is time for a critical evaluation of the whole programme both from the ecological and from the economic angles.

Materials and Methods

Following the initial success and with the bright prospect of victory, a large scale distribution of the weevil along with a hectic propaganda through mass media like newspapers, radio, television, training classes, public meetings, exhibitions and extension lectures was arranged. Most of these programmes were arranged in collaboration with the Department of Agriculture, Kerala.

In the meantime, periodical surveys have been conducted in the area for estimating the extent of weed control, the rate of regrowth, the profit gain of the farmers, the cut-down in fuel loss in motor boats, changes in the aquatic floral patterns etc. The weevil population has also been monitored with the help of light traps and Berlese/Tulgren funnels.

Results and Discussion

The first and foremost question is whether the biocontrol agent has remained strictly host specific to the target plant - salvinia. Fortunately the answer is 'Yes'. So far, there is no record of *C. salviniae* attacking any other plant in Kerala under field conditions. Jayanth and Nagarkatti (1986) reported minor feeding of *C. salviniae* on sweet potato and *Pistia* sp. under stress conditions. Even those plants remained free of weevil under field conditions.

The extent of weed suppression was above ninety per cent in most areas of Kerala, particularly in Kuttanad, except certain water pockets in Shertallai taluk. The weed population fast decreased to negligible levels in rivers, lakes and main canals, though in paddy fields and isolated pools of stagnant water, the suppression was not so quick. In the former locations, almost 99 per cent control was achieved at start. But after an interval of one to two years, reinfestation of the weed took place, the extent of regrowth varying between one to two hectares depending on the fertility status and climatic conditions. However, these fresh mats perished again with the slow but steady regrowth of the weevil population within eight to twelve months. Thus in Kuttanad having 57632 hectares of paddy lands, the cycle of regrowth and destruction of salvinia has become a regular feature.

The vanishing of the aquatic floating fern, salvinia, left a vacuum in the ecosystem of Kerala, offering ample scope for other aquatic weeds to push in. Thus, a conspicuous increase of *Eichhornia crassipes* had occurred. But its population has not yet acquired alarming proportions to pose a threat to farming. In salvinia free localities, water lilly, lotus, *Hydrilla, Urticularia, Vallisneria, Pistia, Lemna* etc. are now coming up, bringing the aquatic flora of Kuttanad back to pre-salvinia days.

The farmers of Kuttanad have benefitted immensely by the weed kill. During the 25 years of salvinia infestation from 1960 to 1985, they had been spending an average of Rs 236 per hectare for removing the weed. Solely from the 29000 ha of Kuttanad facing salvinia menace, the weed kill could save Rs.6.8 million per year, virtually thrown into water for weed removal formerly. The once chocked navigation canals were smoothed out for transportation, thus saving time and energy, especially for the natives using canoes and motor boats. About 25 per cent of time cut and about one litre of diesel cut per hour could be experienced in the weed free canals whereas the canoes which had to be pulled through by four or five workers in the mat-thick canals are enjoying a smooth ride at present.

Fishermen and fish fauna also benefited by the weed clearing. Fishing was tiresome in weed infested spots and fish growth was unsatisfactory due to poor availability of light and oxygen for phytoplankton and zooplankton. Lime-shell collection, a major occupation in the area was gravely obstructed by the thick blankets of salvinia. The weed suppression has turned out to be a real blessing to the lime-shell collectors.

The risk of a biocontrol agent turning to crop plants in the absence of preferred host plants is a cause for anxiety not only for farmers but scientists as well. But shifting host plants is not common among insects and particularly so for a highly host specific insect like *C. salviniae*. If at all an alternate host plant is chosen, it will usually be of the same family or genus. As for salvinia the only close relative is azolla, which need not cause a headache.

The total eradication of either the weevil or the weed is a question unlikely in a biocontrol programme. All that can be expected is a balance between the host and the pest. Once the weed gets eradicated totally, the host specific weevil will also be extinct along with. So far as the weed is there, the weevil is sure to thrive along. For a sturdy weevil like *Cyrtobagous*, the total elimination from the ecosystem is a chance far remote. Besides, Kerala climate offers optimum conditions for the survival of both the weed and the insect. Supposing the weevil gets eliminated and the weed reappears, we can just see to the reintroduction of the weevils.

The level of salvinia suppression obtained in Kuttanad is beyond the expectation of many. Usually a successful biocontrol project wins 70 to 90 per cent control. But the salvinia control project grabbed even 99 per cent control in some places. This results in the scarcity of food for the weevils and drastically reduces the weevil population. Once the weevil density sinks very low, the fast growing salvinia quickly makes its resurgence. The slow-breeding insect takes its own time to gather adequate strength to suppress the weed again. This appears to account for the reappearance of salvinia in some pockets at intervals.

We can't be definite why the weevil could achieve only a partial suppression in Shertallai. Most of the isolated ponds (numbering more than 75,000) in Shertallai are subject to periodical infiltration of brackish water and this may have adversely affected the establishment and multiplication of *C. salviniae*.

The ponds frequently used for washing and bathing as well as paddy fields receiving frequent doses of fertilizers, are relatively rich in nutrients. Quick regrowth of salvinia can be anticipated in these places leading to large scale invasion of a very large area before the weevil gains the upper hand and achieves a suppression. However, the partial regrowth of salvinia at various location serves to maintain a reserve of *Cyrtobagous* weevils.

Future prospects: *C. salviniae* has proved to be a friend in need, curing Kuttanad, the rice bowl of Kerala and other places, of a grave cancer gnawing into the economy of the state. At this juncture, it seems worth pondering over the future prospects of the equilibrium now visible in most of the areas where *C. salviniae* has well established. Will this equilibrium be permanent? None can be sure. The present check is obtained by a single species of insect and if something goes wrong with the insect, the weed is sure to make its reappearance under the extremely favourable climate and the ecosystem obtaining here. What are the chances of something fatal coming up? One possibility is the development of a pathogen on the weevil. But we can hope that the weevil may develop resistance to the pathogen because it is a sexually reproducing organism possessing built in genetic variability for the development of disease resistance.

Predation too appears a possibility, though distant, since the beetles remain safely concealed among leaf buds, leaf axils, leaf laminae and root masses. Another danger lies in the weed developing a resistance to the weevil. But in a vegetatively propagating organism, owning a uniform genetic build-up, the potential for resistance development is little, if not nil.

Conclusion: Our studies on *C. salviniae* are still going on. The insect population in Kuttanad is being monitored using light traps and samples of salvinia are drawn from the field and the population extracted with Berlese/Tulgren funnels. It has been found that the weevil population in the fields of Kuttanad ranges from 1 to 29 lakhs per hectare. This residual population of the weevil can and will keep under check the occasional resurgence of the weed in one or the other pocket. We may hope that the weed and the weevil will coexist in natural harmony hereafter as an inevitable part of the flora and fauna of Kerala.

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References

Jayanth, K.P. and Nagarkatti, S., 1986. Host - specificity of *Cyrtobagous salviniae* Calder & Sands (Coleoptera: Curculionidae) introduced into India for biological control of *Salvinia molesta*. *Entomon* 12: 1-6.

Joy, P.J., N.V. Satheesan, K.R. Lyla and D. Joseph, 1984. Establishment of *Cyrtobagous salviniae* Calder & sands (Curculionidae : Coleoptera) on *Salvinia molesta* Mitchell in Kerala. *Agric. Res. J. Kerala,* 22(1): 105-106.

Joy, P.J., N.V. Satheesan, K.R., Lyla and D. Joseph, 1985. Successful biological control of the floating weed *Salvinia molesta* Mitchell using the weevil *Cyrtobagous salviniae* Calder & Sands in Kerala (India). *Proc. 10th Asian Pacific Weed Sci Soc. Conference.* Chiangmai, Thailand, p. 622-626.

Influence of field crops on Growth and flowering of *Parthenium hysterophorus*

S.Sankaran, O.S. Kandasamy, C. Loganathan and N. Balasubramaniam, Scheme on Biocontrol of weeds, Department of Agronomy, Tamil Nadu agricultural University, Coimbatore - 641 003. India.

Abstract. Experiments were conducted in Tamil Nadu agricultural University experimental farm to evaluate suitable rainfed crops for the management of parthenium, to findout the smothering effect of field crops on the growth and flowering of the weed and to estimate the yield loss due to the infestation of parthenium in various field crops. On average, maize, sorghum and sunflower significantly suppressed the parthenium population (10.1/m^2), dry weight (320 g/m^2) and number of flower heads (1232 / parthenium weed) compared to control (31 weeds / m^2 with 1483 g dry weight and 3237 flower heads / parthenium). Because of early vigor and smothering effect of these crops, parthenium could not able to compete much. The less competitive crops like pearl millet, sesamum, groundnut and pulses were greatly affected due to the infestation of parthenium resulting in an average yield loss of more than 20 per cent while the yield loss in the above mentioned competitive field crops was only 13.7 per cent.

Key words. Field crops, flower heads, *Parthenium hysterophorus*, smothering effect, yield loss.

Introduction

Parthenium hysterophorus is an obnoxious, aggressive weed of disturbed habitats in many new and old world countries, especially in the tropics. Despite, a plethora of information available on various aspects of the parthenium problems, over the last more than three decades its menace has only intensified and not reduced (Tripathi *et al.*,1991). Very little attention has been paid for systematic large scale eradication of this weed by any of the known methods. The problems associated with this weed reflect day by day a gloomy picture. In India, long term exposure to parthenium was observed to cause a severe dermatitis, particularly, although not exclusively, in adult males (Lonkar *et al.*, 1974). There is also an increasing incidence of respiratory allergies, with seven per cent of a sample of Bangalore residents suffering from allergic rhinitis due to parthenium pollen, and 42% of sufferers from nasobronchial allergy in Bangalore sensitive to parthenium pollen (Towers and Subba Rao, 1992).

Parthenium produces enormous quantity of pollen (on an average 624 million / plant) which is carried away atleast to short distance in cluster of 600-800 grains and settles on the vegetative and floral parts, including stigmatic surface. The pollen grains are reported to inhibit fruit set in crops like tomato, brinjal, beans, capsicum and maize (Singh, 1993). Agricultural losses can also be severe. In India, parthenium can cause a yield decline of up to 40% in agricultural crops (Khosla and Sabti, 1981) and is reported to reduce forage production in grasslands by upto 90% (Nath, 1988). In the Caribbean, where crop losses due to weeds average about 20% and parthenium is the fourth most serious crop weed, largely because of its resistance to the widely used herbicide paraquat (Hammerton, 1981). Mechanical removal of parthenium has very limited scope as it is not safe to come in frequent contact with parthenium. Using a harmless plant to displace a harmfull plant is considered a noval approach. With this background an attempt was made to findout the influence of field crops on growth and flowering of parthenium weed.

Materials and Methods

Field experiments were conducted during 1994 - 95 at Tamil Nadu Agricultural University, Coimbatore. The treatment crops included were cereal (maize), millets (sorghum and pearl millet), oilseeds (sesamum, groundnut and sunflower) and pulses (urd bean, moong bean,soybean cowpea and pigeonpea). The seeds were sown in a dryland field where there was natural shedding of parthenium seeds. Recommended agronomic practices were adopted for the respective crops except weed control. Separate plots were maintained to have a weed free and a parthenium infested environment with a relative density of more than 70% to total weed population. Parthenium population was recorded using a 0.50 x 0.50 m quadrate. The experiment was laid out in a randomized block design with three replications of 5 x 4 m plot size. Parthenium population and dry matter production was recorded on 25 d, 50 d and at harvest whereas, the flower count was recorded at harvest stage of the crop. Yield components and yield of the respective crops were recorded with adequate care from the treatment plots.

Results and discussion

Results of the experiments are presented in Tables I and II. The research clearly indicated that growing of maize, sorghum and sunflower significantly suppressed the population as well as biomass production of parthenium (Table I) compared to other treatments. Interestingly, reduced flower heads of parthenium (Table I) was also observed with these crops. Such a growth suppressing effect of these crops might be due to their smothering effect and competitive superiority over parthenium stand. Because of their early vigor, parthenium could not able to compete much for its growth and development which resulted in reduced flower heads production. However, pulses (urd bean, moong bean, soybean, cowpea and pigeonpea) and oil seeds (sesamum and ground nut) had only marginal influence on parthenium, as they are slow growing and short statured in nature. To combat parthenium menace, growing of competitive crops like fodder sorghum or maize has been recommended from the earlier research (Singh, 1993).

The yield reduction due to parthenium in maize, sorghum and sunflower was 12.3%, 14.7% and 14.1% respectively (Table II), which proves the competitive superiority of the field crops over parthenium where as sesamum, groundnut and other pulses were greatly affected by the infestation of parthenium weed as seen from the yield loss of more than 20%. Hence in dry lands, where weeding could not be done as required, growing of maize or sorghum or sunflower will serve on biological means of parthenium control.

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References

Hammerton, J.L. 1981. Weed problems and weed control in the Commonwealth Caribbean. Trop. Pest Mgmt. **27**, 379 - 387.

Khosla, S.N. and S.N.Sabti. 1981. Effective control of *Parthenium hysterophorus* Linn. Pesticides (India) **15**(4), 18-19.

Lonkar, A., J.C. Mitchell and C.B.Calnan. 1974. Contact dermatitis from *Parthenium hysterophorus*. Trans. St. Johns Dermatol. Soc. **60**, 43-53.

Nath, R. 1988. *Parthenium hysterophorus* L. - A review. Agric. Rev. **9**, 171 - 179.

Singh, S.P. 1993. Integrated management of parthenium . In : Proc. Int. Symp. Indian Society of Weed Science, Hisar, November 18-20, 1993 Vol. I, 393 - 398.

Towers, G.H.N. and P.V. Subba Rao. 1992. Impact of the tropical weed *Parthenium hysterophorus*. L. on human affairs. In : Proc. Ist Int. Weed control Congr. Melbourne (ed. R.G. Richardson), pp. 134-138, Weed Science Society of Victoria, Inc. Melbourne, Victoria, Australia.

Tripathi, B., A. Barla and C.M. Singh. 1991. Carrot Weed *Parthenium hysterophorus* L. - Over view of the problems and strategy for its control in India. Indian J. Weed Sci. **23**(3&4), 61-71.

Table I. Effect of field crops on population and biomass production of *Parthenium hysterophorus*

Crops	Parthenium population (m^2)			Parthenium DMP (g/m^2)			Parthenium flower heads / plant
	25	50	At harvest	25	50	At harvest	
Sorghum	10.3 (1.014)	11.3(1.054)	10.6 (1.028)	0.4	127	336	1256
Pearl millet	11.6 (1.066)	15.0 (1.176)	12.0 (1.079)	0.9	195	399	1410
Maize	10.0 (0.966)	10.3 (1.014)	08.6 (0.937)	0.3	127	261	1058
Sesamum	14.6 (1.166)	21.0 (1.322)	18.6 (1.271)	1.3	315	705	2043
Groundnut	22.6 (1.354)	25.0 (1.397)	24.3 (1.386)	3.2	425	1074	2216
Sunflower	10.6 (1.028)	12.3 (1.091)	11.0 (1.041)	0.7	155	363	1383
Urdbean	20.3 (1.308)	24.0 (1.380)	22.6 (1.355)	3.3	416	1288	2402
Moong bean	14.6 (1.164)	21.3 (1.329)	20.0 (1.301)	1.4	300	810	2531
Soybean	14.3 (1.156)	18.6 (1.271)	16.0 (1.204)	1.2	261	572	2466
Cowpea	17.0 (1.230)	22.3 (1.348)	20.0 (1.301)	1.7	364	843	2382
Pigeonpea	23.0 (1.361)	26.0 (1.414)	26.6 (1.425)	3.9	494	1234	2690
Control (Parthenium only)	23.0 (1.361)	28.0 (1.447)	31.0 (1.491)	3.9	999	1483	3237
S.ED.	0.154	0.075	0.075	0.9	77	144	50.9
C.D. (at 5% level)	N.S.	0.155	0.156	1.9	160	299	105.5

Figures in parenthesis are log transformed values; N.S. = Non-significance

Table II. Estimated yield loss in field crops due to *Parthenium hysterophorus*

Crops	Yield (kg/ha)		Loss in yield (kg/ha)	Percent yield loss
	Weed free environment	Parthenium unweeded		
Sorghum	3021	2576	445	14.7
Pearl millet	1693	1299	394	23.3
Maize	3390	2974	416	12.3
Sesamum	300	225	75	25.0
Groundnut	1249	907	342	27.4
Sunflower	1114	957	157	14.1
Urdbean	807	615	192	23.8
Moong bean	884	697	187	21.2
Soybean	1086	855	231	21.3
Cowpea	1116	892	224	20.1
Pigeonpea	1010	804	206	20.4

Studies on the Effect of Competitive plants, Eucalyptus Leaves and Oil on *Parthenium hysterophorus*

S.Sankaran, O.S.Kandasamy, C.Loganathan and N.Balasubramaniam, Scheme on Biocontrol of weeds, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore - 641 003, India.

Abstract. Field experiment was conducted to study the effect of *Abutilon indicum, Cassia sericea, Cassia tora, Cassia occidentalis, Croton sparsiflorus, Tephrosia purpurea*, eucalyptus fresh and dried leaves and oil on the growth of parthenium weed. Results revealed that *Cassia sericea* and *Abutilon indicum* significantly suppressed the parthenium in terms of population (18.3/m^2), dry matter production (5.8 g/ plant), leaf dry weight (3.1 g/plant), root volume (3.1 ml water displacement), tap root length (11.0 cm) and root dry weight (0.8 g/plant). Effect of *Tephrosia purpurea* and *Cassia occidentalis* was also satisfactory. Eucalyptus leaves and oil did not substantially affect the germination and growth characters of parthenium.

Key words. *Abutilon indicum,Cassia sericea*, competitive plants, eucalyptus leaves, *Parthenium hysterophorus.*

Introduction

Parthenium, an annual herb was first described in India from Pune (Rao, 1956) and now occurs in almost all the states of India as a naturalized terrorist. Native to Mexico, the parthenium, within the last 100 years, has found its way to Africa, Australia and Asia, and now enjoys worldwide distribution (Haseler, 1976), but is not reported from Thailand or other countries of South - East Asia. Parthenium does not compete with established perennial grasses as it requires bare soil to germinate. A large plant can produce more than 15,000 seeds but do not exhibit dormancy (Williams and Groves, 1980). Most of the seeds germinate within two years, if conditions are suitable, although upto 12% of buried seed may be viable after two years (Butler, 1984). However, the weed remained in obscurity for about a decade after its discovery and rose to prominence only after its hazardous effects on the lives of people reached intolerable levels.

There is a growing awareness today that parthenium is a hazardous weed to crops, human and animal health. Although several methods have been proposed for the suppression of this weed, each has its own disadvantages. For instance, mowing the parthenium as soon as it flowers, though preventing seed production, results in regeneration of new shoots leads to repeated operations (Gupta and Sharma, 1977). Mechanical uprooting is constrained by the development of dermatitis in workers engaged in the operation (Krishnamoorthy *et al.*, 1977). Chemical control, though effective, is temporary and needs repeated application, besides having problems of residues, selectivity and cost of application. Moreover, it is rather impossible to adopt these methods in vast stretches of wasteland. These disadvantages prompt us to include competitive plants and other programs as a component of parthenium control.

Materials and Methods

Field experiment was conducted during 1994 to study the effect of different competitive plants (Table 1), eucalyptus leaves and oil on the growth of parthenium hysterophorus at Tamil Nadu Agricultural University experimental farm. Fresh seeds of all the plants were collected and sown in a field where parthenium plants had natural seeding with a spacing of 50 x 50 cm. Treatments were replicated thrice in a randomized block design. Required quantity of eucalyptus fresh and dried leaves was uniformly spreaded over the plot. Eucalyptus oil was mixed with equal volume of soap solution and sprayed as pre-emergence with a spray volume of 500 l/ha. Observations were recorded at 30,60 and 90 days after imposing the treatments. Two handweedings on 30th and 60th day were given for the establishment of competitive plants.

Results and discussion

The summarized results of the experiment of the effect of competitive plants, eucalyptus leaves and oil on *Parthenium hysterophorus* are presented in Tables I and II. Results of this research indicated that *Cassia sericea* and *Abutilon indicum* significantly suppressed the growth and development of parthenium weed by reducing the population to a tune of 59.3% and 52% respectively, compared to control on 90 days after sowing. Parthenium leaf, root and total dry weight, root length as well as root volume was also reduced considerably in association with the above competitive plants. Effect of *Tephrosia purpurea* and *Cassia occidentalis* was also satisfactory. Both eucalyptus fresh and dried leaves and oil did not influence much in reducing parthenium population and all other growth characters.

Phenolic leachates emanating primarily from the germinating seeds of *Cassia sericea* (Syamasundar Joshi, 1991) and *Abutilon indicum* significantly inhibit the germination of parthenium seeds. Even though few parthenium seeds still manage to germinate, seedling vigor is significantly reduced and thus the competitive plants effectively suppresses parthenium at the most vulnerable seedling stage. Allelopathic effect of fresh leaf leachates of *Abutilon indicum* on parthenium seed germination and seedling growth was previously reported by Loganathan *et al.*, 1994. The young seedling of *Cassia sericea* and *Abutilon indicum* are larger than those of parthenium, with well developed root and shoot systems. This advantage enables them to suppress the vegetative growth of parthenium, delaying flowering and reducing the number of capitula as well as seeds (Syamasundar Joshi, 1991) . Once established competitive plants follows a centrifugal mode of expansion, driving away parthenium to the periphery of the colony, causing its disappearance from the area in 3-5 years.

Successful biocontrol of parthenium by *Cassia sericea* and *Abutilon indicum* reduces the expenditure of the farmer in controlling parthenium and avoids allergic problems in sensitized humans and cattle. In addition they provides valuable firewood, thus reducing the demand of forest trees. For larger areas, these plants alone does not seem to be capable of complete weed control. An integrated weed management system should therefore be developed, giving due consideration to the classic manual, mechanical, chemical and other biocontrol methods for maximizing the effect of the replacement method.

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References

Butler,J.E. 1984. Longevity of *Parthenium hysterophorus* L. seed in the soil. Aust.Weeds,**3**, 6.

Gupta, O.P. and J.J. Sharma. 1977. Parthenium menace in India and possible control measures. FAO Pl. Prot. Bull. **25**, 112-117.

Haseler, W.H. 1976. *Parthenium hysterophorus* L. in Australia. PANS **22**, 515 - 517.

Krishnamoorthy, K., T.V. Ramachandra Prasad, T.V Muniappa, and B.V. Venkata Rao. 1977. Parthenium - A new pernicious weed in India, UAS Tech. Ser. No. **17**. UAS, Bangalore, India. pp. 46.

Loganathan. C., O.S. Kandasamy, N. Balasubramaniam and S.Sankaran. 1994. Allelopathic effect of leaf leachates of different plant species on germination and seedling growth of *Parthenium hysterophones*. Abs. Int. Symp. "Allelopathy in sustainable Agriculture, Forestry and Environment (eds. S.S. Narwal and P. Tauro). Indian society of Allelopathy, held at IARI, New Delhi. September 6-8, 1994. pp. 33.

Rao, R.S. 1956. *Parthenium hysterophorus* Linn. A new record for India. J. Bombay Nat. Hist. Soc. **54**, 218 - 220.

Syamasundar Joshi. 1991. Interference effects of *Cassia uniflora* Mill. on *Parthenium hysterophorus* L. Plant and Soil **132**, 213 - 218.

Williams, J.D. and R.H.Groves. 1980. The influence of temperature and photoperiod on growth and development of *Parthenium hysterophorus* L. Weed Res. **20**, 47 - 52.

Table I. Summary of the results of the experiment on the effect of various treatments on *Parthenium hysterophorus.*

Treatments	Parthenium population (m^2)			Parthenium DMP (g/plant)			Leaf dry weight (g/plant)		
	30	60	90	30	60	90	30	60	90
Abutilon indicum	13.6 (1.135)	20.6 (1.315)	21.6 (1.335)	0.14	6.5	6.9	0.10	3.1	3.5
Cassia sericea	13.0 (1.113)	17.0 (1.230)	18.3 (1.263)	0.12	5.9	5.8	0.09	2.8	3.1
Cassia tora	21.3 (1.329)	25.0 (1.397)	26.6 (1.425)	0.16	15.2	14.9	0.17	5.5	5.9
Cassia occidentalis	18.3 (1.263)	24.3 (1.386)	25.3 (1.403)	0.15	11.8	12.5	0.14	5.5	5.9
Croton sparsiflorus	21.6 (1.335)	27.0 (1.431)	27.6 (1.441)	0.16	16.7	17.2	0.18	7.4	7.5
Tephrosia purpurea	16.6 (1.221)	23.0 (1.361)	24.6 (1.392)	0.15	11.4	11.9	0.11	3.2	3.7
Eucalyptus fresh leaves @ 10 t / ha	24.0 (1.380)	31.3 (1.496)	35.3 (1.548)	0.19	19.3	21.5	0.19	9.6	10.7
Eucalyptus dried leaves @ 2 t / ha	24.0 (1.380)	33.0 (1.518)	33.6 (1.527)	0.21	18.7	20.8	0.19	9.1	10.6
Pre-emergence eucalyptus oil @ 4 litres / ha	26.6 (1.425)	34.6 (1.539)	35.3 (1.548)	0.22	22.2	22.5	0.23	9.8	11.5
Parthenium only	37.6 (1.575)	39.6 (1.598)	45.0 (1.645)	0.27	23.4	25.7	0.24	11.0	12.8
S.ED.	0.10	0.09	0.09	0.03	0.15	0.70	0.05	0.20	0.30
C.D. (at 5% level)	0.20	0.18	0.18	0.07	0.30	1.40	0.09	0.40	0.70

Figures in parenthesis are log transformed values.

Table II. Summary of the results of the experiment on the effect of various treatments on *Parthenium hysterophorus.*

Treatments	Root volume (ml. water displacement)			Root length (cm)			Root dry weight (g/plant)		
	30	60	90	30	60	90	30	60	90
Abutilon indicum	0.17	3.5	3.7	4.3	11.4	12.5	0.02	0.8	0.9
Cassia sericea	0.18	3.0	3.1	3.5	11.0	11.0	0.02	0.6	0.8
Cassia tora	0.16	4.7	4.8	4.2	18.5	19.2	0.02	1.9	1.9
Cassia occidentalis	0.18	4.2	4.7	4.2	17.4	19.2	0.02	1.5	1.5
Croton sparsiflorus	0.20	4.7	4.9	4.5	18.3	20.5	0.02	2.1	2.2
Tephrosia purpurea	0.17	3.6	4.2	3.8	12.8	18.5	0.02	0.9	1.0
Eucalyptus fresh leaves @ 10 t / ha	0.17	5.7	6.1	6.2	19.1	20.8	0.02	3.5	3.8
Eucalyptus dried leaves @ 2 t / ha	0.18	5.5	6.0	5.7	19.3	20.5	0.02	3.1	3.6
Pre-emergence eucalyptus oil @ 4 litres / ha	0.17	6.3	6.4	5.8	20.5	22.8	0.02	3.7	3.9
Parthenium only	0.20	9.8	11.6	6.3	22.6	25.6	0.02	3.8	4.5
S.ED.	0.03	0.30	0.30	0.90	1.20	0.70	0.007	0.03	0.2
C.D. (at 5% level)	N.S.	0.70	0.70	1.90	2.50	1.60	N.S.	0.05	0.4

N.S. = Non-significance.

Integrated Weed Management in Pulse crops: Indian experience

G. C. DE

Institute of Agriculture, Visva-Bharati
Sriniketan – 731 236, West Bengal, India

Abstract : Pulses are grown in different soils, systems, sequences, seasons and situations resulting in a varied nature and extent of infestation of different weed species and causing a more than 35 per cent loss of crop yield. Field experiments were conducted with pre-em herbicides (fluchloralin, alachlor and pendimethalin) alone, physical weeding (hand weeding and/or wheel hoeing) alone and their combinations on blackgram (cv. B 76) and chickpea (cv. Mahamaya 1) at the Agricultural Farm, Inst. of Agriculture. Integration of herbicides and physical weeding is the most effective weed management, resulting in higher root nodulation, crop growth and yield but the cost is higher and net return is less.

Key words : Fluchloralin , Alachlor, Pendimethalin, Integrated weed management, Pulses.

Introduction

Pulses are considered as *'golden grains'* for vegetable proteinand biological nitrogen. In India pulses are grown in 23.6 M ha under different types of soils, systems, sequences and situations save extreme soil reaction and wet soil, producing 13.5 M t with the productivity of only 556 kg/ha (FAI, 1994) while productivity of blackgram is 412 kg/ha which is far less than pigeonpea (678 kg/ha) and chickpea (623 kg/ha) (Lal, 1989). Poor productivity of pulses is associated with low coverage under modern varieties, scanty use of *Rhizobium* culture, use of hardly 10% of recommended fertiliser level, only 9.8 % area under irrigation and very low plant protection against insect-pests, disease and weeds resulting in yield fluctuation from 50 to 75%. Under the possibility of improved level of management pulses are often replaced by apparently more remunerative crops. To achieve national production target of 17 M t by 1996-97 yield must be improved horizontally, vertically and temporally at the same time reduction of potential yield must be minimised. Among the constraints weeds pose a great problem and reduce yield to the extent of 48.3 to 87% in chickpea (Singh *et al.* 1985). If the weeds are controlled from the very day of germination for a period of three to six weeks the crop is able to utilize the available inputs in a better way. Though pre-em herbicides are available but because of periodicity of weed seed germination, variable soil moisture and difficulty in uniform application of herbicides weed-free crop field is not always achieved. All the herbicides are also not equally effective against all the weed species thus shifting of dominance of weed flora occurs. Herbicides pollute the environment, affect non-target organisms and very often provides a false notion that intercultural operations can be dispensed with resulting into poor aeration of rhizosphere and reduction of root growth and activity. Integration of chemical and physical methods ensures better weed management, crop growth and yield but the cost becomes higher. Present investigations have been designed to find out the best and profitable weed management techniques for summer (blackgram) and winter (chickpea) pulses under Indian conditions.

Materials and Methods

Field experiments were conducted on blackgram (*Phaseolus mungo* cv. B 76) during summar 1991 and on chickpea (*Cicer arietinum* cv. Mahamaya 1) during winter 1989-90 at the Agricultural Farm, Inst. of Agriculture (located at 23°39' N latitude and 27°42' E longitude with the altitude of 58.9 m above MSL), Sriniketan, West Bengal, India, having sandy-loam lateritic soil with 0.44% organic C, 305, 40 and 112 kg/ha available N, P_2O_5 and K_2O respectively and with pH 6.0. The experiments were laid out in randomised block design with three replications of 12 treatments. Seeds of blackgram (30 kg/ha) and chickpea (50 kg/ha) were sown in five cm deep rows 30 cm apart in 4.5 m X 4 m plots on 4 March and 27 November after the basal dose of 20:40:20 kg/ha of N : P_2O_5 : K_2O. Herbicides were applied as spray on soil. Blackgram received 183 mm and chickpea experienced 259 mm rainfall during their 75 and 146 day field duration. Irrigations were scheduled at 15, 35 and 60 DAS in blackgram while at 35,60 and 80 DAS in chickpea by border strip method. Malathion 0.05% was applied against insect infestation.

Results and Discussion

Nature of weed infestation :

In blackgram broad-leaves, grasses and sedges constituted 48,43 and 9% respectively. The predominant flora were *Echinochloa colona, Digitaria sanguinalis and Trianthema portulacastrum*. The chickpea field was infested by 63% broad-leaves, 30% grasses and 7% sedges. The predominant species were *Gnaphalium indicum, Spergula arvensis* and *Digitaria sanguinalis*. Species common to both crops were *Digitaria sanguinalis, Echinochloa colona, Cynodon dactylon, Eclipta alba, Solanum nigrum, Phyllanthus niruri and Cyperus rotundus*. Weed population in chickpea was about seven times that of in blackgram due to favourable soil moisture during early stage.

Weed population and biomass :

All the herbicides were good grass killers. Integration of pre-em herbicides with one hand weeding (HW) was the most effective in reducing weed population and biomass in both the crops. In blackgram the maximum reduction of population (79%) and that of biomass (80%) of weeds were in pendimethalin 1.0 kg + one HW. In chickpea one HW was the best with 77% reduction of weed biomass.

Nodule production :
Herbicides were safe to the production of root nodules and produced more nodules than in unweeded control. Increased aeration of rhizosphere in physical weeding produced more effective nodules in both the crops.

Yield :
Weed management increased 38% (in two HW) and 54.7% (in fluchloralin 0.5 kg + one HW) seed yields in blackgram and chickpea respectively. Integration of chemical with physical method produced more pods/plant, seed and stover yields. However, the maximum number of pods/plant (28.7) of blackgram was in weed-free check and in chikpea alachlor 1.0 kg + one HW produced maximum pods/plant (30.3) and more pods/plant were produced in physical weeding than in herbicides alone. In chickpea except fluchloralin 0.5 kg + one HW all the physical, chemical and integrated methods were equivalent and superior to unweeded control in seed yield production while in blackgram one HW and fluchloralin 1.0 kg produced above 15% and all other treatments produced more than 20% seed yield and pendimethalin 1.0 kg + one HW was the best integrated treatment in seed yield production.

Economics :
Weeds incurred a loss of Rs. 2431/ha in blackgram and Rs. 3187/ha in chickpea. Integrated methods were costlier thus net returns were less since yield increments were not proportional to cost of treatments except in fluchloralin 0.5 kg + one HW in chickpea and returns per rupee investment were meagre in hand weeding with or without herbicides. The most profitable weed management treatments were hand weeding twice followed by pre-em alachlor 1.0 and 0.5 kg in blackgram and integration of pre-em fluchloralin 0.5 kg + one HW, fluchloralin 0.5 and 1.0 kg in chickpea. Therefore, it is imperative to consider economics in deciding suitable weed management technique and yield of individual crops and crops in sequence.

Reference

Fertiliser Association of India. (1994). Fertiliser Statistics, 1993-94, New Delhi.

Lal, S. (1989). Pulses Production in India : Perspective and possibilities for 2000 AD. Nat. Sympo. on New Frontiers in Pulses. R & D.DPR.Kanpur.

Singh, R. C., M. Sigh and D.R. Dahiya. (1985). Comparative studies of herbicides in relation to agronomic practices in chickpea (Gaurav). Abs. Annual Conf. Indian Soc. Weed Sci. pp. 56-57.

Table : 1 Effect of treatments on population and biomass of weeds, nodulation, yield and economics of weed management in blackgram

Treatments	Weed Population $/m^2$ at 30 DAS	Weed biomass (g/m^2) at 30 DAS	Effective nodule $/m^2$ at 30 DAS	No. of pods/ plant	Yield (q/ha) Seed	Yield (q/ha) Stover	% Yield increase over control	Cost of treatment (Rs./ha)	Net profit over control (Rs./ha)	Return/ rupee investment (Rs.)
Flu 1.0 kg/ha at 1 DAS	40.7	23.1	18.2	21.1	11.01	23.46	15.9	564	1035	1.84
Flu 1.0 kg/ha at 1 DAS + 1 HW at 25 DAS	26.9	16.6	19.0	23.0	11.55	24.76	21.6	1374	798	0.58
Ala 0.5 kg/ha at 1 DAS	42.9	24.7	21.0	22.9	11.53	23.80	21.4	136	1992	14.65
Ala 0.5 kg/ha at 1 DAS + 1 HW at 25 DAS	30.5	18.2	20.8	23.9	11.82	26.03	24.4	946	1527	1.61
Ala 1.0 kg/ha at 1 DAS	35.3	20.3	18.1	23.3	11.64	25.00	22.5	245	2023	8.26
Ala 1.0 kg/ha at 1 DAS + 1 HW at 25 DAS	25.3	16.2	19.5	24.0	11.85	27.00	24.7	1055	1473	1.40
Pen 1.0 kg/ha at 1 DAS	37.3	20.8	20.8	22.9	11.44	24.11	20.4	681	1364	2.00
Pen 1.0 kg/ha at 1 DAS + 1 HW at 25 DAS	21.0	15.9	21.4	25.4	12.64	27.41	33.1	1491	1837	1.23
1 HW at 25 DAS	32.2	30.0	24.5	19.7	10.97	21.20	15.5	810	693	0.86
2 HW at 25 & 45 DAS	36.7	30.8	25.7	26.7	13.06	28.73	37.5	1350	2431	1.80
Weed-free check	6.5	3.6	28.3	28.7	13.11	29.11	38.0	1890	1950	1.03
Unweeded control	99.0	80.8	15.1	16.0	9.50	19.90	0.0	-	-	-
SEm ±	1.8	0.3	0.8	0.2	0.24	0.39	-	-	-	-
CD (at 0.05)	5.4	0.8	2.3	0.5	0.71	1.14	-	-	-	-

Flu = fluchloralin (Basalin 45 EC @ Rs. 244=00/lit), Ala = alachlor (Lasso 50 EC @ Rs. 109=00/lit), Pen = pendimenthalin (Stomp 30 EC @ Rs. 198=00/lit), HW = hand weeding, DAS = days after sowing, Blackgramgrain @ Rs. 1000=00/q, Stover @ Rs. 25=00/q, First hand weeding @ Rs. 27=00 X 30 labours, second hand weeding @ Rs. 27=00 X 20 labours and in weed-free check third weeding @ Rs. 27=00 X 20 labours.

Table : 2 Effect of treatments on population and biomass of weeds, nodulation, yield and economics of weed management in chickpea

Treatments	Weed Population /m² at 30 DAS	Weed biomass (g/m²) at 30 DAS	Effective nodules /m² at 30 DAS	No. of pods/ plant	Yield (q/ha) Seed	Yield (q/ha) Stover	% Yield increase over control	Cost of treatment (Rs./ha)	Net profit over control (Rs./ha)	Return/ rupee investment (Rs.)
Pen 0.5 kg/ha at 1 DAS	293	22.2	858	18.3	12.32	48.57	37.8	354	2552	7.21
Pen 0.5 kg/ha at 1 DAS + 1 HW at 21 DAS	224	18.6	859	27.7	12.39	48.50	38.6	1164	1799	1.55
Pen 1.0 kg/ha at 1 DAS	247	21.1	667	22.3	12.59	50.20	40.8	680	2483	3.65
Ala 1.0 kg/ha at 1 DAS	339	20.8	738	21.3	12.21	48.00	36.6	245	2559	10.44
Ala 1.5 kg/ha at 1 DAS + 1 HW at 21 DAS	292	21.0	672	30.3	12.70	52.15	42.1	1055	2244	2.13
Ala 1.5 kg/ha at 1 DAS	255	15.6	769	21.3	12.32	48.86	37.8	354	2559	7.23
Flu 0.5 kg/ha at 1 DAS	364	29.5	759	25.3	12.76	53.20	42.7	295	3079	10.44
Flu 0.5 kg/ha at 1 DAS + 1 HW at 21 DAS	269	11.5	953	27.0	13.83	55.68	54.7	1105	3187	2.88
Flu 1.0 kg/ha at 1 DAS	317	23.6	698	21.0	12.96	52.60	45.0	564	2955	5.24
1 HW at 21 DAS	527	41.6	1082	26.3	12.29	50.50	37.5	810	2120	2.62
2 HW at 21 & 42 DAS	291	30.5	1309	26.7	12.56	51.65	40.5	1350	1825	1.35
Unweeded control	683	50.0	625	29.7	8.94	40.50	0.0	-	-	-
SEm ±	8.5	1.6	51.8	1.1	0.27	0.53	-	-	-	-
CD (at 0.05)	25.0	4.8	152.0	3.3	0.79	1.54	-	-	-	-

Pen = pendimethalin (Stomp 30 EC @ Rs. 198=00/lit), Ala = alachlor (Lasso 50 EC @ Rs. 109=00/lit), Flu = fluchloralin (Basalin 45 EC @ Rs. 244=00/lit), HW = hand weeding, DAS = days after sowing, Chickpea grain @ Rs. 800=00/q, Stover @ Rs. 25=00/q, First hand weeding @ Rs. 27=00 X 30 labours and second hand weeding @ Rs. 27= 00 X 20 labours.

Weed Succession of Long - term Application of Herbicide in Lowland Rice System

O.S.Kandasamy and S.Sankaran. Tamil Nadu Agricultural University, Coimbatore 641 003, India.

Abstract. Field experiments were conducted to study the effect of continuous application of herbicide on weed growth and yield of rice-rice-pulse cropping sequence over nine cropping seasons. The dominant weed species were *Marselia quadrifolia, Echinochloa crus-galli, Cyperus difformis* and *Monochoria vaginalis*. In hand weeded plots *M. quadrifolia* and annual grass *E. crus-galli* were dominant in the early crops. but *E. crus-galli* with a shift to *M. vaginalis* in dicot. Continuous application of herbicides caused a population shift from dicots to monocots particularly grasses. Among grasses, again, *Leptochloa chinensis*, a difficult weed to control replaced dicots and reduced *E. crus - galli*. Integrated weed control and manual method of weeding maintained the yield of rice throughout the period of study.

Key words. Continuous application, herbicide, weed growth, population shift, integrated method.

Introduction

Herbicide use for the control of weeds, especially in intensive rice based cropping system is increasing because of increasing cost of manual weeding. Unfortunately, due to the inherent selectivity of herbicides used in transplanted rice, a shift in the weed flora from annuals to perennials which are often difficult to control is likely to occur (Kim, 1983). In Korea, repeated application of butachlor, thiobencarb and 2,4 -D have resulted in the predominance of perennial sedge, *Cyperus serotinus* Rottb. and *Eleocharis kurogawi* Ohwi (Ahi *et al.*, 1975). In Japan, a shift to perennial weeds after long - term herbicide application has been observed (Ueki, 1983). In the Philippines, annual applications of herbicides have resulted in *E. crus-galli*. (L.). P.Beauv. and *M. vaginalis* becoming minor weeds and *Scirpus maritimus* L., a perennial sedge, becoming increasingly dominant (De Datta, 1977).

This experiment was conducted to determine the effect of continuous application of herbicides in a rice-rice-pulse cropping sequence on weed flora and its effect on the yield.

Materials and Methods

The experiment was conducted from October, 91 to 1994 at Tamil Nadu Agricultural University, Experimental Farm, Coimbatore in larger plot of 300 m^{-2}. The treatments viz., butachlor 1.25 applied on 3 day after transplanting (DAT) followed by 2,4 - D Na Salt 1.0 at 20 DAT (chemical method, T1), butachlor 1.25 followed by hand weeding once at 35 DAT (integrated method, T2) and hand weeding twice at 20 and 35 DAT (manual method, T3) were studied in both the rice crops, while no weed control was done in rice fallow pulse crop. The pre emergence butachlor was applied by broadcast mixed with sufficient quantity of sand on 3 DAT, maintaining a thin film of water in the field. The post emergence 2,4 - D was sprayed using a knapsack sprayer which delivered a spray volume of 500 L ha^{-1}. Recommended packages of crop management practices were followed to the crops in the sequence.

At the start of the experiment, the whole area was uniformly prepared and plots of 300 m^2 were separated. Thereafter, individual plots were prepared to prevent weed movement between plots. Weeds were sampled at 50 DAT using eight 50 x 50 cm quadrats in each plot (replicates). They were sorted by species, counted, dried and weighted. The summed dominance ratio (SDR) of the weed species were computed using the following equations :

$$SDR = \frac{\text{Relative density (RD)} + \text{Relative dry weight (RDW)}}{2}$$

$$RD = \frac{\text{Density of a given species}}{\text{Total density}} \times 100$$

$$RDW = \frac{\text{Dry weight of a given species}}{\text{Total dry weight}} \times 100$$

Grain yield was determined from 4 m^2 harvest area of 8 replicates in the net plot area. yield were converted to kg / ha at 14 per cent moisture.

Results and Discussion

The overall data on weed flora of the experimental field recorded at the start of the experiment and after the ninth crop in the sequence clearly indicate the shift in weed flora from dicots to monocots. The dicots which were two-third of the total weed at the start of the experiment were reduced to one fourth during ninth crop. There were significant variations in the change of weed flora due to different weed management practices in transplanted rice. In hand weeded plots *M. quadrifolia* and the annual grass *E. crus-galli* were dominant (44.8 and 15.5 per cent respectively) in the early crops, but *E. crus-galli* constituted the major weed of the field with 32.2 per cent. There was also a shift to *M. vaginalis* (25.4 per cent from 9.3 per cent) from *M. quadrifolia*, which was reduced to 11.3 per cent from 44.8 per cent.

In the continuously herbicide - treated plots, (chemical method of control), caused a population shift from dicots (annual weeds) in the early croppings to monocots, particularly grasses. Among grasses, the minor weed *L. chinensis* dominated with 67.5 SDR values, which is difficult weed to control. The corresponding SDR values for this weed with hand weeding treatment was 16.1. However, the crop associated weed *E. crus-galli* increased to 32.3 from 15.5 SDR with herbicide treatment. In the later crops, the herbicide treatment plot was inferior to hand weeding in controlling weeds. In integrated weed control practice (herbicide + hand weeding) again, the weed shift was towards monocots, especially *L. chinensis*, though with less intensity compared to herbicide alone treated plots.

The grain yield were almost equal in the earlier crops (Table I). Continuously herbicide alone applied plots did not control the weeds effectively and caused an weed shift to perennial weeds, which resulted in reduced grain yield in the later crops. Throughout the period of study, hand weeding twice or herbicide with a follow up hand weeding controlled the weeds and maintained the grain yield.

References

Ahn,S.B., B.S.Y.Kim and K.M.Kim. 1975. Effect of repeated annual application of pre-emergence herbicide on paddy field weed populations. Pages 287 - 292. In: Proc. 5th Asian-Pac. Weed Sci.Soc.Conf., Tokyo, Japan.

De Datta,S.K. 1977. Approaches in the control and management of perennial weeds in rice. Pages 204 - 226. In: Proc. 6th Asian-Pac. Weed Sci.Soc.Conf., Jakarta, Indonesia.

Kim,K.U. 1983. Control of perennial weeds in rice in temperature zones. Pages 243 - 253. In: IRRI Weed Control in Rice. Los Banos, Laguna, Philippines.

Ueki, K. 1983. Weed succession of long term application of herbicides in japan. Pages 319 - 324. In: J. Miyamoto and P.C.Kearney (ed.) Chemistry: Human Welfare and the Environment. Vol.2. Pergamon Press, Oxford, England.

Table I. Effect of treatments on weeds (summed dominance ratio) and crop yield

Weed species	First crop			Ninth crop		
	T_1	T_2	T_3	T_1	T_2	T_3
Echinochloa crus-galli	14.0	20.3	15.5	9.1	13.4	32.2
Leptochloa chinensis	5.2	3.7	5.4	67.5	54.1	16.1
Cyperus difformis	7.8	5.6	7.3	16.5	23.9	12.9
Marsilea quadrifolia	37.4	37.9	44.8	4.2	6.7	11.3
Monochoria vagenalis	13.7	18.1	9.3	2.8	1.6	25.4
Ludwigia parviflora	1.9	1.3	6.5	-	-	2.4
Others	11.8	4.9	3.0	-	-	-
Grain yield kg ha^{-1}	5025	5125	5180	5210	5780	5820

Weed Succession by Continuous Herbicide application in Sorghum-Cotton Cropping Sequence.

K.Ponnuswamy.,O.S.Kandasamy and N.Balasubramaniam, AICRP on Weed Control Scheme, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641003, India.

Abstract. To study the influence of management practices including continuous herbicide application on weed dynamics in a sorghum-cotton crop sequence, field experiments were conducted during kharif and rabi seasons of 1993. The herbicides atrazine and alachlor were included for the first crop of sorghum, and pendimethalin and fluchloralin for the second crop of cotton in the cropping sequence along with intercropping, handweeding and unweeded check. The findings clearly indicated that atrazine (0.25 kg) - pendimethalin (1.0 kg) applied to the sorghum-cotton cropping sequence eliminated the population of broad-leaved weeds completely but the dominance of *Cynodon dactylon* was noticed. Alachlor also provided better control of weeds but was phytotoxic to sorghum crop. Manual weeding or raising intercrops had little effect on the control of weeds. The yields of both crops were increased by herbicide rotation which kept the weeds under threshold level.
Key words. Crop sequence, herbicide rotation, kapas, weed dynamics.

Introduction

Sorghum - Cotton cropping sequence is widely adopted in the North-Western Zone of Tamil Nadu, in which weed control challenges the farmers. Weed management in a cropping sequence Is a continuous process. Successive application of herbicides have definite impact on the nature of weed species occuring in both the crops in a sequence. Sometimes continuous application of herbicides in a sequence may lead to shift in weed flora and a particular weed may become difficult to control due to the development of resistance. Vega *et al.*,(1971) observed that the continuous application of herbicides in transplanted rice controlled annual weeds such as *Echinochloa crus-galli, Monochoria vaginalis* and *Cyperus difformis* but led to a build up of *Scirpus maritimus.* To know such shift in the sorghum-cotton crop sequence experiments were conducted under irrigated condition.

Materials and Methods

Fied experiments were conducted during kharif and rabi seasons of 1993 at Tamil Nadu Agricultural University, Coimbatore in a crop sequence of sorghum (Co 26) and cotton (MCU 5) to study the influence of management practices on weed dynamics. Weed management practices such as herbicides, intercropping and handweeding were included for both the crops. For the first crop of sorghum, herbicides viz., atrazine (Atrataf 50% WP) @ 0.25 kg / ha (M_1), alachlor (Lasso 50%) @ 1.25 kg / ha (M_2) were included along with intercropping of cowpea (M_3), handweeding (M_4) and unweeded check (M_5) as other treatments in the main plots. Uniform handweedig was done in all the treatments on 20th day except in unweeded check. These plots were sub divided and treatments viz., pendimethalin (Stomp 30%) @ 1.0 kg / ha (S_1), fluchloralin (Basalin 50%) @ 1.0 kg / ha (S_2), intercropping with onion (S_3), handweeding + earthing up (S_4) were imposed to the second crop of cotton with unweeded check (S_5). Specieswise weed flora were recorded and their relative density worked out. Fodder yield for the first crop of sorghum and kapas yield for the second crop of cotton were recorded.

Results and Discussion

Sorghum weed spectrum

In sorghum field, *Trianthema portulacastrum* and *Parthenium hysterophorus* in broad leaved, *Cynodon dactylon* and *Echinochloa colonum* in grasses were observed.

Effect of weed control methods on weed dynamics

Weed control methods influenced the weed population. Response to weed control methods differed from species to species. The weeds like *Trianthema portulacastrum* and *Parthenium hysterophorus* were effectively controlled by herbicides atrazine and alachlor. *Cynodon dactylon* could not be effectively controlled by atrazine but alachlor restricted the density considerably. Manual weeding and inter cropping treatments permitted the emergence of broad-leaved weeds, might be due to delayed effect on weeds which resulted in increased dominance of *Trianthema portulacastrum* and *Parthenium hysterophorus* (Table 1). Similar findings were also reported by Srinivasan et al., (1992) in rice based cropping system.

Effect of treatments on crop yield

The fodder yield of sorghum was moe and comparable under herbicide treated plots and manually weeded plots due to conducive environment for the crop to grow better because of less weed population compared to unweeded check (Table 1). Lacsina and De Datta (1975) reported that herbicide treated plots recorded more grain yield in rice than the untreated plots due to low weed count and weed weights.

Cotton weed spectrum

In the second crop of cotton, it was seen that there was a build up of *Chloris barbata* under all treatments but heavy infestation was noticed under intercropping, hand weeded and unweeded plots. Such shift in weed flora in rice was noticed for different weed control methods by Vega *et al.*, (1971), de Datta (1977) and Janiya and Moody (1987). The population of *Trianthema portulacastrum* and *Cynodon dactylon* were also not reduced to greater extend in these treatments but the continuously herbicide applied treatments reduced the population of these weeds to a greater extend (Table 2 and 3). A shift in weed flora after long term herbicide application in Japan was noticed by Ueki (1983) and in philippines by Moody and Drost (1981) in rice crop.

Effect of treatments on cotton yield

Maximum kapas yield were recorded under continuous herbicide applied situations compared to other weed control practices such as inter cropping and manual weeding. maximum kapas yield of 1497 kg / ha was recorded under alachlor - pedimethalin herbicide rotation which was on par with the rotation of atrazine - pendimethalin (Table 4).

References

De Datta, S.K. 1977. Approaches in the control and management of perennial weeds in ric **e**. Proc. 6th Asian pac. Weed Sci. Soc. Conf. Jaharta, Indonesia. pp.204 - 227.

Janiya,J.D. and K. Moody. 1987. Effect of continuous herbicide application on weed growth and yield of transplanted rice (*Oryza sativa*). Phillip. J. Weed Sci., **14**, 62 - 69.

Lacsina, R.Q. and S.K. De Datta. 1975. Integrated weed management practices for controlling a difficult weed in low land rice. Phillip. Weed Sci. Bull., **2**, 1 - 10.

Moody, K. and D.C. Drost. 1981. The role of cropping system on weeds in rice. Paper presented at the IRRI / IWSS Conference on weed control in rice during 31 Stem bark August - 4th September, 1981. International Rice Research Institute, Los Banos, Laguna, Philippines.

Srinivasan, G., P.Pothiraj and S.Sankaran. 1992. Effect of management practices on weed dynamics in rice (*Oryza sativa*) based cropping system. Indian J. Agron. **37**(1): 13 - 17.

Ueki,K. 1983. Weed succession of long term application of herbicides in Japan. Pages 319-324 in J.Miyamoto and P.C.Kearney (ed.) chemistry. Human welfare and the environment. Vol. **2.** Pargamon press,Oxford, England.

Vega,M.R., E.C. Jr.Paller and R.T.Lubigan. 1971. The effect of continuous herbicide application on weed population and yield of lowland rice. Phillip. Agric. **55**, 201-209.

Table 1. Weed population (no / m^2) and fodder yield of sorghum (kg / ha) in various treatments.

Treatments	15 DAS*				30 DAS*				Fodder yield (kg /ha)
	Tp	Cd	Ph	Ec	Tp	Cd	Ph	Ec	
Atrazine 0.25 kg / ha +handweeding (20 DAS)	4.0(2.2)	25.3(4.7)	0.0(1.4)	12.0(3.0)	4.0(2.2)	26.7(4.7)	0.0(1.4)	13.3(3.2)	10,100
Alachlor 1.25 kg / ha +handweeding (20 DAS)	31.3(4.8)	5.3(2.3)	5.3(2.6)	2.7(2.0)	33.3(5.0)	6.0(2.5)	6.7(2.8)	3.7(2.2)	8,602
Intercropping cowpea +handweeding (20 DAS)	42.7(6.6)	5.3(2.3)	2.7(2.0)	10.7(3.3)	46.3(6.9)	6.7(2.5)	5.3(2.5)	6.3(2.5)	9,447
Hand weeding twice(20 and 40 DAS)	36.0(4.1)	25.3(5.1)	13.3(2.7)	6.7(2.8)	1.3(1.8)	1.7(1.6)	0.7(1.6)	6.0(1.4)	9,648
Unweeded check	45.3(6.8)	24.0(5.0)	5.3(2.3)	34.0(5.9)	56.7(7.6)	31.0(5.7)	7.3(2.7)	39.3(6.4)	5,068
CD. (5%)	1.62	NS	NS	NS	1.67	2.70	NS	2.65	600

Figures in Parenthesis are $\sqrt{x+2}$ transformed values; DAS* -Days After Sowing.Tp-Trianthema portulacastrum; Cd-Cynodon dactylon ;

Ph = *Parthenium hysterophorus* ; Ec = *Echinochloa colonum*.

Table 2. Weed population (no/m^2) as influenced by treatments in cotton (15DAS)

Treatments	*Trianthema portulacastrum*					*Cynodon dactylon*				
	S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
M_1	6.0(2.7)	4.0(2.3)	20.7(4.4)	39.3(6.3)	45.0(6.9)	7.3(2.8)	8.0(2.9)	22.0(4.9)	30.7(5.7)	34.3(6.0)
M_2	6.0(2.8)	6.0(2.8)	28.7(5.5)	14.0(6.8)	56.0(7.6)	8.0(3.1)	5.3(2.5)	20.0(4.7)	29.3(5.6)	42.7(6.6)
M_3	5.3(2.7)	4.7(2.5)	25.0(5.1)	38.0(6.3)	58.7(7.8)	5.3(2.7)	4.7(2.4)	32.0(5.8)	31.3(5.8)	35.3(5.9)
M_4	3.3(2.3)	5.7(2.7)	20.7(4.7)	44.0(6.8)	64.0(8.1)	6.7(2.9)	5.0(2.5)	28.7(5.4)	34.0(5.9)	44.0(6.8)
M_5	6.0(2.8)	6.7(2.8)	28.0(5.4)	42.0(6.6)	62.0(8.0)	10.7(3.5)	5.3(2.5)	23.3(5.0)	30.0(5.6)	31.3(5.7)

Treatments	*Chloris barbata*					*Parthenium hysterophorus*				
	S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
M_1	6.0(2.6)	8.0(3.0)	24.6(4.8)	27.3(5.3)	36.3(6.0)	3.0(2.2)	0.7(1.6)	20.0(4.6)	24.0(5.0)	32.7(5.9)
M_2	3.3(2.1)	7.3(3.0)	16.7(4.3)	27.3(5.4)	32.7(5.8)	1.3(1.8)	5.3(2.5)	18.7(4.6)	16.7(4.3)	28.3(5.5)
M_3	6.7(2.9)	4.7(2.5)	20.7(4.7)	32.0(5.6)	35.0(5.9)	1.7(1.8)	4.7(2.5)	19.7(4.6)	31.3(5.7)	31.0(5.7)
M_4	1.3(1.8)	4.0(2.4)	14.0(3.8)	24.3(5.1)	36.7(6.1)	4.7(2.5)	3.3(2.2)	18.0(4.4)	24.7(5.1)	52.7(7.4)
M_5	2.7(2.1)	4.0(2.3)	24.7(5.0)	34.7(6.0)	43.0(6.6)	12.7(3.6)	11.3(3.0)	20.0(4.7)	23.7(5.0)	31.3(5.7)

Figures in parenthesis are $\sqrt{x+2}$ transformed values,

Table 3. Weed population (no/m²) as influenced by treatments in cotton (30DAS)

Treatments	*Trianthema portulacastrum*					*Cynodon dactylon*				
	S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
M_1	8.0(3.1)	5.7(2.7)	29.0(5.5)	42.0(6.6)	48.7(7.0)	9.0(3.2)	8.7(3.1)	25.0(5.2)	33.3(6.2)	37.0(6.2)
M_2	7.3(2.9)	7.3(3.1)	29.7(5.6)	44.0(6.8)	59.0(7.8)	10.0(3.5)	7.0(2.8)	22.7(4.9)	31.3(5.8)	45.3(6.8)
M_3	7.3(3.0)	5.7(2.7)	26.7(5.3)	41.7(6.6)	62.0(7.9)	6.3(2.8)	6.3(2.8)	35.7(6.1)	37.0(6.2)	31.0(5.7)
M_4	5.3(2.7)	7.7(3.1)	22.0(4.8)	47.0(6.9)	67.0(8.3)	8.3(3.2)	7.0(2.9)	33.0(5.8)	38.7(6.3)	41.3(6.5)
M_5	8.3(3.2)	8.3(3.2)	33.3(5.9)	45.0(6.8)	63.7(8.1)	12.3(3.7)	7.7(2.9)	27.0(5.4)	32.3(5.8)	34.7(6.0)

Treatments	*Chloris barbata*					*Parthenium hysterophorus*				
	S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
M_1	7.7(3.0)	9.3(3.2)	18.7(4.4)	31.0(5.7)	37.0(6.1)	4.7(2.5)	2.7(2.1)	22.0(4.8)	27.3(5.3)	35.3(6.1)
M_2	5.3(2.6)	9.3(3.3)	26.0(5.2)	32.3(5.8)	43.0(6.6)	4.0(2.4)	8.0(3.1)	23.0(5.0)	23.0(4.9)	32.7(5.8)
M_3	7.0(2.9)	6.7(2.9)	28.0(5.4)	36.0(6.0)	42.3(6.5)	3.7(2.2)	6.3(2.7)	22.3(6.9)	37.0(6.2)	38.7(6.3)
M_4	2.0(1.9)	7.0(2.9)	36.0(6.0)	26.3(5.3)	39.7(6.3)	6.7(2.9)	5.3(2.7)	20.0(4.6)	27.7(5.4)	54.7(7.6)
M_5	4.3(2.5)	6.7(2.9)	27.3(5.3)	38.0(6.3)	48.0(7.0)	14.0(3.8)	13.0(3.8)	24.7(5.2)	31.7(5.7)	35.0(6.0)

Figures in parenthesis are $\sqrt{x+2}$ transformed values;

Table 4. Yield of cotton (kg / ha) under various treatments

Treatments	Yield of kapas (kg / ha)				
	S_1	S_2	S_3	S_4	S_5
M_1	1482	1185	1509	865	608
M_2	1497	1260	1413	898	527
M_3	1395	1252	1233	1040	645
M_4	1202	1192	1280	877	567
M_5	1405	1323	930	723	443

	SED	CD (5%)
M	51.4	118.5
S	47.3	95.7
M x S	105.9	213.9
S x M	107.7	224

Evaluation of Herbicides for Phytotoxicity and Weed control in Wet-seeded Lowland Rice

O.S.Kandasamy, R.Chandrababu and S.Sankaran. Tamil Nadu Agricultural University, Coimbatore 641 003, India.

Abstract. The effect of herbicide, herbicide mixtures and their time on weed control and yield of wet-seeded rice (*Oryza sativa* L.) were studied in three experiments in Coimbatore. Herbicides applied 4 or 8 days after seeding (DAS) caused significant reduction in rice stand. Herbicide mixtures reduced the plant stand substantially (14 per cent) especially anilofos + 2,4 - D EE (33.4 per cent). Application of pretilachlor (+ safener) or thiobencarb either at 4 days before seeding (DBS) or 8 DAS gave better weed control and higher yields and economics in wet-seeded rice.
Key words. Herbicide, herbicide mixture, rice stand, safener, wet-seeded rice.

Introduction

In tropical Asia, rice (Oryza sativa L.) is usually transplanted. The traditional cultural practices associated with transplanting are extremely time-consuming, laborious and costly. In the paucity of labour for transplanting, even under adequate irrigation water availability situation, rice is being direct seeded (dry or wet) and maintained as irrigated lowland rice.

A major problem encountered in the wet - seeding of rice is weed control. Hand weeding in a transplanted crop is relatively easy, because the seedlings are planted in rows between which the weeder can walk (Heinrichs *et al.* 1987). Herbicides will remain a vital tool for weed control in wet - seeded rice because other means such as hand weeding and cultivation are impractical (Navarez and Moody, 1979). However, herbicide selectivity is often marginal because of similarities in morphological characteristics between rice and grass seedlings of the same age (Moody and Cordova, 1985).

Herbicide toxicity can be reduced by applying reduced rates, but this may be accompanied by loss of weed control (Mercado, 1980). Varying the time of herbicide application may also reduce herbicide damage to rice seedling (Maabbayad and Moody, 1985). This study was conducted to determine the effect of herbicide, herbicide mixtures and their time of application on crop growth, weed control and yield in wet - seeded rice.

Materials and methods

Three experiments were conducted at the wetland of Tamil Nadu Agricultural University, Coimbatore during summer, 1992, Kharif and rabi, 1993. A split plot design with three replicates was used. The time of herbicide application formed the main plot treatments and herbicides in the sub-plots. Pre-germinated rice seeds were broadcast - seeded at 100 kg/ha onto puddled and levelled soil. The field was irrigated 4 DAS and 2-5 cm water was maintained for the duration of the crop. Fertilizer was applied at the rate of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha.

The herbicides used and their time of application in the experiments are given in the respective table. The calculated quantity of herbicides were mixed with sand and broadcasted on the field either before or after seeding as pre treatment. In all the experiments rice stand count, weed count and weed dry weights were taken from two 0.25 m^{-2} quadrats per plot at 50 DAS. Rice grain yields are reported in t/ha at 14% moisture content and are based on a harvest area of 6 m^{-2}

Results and discussion

The major weed species occurred in the experimental field were *Echinochloa crus-galli, Marselia quadrifolia, Cyperus difformis* and *Eclipta alba.* Compared to other treatments, herbicide and herbicide mixture applied 6 DAS caused stand reduction (Tables). Stand reduction due to herbicide application at 6 DAS in wet seeded rice has been reported by Imperial (1980).

Among the herbicides, anilofos either singly or in combination with 2,4 - D EE caused substantial stand reduction at higher and lower doses. Moody (1984) warned about the likelihood of herbicide toxicity to wet - seeded rice when 2,4 - D is added to residual soil applied herbicides such as thiobencarb. Use of granular formulation of 2,4 - DEE or readymix formulation of anilofos plus (anilofos + 2,4 - D) did not appreciably improved the selectivity (Table II and III)

Varying effects have been recorded with weed dry weight under different time of application of herbicides. This might be due to variations in the weed flora and density observed in different seasons of experimentation.Compared to the other herbicides, pretilachlor (safener) significantly reduced weed weight over seasons (Tables). Weed weights were generally lower with single herbicide application at medium rates compared to herbicide mixtures at lower rates. This might be due to reduced plant stand caused by increased crop phytotoxicity with herbicide mixtures and consequent resources availability for weed growth.

The yields reflect the interaction between the degree of weed control achieved with a particular herbicide treatment and the degree of crop damage it caused. Less effective weed control combined with crop damage caused by anilofos + 2,4 - D EE resulted high yield reduction compared to the highest yielding herbicide treatments (see weed index). Yields were best in the plots treated with a single herbicide application either at 4 DBS or 8 DAS. Diop and Moody (1989) observed that herbicides applied 3 DBS reduced rice stand and yield and recommended application after 6 DAS. Application of pretilachlor (safener) or thiobencarb at 4 DBS or 8 DBS resulted in better weed control and yields.

The economic analysis (B:C ratio) of the timing of herbicide application revealed the advantage of herbicide application at 4 DBS or 8 DAS to wet - seeded rice. The economic returns were always highest with pretilachlor (safener) application. The next best herbicide would be thiobencarb. Therefore, better weed control and yield with higher selectivity in wet seeded rice could be obtained by application of pretilachlor (safener) at 0.30 kg/ha or thiobencarb at 1.25 kg/ha at 4 DBS or 8 DAS with a follow up hand weeding.

References

Diop, A.M. and K. Moody. 1989. Effect of rate and time of herbicide application on yield and marginal cost - benefit ratio of wet - seeded rice in the Philippines. J. Pl. Prot. Tropics **6**(2) : 139 -146.

Heinrichs, E.A., F.V. Palis, K. Moody and G.B. Aquino. 1987. The effects of timing of butachlor application on the economics of direct seeded rice production. J. Pl. Prot. Tropics **4**(2) : 95 - 100.

Imperial, E.M. 1980. Chemical weed control in direct - seed rice (*Oryza sativa L.*) grown under puddled conditions. Philipp. J. Weed Sci., 7:70 - 75.

Maabbayad, M.O. and K.Moody, 1985. Improving butachlor selectivity and weed control in wet seeded rice. J. Pl. Prot. Tropics **2** : 117 - 124.

Mercado, B.L. 1980. Weed and herbicide use in rice. In : Development in Pest Management in the Philippines, pp. 20 - 26, Pest Control Council of the Philippines, Manila, Philippines.

Moody, K. 1984. Possible ways of reducing herbicide toxicity in wet seeded rice. In : Proc. First Trop. Weed Sci. Conf., pp. 15 - 25. Hat Yai, Sangkhla, Thailand.

Moody, K. and V.G. Cordova, 1985. Wet seeded rice. In : Women in Rice Farming, pp. 467 - 480. Int. Rice Res. Inst. Los banos, Laguna, Philippines and Gower Alderhot, Hants, England.

Navarez, D.C. and K. Moody, 1979. Farmers weed control practices in rainfed lowland rice growing areas in Manaoag, Panasinam, Philippines, Philipp. J. Weed Sci. **6** : 23 - 31.

Table I. Effect of treatments on stand count, weed weight, yield and economics of wet seeded rice IR.50, summer 1992

Treatment details	Weed dry weight g / m^2 (50 DAS)	Plant stand / m^2 (25 DAS)	Panicles/m^2	Grain yield t / ha	Weed index (%)	B:C ratio
Time of herbicide application						
4 days before sowing (4 DBS)	62.1 (1.79)	221	330	4.26	0.02	2.29
4 days after sowing (4 DAS)	63.6 (1.80)	186	286	3.63	16.2	1.95
8 days after sowing (8 DAS)	45.0 (1.65)	214	330	4.33	-	2.30
SED	0.07	4.3	7.8	0.08	-	-
CD 5%	NS	11.9	21.7	0.23	-	-
Herbicides						
Thiobencarb 1.25 kg ha^{-1} fb HW	53.5 (1.73)	230	359	4.70	0.05	2.43
Pretilachlor 0.45 " (safener)	39.9 (1.60)	254	376	4.97	-	2.56
Anilofos 0.40 "	54.7 (1.74)	191	288	3.72	25.1	2.03
Thiobencarb 0.75 + 2,4 -DEE 0.40 kg ha^{-1} fb HW	62.2 (1.79)	211	303	3.93	20.9	2.16
Pretilachlor 0.30 + 2,4 -DEE 0.40 kg ha^{-1} fb HW	55.9 (1.75)	213	342	4.34	12.7	2.34
Anilofos 0.30 + 2,4 -DEE 0.40 kg ha^{-1} fb HW	72.0 (1.86)	143	222	2.75	44.6	1.56
SED	0.03	5.6	10.3	0.11	-	-
CD 5%	0.07	11.5	21.0	0.23	-	-

Figures in parenthesis are log transformed values; fb - followed by; HW - Hand weeding

Table II. Effect of treatments on stand count, weed weight, yield and economics of wet seeded rice ADT 36 ,Kharif, 1993

Treatment details	Weed dry weight g / m^2 (50 DAS)	Plant stand / m^2 (25 DAS)	Panicles/m^2	Grain yield t / ha	Weed index (%)	B:C ratio
Time of herbicide application						
2 days before sowing (2 DBS)	13.5 (1.01)	196	547	5.02	11.0	2.46
6 days after sowing (6 DAS)	7.0 (0.72)	187	562	5.64	0.2	2.75
8 days after sowing (8 DAS)	14.0 (1.02)	237	625	5.65	-	2.76
SED	0.05	41.7	21.8	0.22	-	-
CD 5%	0.14	NS	60.5	0.60	-	-
Herbicides						
Thiobencarb 1.25 kg ha^{-1} fb HW	5.4 (0.54)	214	571	5.92	-	2.91
Pretilachlor 0.30 " (safener)	3.8 (0.44)	251	649	5.85	1.1	2.90
Anilofos (2G) 0.40 "	9.0 (0.03)	249	605	5.65	4.5	2.83
Thiobencarb 0.75 + 2,4 -DEE (4 G) 0.40 kg ha^{-1} fb HW	7.7 (0.80)	225	557	4.83	18.4	2.35
Pretilachlor (safener) 0.20 + 2,4 -DEE (4G) 0.40 kg ha^{-1} fb HW	19.4 (1.26)	213	603	5.06	14.5	2.48
Anilofos plus 0.32 + 0.24 kg ha^{-1} fb HW (readymix Anilofos + 2,4 - D)	23.5 (1.31)	187	483	5.31	10.3	2.57
SED	0.08	42.0	47.2	0.32	-	-
CD 5%	0.17	85.7	96.4	0.65	-	-

Figures in parenthesis are log transformed values; fb - followed by; HW - Hand weeding

Table III. Effect of treatments on stand count, weed weight, yield and economics of wet seeded rice ADT 36,Rabi, 1993.

Treatment details	Weed dry weight g/m^2 (50 DAS)	Plant stand $/m^2$ (25 DAS)	Panicles/m^2	Grain yield t / ha	Weed index (%)	B:C ratio
Time of herbicide application						
4 days before sowing (4DBS)	30.3 (1.33)	269	519	5.34	2.1	2.58
6 days after sowing (6DAS)	36.8 (1.45)	243	460	5.29	3.0	2.55
8 days after sowing (8DAS)	46.9 (1.58)	277	532	5.45	-	2.64
SED	0.02	4.22	9.8	0.57	-	-
CD 5%	0.06	11.7	12.6	NS	-	-
Herbicides						
Thiobencarb 1.25 kg ha^{-1} fb HW	43.5 (1.62)	288	534	5.54	4.04	2.70
Pretilachlor 0.30 " (safener)	30.2 (1.33)	312	485	5.80	-	2.85
Anilofos (2 G) 0.40 "	47.5 (1.67)	237	582	5.39	7.1	2.66
Thiobencarb 0.75 + 2,4 -DEE(4G) 0.40 kg ha^{-1} fb HW	53.7 (1.72)	264	483	5.21	10.2	2.50
Pretilachlor (safener.) 0.20 + 2,4 -DEE (4G) 0.40 kg ha^{-1} fb HW	46.7 (1.66)	270	498	5.30	8.6	2.55
Anilofos plus 0.32 + 0.24 kg ha^{-1} fb HW (readymix Anilofos + 2,4 - D)	59.3 (1.77)	213	436	4.92	15.1	2.36
SED	0.06	5.8	39.5	0.96	-	-
CD 5%	0.12	11.8	80.7	1.96	-	-

Figures in parenthesis are log transformed values; fb - followed by; HW - Hand weeding

Effect Of Trifluralin On *Rhizoctonia solani* AG4, Causal Agent Of Soybean Damping off

M. Montazeri and A. Hamdollah-Zadeh
Agricultural Research Center,Gorgan 49165-363,Iran

Abstract Effect of trifluralin on development and virulence of *Rhizoctonia solani* AG4 , and reaction of soybean to the fungus was investigated. The growth rate of *R. solani* AG4 on malt agar had negative relationship with increasing rate of trifluralin.The herbicide had no effect on virulence of the pathogen against soybean.In the soil treated by trifluralin, incidence of soybean damping off caused by *R. solani* AG4 was significantly more than in untreated soil. Results showed that trifluralin increases the susceptibility of soybean to the fungus.
Key words:Trifluralin, *Rhizoctonia solani* AG4, Damping off, Soybean, Fungus

Introduction

In the soybean fields of the Gorgan area , in north part of Iran , trifluralin is applied more than other herbicides.In the other hand ,incidence of soybean damping off caused by *Rhizoctonia solani* Kuehn anastomosis group 4 , is a common disease in the fields(2).
Trifluralin is strongly absorbed on soil and shows negligible leaching(3). Major effects of dinitroanilin herbicides (including trifluralin) are on root growth which they stop by interfering with mitosis and preventing normal cell wall formation(4).An increased incidence of *R. solani* on cotton in soil treated with trifluralin has been reported(1).
Based on our observation, the application of trifluralin in the soybean fields of this area, resulted to increasing the occurrence of the disease. This report shows the results of investigation on the effect of trifluralin on growth and virulence of *R. solani* AG4 and changes in resistance of the host to the pathogen.

Materials and Methods

Effect of the trifluralin (Treflan EC 48% ai) on growth of *Rhizoctonia solani* Kuehn AG4 was tested on malt agar to which the herbicide was added at 0, 50, 100 and 200 ppm (by six replicates),after an autoclaving of the medium.The diameter of the fungal colonies was measured after four days incubation at 24 C.
Effect of trifluralin on the virulence of *R solani* was investigated by sowing the soybean cv Williams in the soil inoculated by the fungal colonies which were grown on malt agar treated with the herbicide at 0-200 ppm.The experiment was conducted by six replicates.The pots were kept in a temperature-controlled (25-27 C day, 20-22 C night) greenhouse.Disease incidence was determined by assessment of the percentage of plants affected by pre-emergence and post-emergence damping off up to 14 days after planting.

To test the hypothesis that trifluralin increases the susceptibility of soybean to *R. solani* ,seedlings were grown in sterilized soil either treated with trifluralin (at 0 , 0.5 , 1 and 2 μ g ai/g soil) or left untreated. After seven days , the seedlings were removed , washed and replanted in sterilized soil free of the herbicides but infested with *R. solani* AG4.The percentage of the plants affected by damping off was determined up to 21 days. Then the pathogen was re-isolated from diseased plants.

Results and Discussion

The application of trifluralin to the malt agar, associated with reducing growth of *R. solani* AG4.The growth rate of the fungus had negative relationship with increasing of the herbicide (Fig.1).

Data presented in fig.2,shows that trifluralin did not have significant effect on the virulence of the pathogen toward soybean cv Williams.

The seedling of soybean grown in the soil treated with trifluralin were more susceptible to the pathogen than those grown in untreated soil (fig 3).

The results of this investigation revealed that , although trifluralin suppressed development of *R. solani* Ag4 , but increases the susceptibility of the host to the pathogen in soil.It may be related to the effect of the herbicide on prevention of cell wall formation (4).While, trifluralin had no effect on virulence of the fungus.

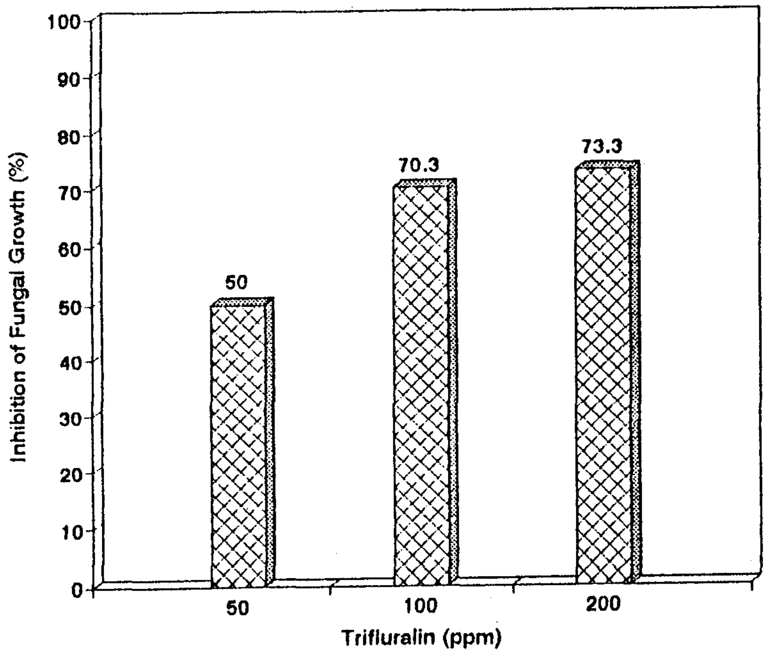

Fig.1. Effect of trifluralin on growth of *Rhizoctonia solani* AG4 on malt agar after four days at 24 C. Values are average for six replicates. Control (no herbicide), average diam=7.1 cm,significantly differ-rent from trifluralin treatments (p=0.05)

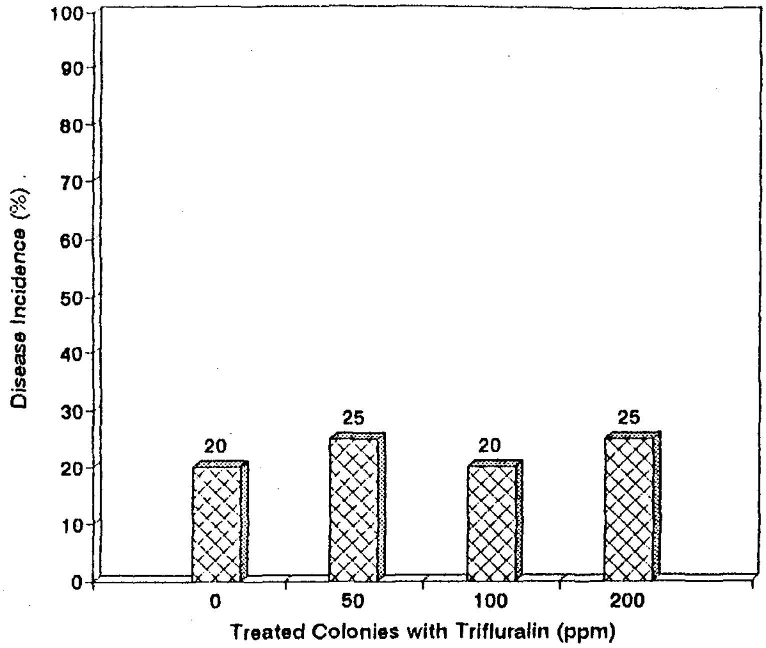

Fig.2.Percentage of infected seedlings in soil inoculated by fungal colonies which were grown on malt agar treated by trifluralin,after 14 days.There was no significant difference between the fungal colonies (P=0.05). Values are average for six replicates , each containing five seedlings.

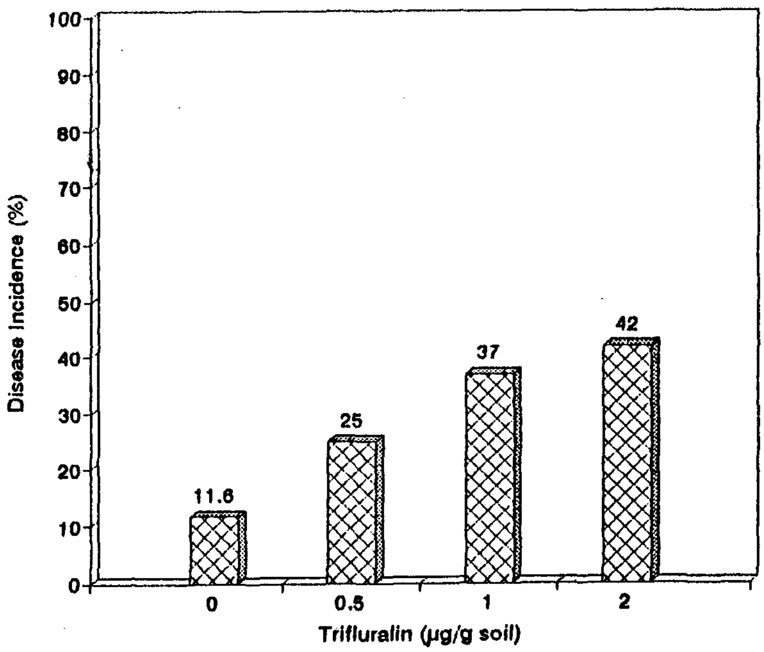

Fig. 3. Effect on susceptibility to Rhizoctonia solani AG4 of soybean cv Williams pretreated with trifluralin and then inoculated with the pathogen. Values are averages for six replicates, each containing five seedlings.

References

1-Chandler,J.,and Santelman P.W. 1967.Interaction of four herbicides with *Rhizoctonia solani* in seedling cotton. Weed Sci. 16:453.

2-Hamdollah-Zadeh,A.,and Rahimian,H.1989.Anastomosis group 4 is the major cause of *Rhizoctonia solani* of cotton & soybean in Gorgan.Proceedings of the ninth Plant Protection Congress of Iran,9-14 Sept.1989,Mashhad, Iran.p 110

3-Humburg,N.E.,Colby,S.R.,Hill,E.R.,Kitchen,L.M.,Lym,R.G. McAvoy,W.J.,and Prasad,R. 1989.Herbicide Handbook.Sixth edition.Weed Science Society of America.p 254.

4-Ross,M.A.,and Lembi,C.A. 1985.Applied Weed Science. Burgess Publishing Company,Minneapolis,Minnesota.p 203

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