PROCEEDINGS OF THE EIGHTH ASIAN-PACIFIC WEED SCIENCE SOCIETY CONFERENCE

Bangalore, India
November 22 to 29, 1981

II Volume

Published by the Organising Committee
Eighth Conference of
Asian-Pacific Weed Science Society
159, I Cross, Vasanthnagar,
Bangalore-560 052, INDIA
1981

Dedicated to the memory of
Dr H.R. Arakeri
President of the APWSS, 1979–81
who passed away at New Delhi on Sept. 20, 1982

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Photoset at Eastern Fototype, Bangalore – 560 011
Printed at Pacprint Private Limited,
No. 4, Bannerghatta Road, Bangalore – 560 029, India.

PREFACE

The Post-Conference volume of the proceedings is the record of additional invited and contributed papers presented at the eighth Asian-Pacific Weed Science Society Conference held at West-End Hotel, Bangalore, India, on November 22-29, 1981. This volume includes Welcome address, Inaugural address, Keynote address, Presidential remarks, report of the conference, recommendations of the conference, minutes of the meetings of General Business Committee and the Executive Committee of the Society, list of Chairmen and Co-chairmen of Sessions, members of APWSS executive and Industry-sustaining members as well as list of delegates attending the conference from various countries with their addresses so as to help maintain contact among participants.

It is a pleasure for me to place on record the sustained assistance received from my young friends Mr. T. V. Ramachandra Prasad of the Weed Control Project of the University of Agricultural Sciences, GKVK, Bangalore and Mr. N. Gopalakrishna, formerly of the UAS Publications and presently at the National Institute of Mental Health and Neuro Sciences, Bangalore.

The proceedings of 1981 and this 2nd volume are available at US $ 35 (Rs. 250/-) and US $ 15 (Rs. 100) [inclusive of postal and package charges – Vol. I & II US $ 40 (Rs. 300/-)] from the

Organising Secretary,
8th Conference of the Asian-Pacific Weed Science Society
159, I Cross, Vasanthanagar,
Bangalore 560 052, INDIA.

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Editor

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WELCOME ADDRESS

Dr. N. G. Perur,
Chairman, Organising Committee, 8th Conf. of APWSS.

His Excellency the Governor of Karnataka Shri Govind Narain, Dr. H. R. Arakeri, President, Asian-Pacific Weed Science Society (APWSS), Dr. O. P. Gautam, Director-General, Indian Council of Agricultural Research, Dr. S. Matsunaka, President, International Weed Science Society, Dr. K. Krishnamurthy, Organising Secretary, Dr. U. C. Upadhyay, Vice-President (ISWS), Members of the APWSS, Members of the Indian Society of Weed Science (ISWS), Members of the local organising committee Distinguished Delegates to the 8th Conference of the APWSS, Dignitaries and Scientists of the various Government and Private Institutions and Organisations, Representatives of the Press and All-India Radio, Other Distinguished Guests, Ladies and Gentlemen,

I consider it an unique privilege to extend a warm welcome to you all to the inaugural function of the 8th Conference of the APWSS.

It is kind of Shri Govind Narain, His Excellency the Governor of Karnataka, to acceed to our request to grace the occasion and to inaugurate the conference. I extend a very cordial welcome to him, on behalf of the organisers of the conference and on my own.

Dr. H. R. Arakeri, the Chairman for this morning session, is the main architect of this conference. We would like to express our appreciation to him and to the Executive of the APWSS for deciding to hold its Eighth Conference at Bangalore. Dr. Arakeri although placed at New Delhi, frequently visited Bangalore and provided guidance in the organisation of the conference. We extend to him a very warm welcome.

Dr. O. P. Gautam, the Director-General, Indian Council of Agricultural Research, New Delhi, although returned from his foreign trip only a few days ago, has been able to spare his valuable time and be with us this morning to address at the inaugural session. We are grateful to him for this and extend a very warm welcome.

There has been a spontaneous response to our requests from weed scientists of several countries and many States in India. Delegates from 17 foreign countries, namely, Australia, Canada, UK, West Germany, Indonesia, Italy, Japan, Nepal, New Zealand, Pakistan, Philippines, Bangla Desh, Malaysia, Singapore, Sri Lanka, Thailand and United States of America, have come for the Conference. About 115 delegates from abroad and about 163 delegates from various States in India are participating in the conference. Another 20 interested associate delegates, student delegates and farmer delegates have also come to attend the conference. Most heartily we welcome them all.

My colleagues in the Organising Committee have taken much trouble and have made elaborate arrangements to receive the delegates, house them properly in this garden city of Bangalore and to look after their comforts during their stay here. Bangalore City has fine weather during this part of the year. Both mid-conference and post-conference tours and visits to places of interest in Bangalore City have been planned for the benefit of the delegates. I am sure the delegates will enjoy their stay in Bangalore and profit by their participation in the conference.

The different technical sessions of the conference are organised to cover the diverse fields of weed science. I am sure the rich knowledge and experience of all the participating delegates will help the deliberations of the conference, leading to useful results.

Many private firms and organisations have extended their help in organising the conference. We extend a warm welcome to them through their representatives who are attending the meet.

Many distinguished guests, representatives of the Press and the All India Radio have readily responded to our invitation and we heartily welcome them all.

INAUGURAL ADDRESS

Shri Govind Narain,
His Excellency, the Governor of Karnataka, Bangalore, India and Chief Guest

Dr. H. R. Arakeri, Dr. N. G. Perur, Dr. O. P. Gautam, Dr. S. Matsunaka, Dr. K. Krishnamurthy, Dr. U. C. Upadhyay, Members of the Asian-Pacific Weed Science Society (APWSS), Members of Indian Society of Weed Science (ISWS), Learned Scientists, Distinguished Guests, Ladies and Gentlemen,

I deem it a privilege to be with you this morning to inaugurate this important conference which has brought here eminent scientists from the different parts of the world for important and serious scientific discussions and to find out practical solutions to the problem encountered by the farmers.

Crop production is dependent on the biogenetic potential of the crop, bioecosystem of the soil and the environment. Of the seveal constraints in production, weeds constitute a major one, causing considerable loss and frustation to the farmer. The problem of weeds and their control is as old as agriculture. The weed problem has, of late, assumed serious proportions and has become aggravated as man intensified his efforts in maximising production to meet the demands of the increasing population. New problems are arising every year as the newer technology generated tended to mollify the bioecosystem and the environment.

Of the total estimated loss caused by pests, insects, diseases and weeds in the world agriculture, weeds alone cause one third of the loss, amounting to about 25 billion dollars. In recent years, owing to large scale escalation of costs in petroleum products coupled with the well known energy crisis, the problem has been aggravated further by the increase in the cost of inputs in agriculture. For us now, it is a serious challenge to be able to raise a crop successfully and profitably too. Control of weeds is of course needed in cultivated fields but we also need to suppress the unwarranted and unwanted vegetation in other areas such as the banks of rivers, canals and drains, roadsides, grazing areas and forests.

In the process of domesticating the useful plants and in a bid to increase the production, several methods of control of weeds are in vogue depending on the situation. More recent research and technological development in weed control have been the use of chemicals to control unwanted vegetation. In many cases, crop substitution and adoption of some agronomic practices reduce the weed problem. Utility of host specific biotic agents in salvage of problematic weeds on a large area without altering the bioecosystem and in recent years, use of integrated methods of weed control appeared to brighten the prospects of increasing production by minimising the weed menace.

It is of paramount importance to tackle this world wide weed problem with a consortium-approach of scientists drawn from Agricultural

Universities, National Institutes and International Organisations. I am hoping that the participating weed scientists will give some thought to the development of integrated methods of weed control for various crops and situations. In addition, scientists should make safe use of herbicides with least possible hazards and allay the apprehensions in the minds of the public.

Friends, I have putforth some of my stray thoughts before this august gathering. Maybe, I might have made some observations which to you would appear simple and common place. But I am not an expert and I have only placed before you the layman's point of view. I am greatly impressed with the rapid strides that science has made. I am equally aware of the excellent work being done by you and others in your chosen fields, but it is my anxiety to see that this scientific gathering will bear fruitful results, which is possible only when a technology relevant to the needs of the farmer, especially the average unskilled farmer is generated and taken to his fields to enable him to adopt the same with ease.

I would like to express my deep appreciation for the opportunity given to me to share some of my thoughts with you and to inaugurate this talented conference, which I do now with great pleasure and I also wish your deliberations full success.

KEYNOTE ADDRESS

Dr. O. P. Gautam,
Director General, Indian Council of Agricultural Research,
New Delhi, India

Your Excellency the Governor of Karnataka, Dr. H. R. Arakeri, Dr. N. G. Perur, Dr. S. Matsunaka, Dr. K. Krishnamurthy, Members of the Organising Committee, Distinguished Delegates, Ladies and Gentlemen,

I consider it a great privilege and honour to have the opportunity to participate in this inaugural function and to address this 8th Conference of the Asian-Pacific Weed Science Society. Weed science is not the area of my specialisation, and therefore, I speak with some sense of hesitation to this galaxy of weed science specialists who have assembled here from different parts of the world. As a professional agronomist, however, I have had always an innate interest in the development of weed science research and education in this country. First, as the Head of the Division of Agronomy of the Indian Agricultural Research Institute, New Delhi I had the opportunity of organising perhaps the first Weed Science Section in the country in the 1950s. Later, in my capacity as the Deputy Director General (Education) in the Indian Council of Agricultural Research, I had the responsibility to develop the neccessary infrastructure for weed science research at the various Agricultural Universities and ICAR Research Institutes. Now, as the Director General, ICAR, the subject of weed science continues to be of immense interest and utmost concern to me particularly in view of the significance weed control has assumed in the intensive agricultural programmes and the fast changing socio-economic milieu in the country in recent years. I have, therefore, chosen to speak to you on this occasion on the subject of my current concern the Development of Weed Science Research and Education in India and the Future Outlook.

Weed Problems

Weeds have been a probelm for man ever since he took to domestication of plants, and therefore, weed management seems to be as old as agriculture itself. There are over 25,000 plant species in the world. Of these, about 250 have become important weeds in agriculture and non-agricultural system. Weeds occur in cultivated crops, in aquatic systems, forests, plantation crops and non-crop areas. They cause enormous losses and suffering to human beings by way of reduction of crop yields and quality, wastage of human energy and resources and increased expenditure to alleviate the problems caused by them. Many of these weeds are persistent, perennial, pernicious, parasitic, obnoxious and hard to control. They also cause health hazards to human beings as we have recently witnessed with weeds like *Parthenium hysterophorus* and Poison Ivy *(Rhus radicans)*.

In addition to direct reduction in crop yields through competition for nutrition, soil moisture and sunlight, weeds indirectly reduce the yield potential by serving as alternate hosts to a number of crop pests. Weeds like water hyacinth and *Salvinia orculata* impede flow of water in irrigation and drainage channels and even cause flooding and sedimentation. Fish culture is also affected due to aquatic weeds. The irrigation scheme on the Chambal river which was designed to command 1.4 million acres was choked by weeds in the first five years and the flow is reported to have been reduced by as much as 80 per cent.

Weed problems vary from crop to crop, region to region and farm to farm. Also, the spectrum may vary with soil types. The effect of weeds on crop growth is the worst in arid and semi arid regions where soil moisture is the limiting factor. As weeds often have a higher rate of growth initially, they compete very effectively with the crops in early stages of growth. Above all, in the context of new agricultural strategy of raising high-yielding varieties of crops with high inputs of water and fertilizer, the weed menace has to be checked in time. The very purpose of improved technology, which is to maximise the crop yield, will be defeated if the weeds are not checked in early stages of their growth.

Development of Weed Control Technology

The earliest of the methods to control weeds was the physical method – manual or mechanical. Starting with hand-weeding, weed control has gone through a number of stages in its evolution – use of hand tools, hoes, animal-drawn implements, cultural, chemical, biological methods and lastly integrated weed management. The manual or mechanical methods continue to be the mainstay in weed control in field and plantation crops even today. It is a common sight in India that men and women stoop down for days together to weed their fields with hand implements. With the advent of line sowing, a number of mechanical devices and bullock-drawn implements are being increasingly used for inter-culture and weeding. In some situations, as many as 20% of the man-days of crop production are spent in hand-weeding. In recent years, however, labour is becoming increasingly scarce and expensive. Increased literacy, migration from villages to urban areas and changes in social life in villages, particularly the changing role of women in society, are fast contributing to labour shortage at the farm level. The result is that whatever labour is available, it is utilised in most cases for other farm operations at the expense of weed control.

There is no doubt that physical methods of weed control are cumbersome and time consuming. At times, soil and climatic conditions may not permit the use of implements. It is under these conditions that herbicide use has potential even in a country like India.

Chemical weed control, except in plantation crops like tea and lately in intensive farming areas such as in Punjab for crops like wheat and rice and in Gujarat for onions and cumin, has still a long way to go by way of common usage. Biological control methods have so far been restricted to control perennial weeds in non-agricultural lands. With the development of varieties with specific canopy characteristics and with the cost of inputs going up, an integrated approach to use herbicides to complement the cultural methods is being increasingly adopted. It would appear that weed science is no more synonymous with either manual and mechanical methods or with herbicide use.

Herbicidal consumption in India is only about 6.5% of the pesticide consumption compared to 40-50% in the more advanced countries. The difference becomes even more glaring when we realize that pesticide consumption itself is low (only 430 g/ha) in India compared to 11000 g/ha in Japan. Insecticides always take a bigger share in developing countries over herbicides because human/animal labour is cheap; the damage due to insects is more conspicuous than that due to weeds and there is lack of simple, safe and economic herbicides.

Development of Weed Research in India

As early as 1952, ICAR launched Co-ordinated Weed Control Scheme on wheat, rice and sugarcane in eleven states to monitor the weed flora of major regions in the country and the relative feasibility, efficiency and economics of the various herbicides. About the same time, Plantation Crops Research Institutes like Toklai began to experiment with herbicides. Today tea plantations account for 60% of total herbicidal use in India. It was in the fifties that a full-fledged Weed Control Section was established in the Agronomy Division of IARI for the first time.

A number of agricultural universities and institutes have since developed research and development programmes and are major contributors towards weed research today in India. So far, screening and selection of herbicides for particular crops seem to be the major concern of most of the institutions. Comparatively little attention has been given to herbicide physiology, residue analysis, integrated weed management, adjuvants and antidotes, spraying equipment and weed biology and competition.

The latest effort to strengthen weed research in India is represented by the All-India Coordinated Research Programme on Weed Control which ICAR has undertaken at fourteen locations in different agro-climatic zones of the country. In 1968, the Indian Society of Weed Science was established and the first number of the INDIAN JOURNAL OF WEED SCIENCE published by this Society came out in 1969.

In the last decade, substantial work has been done to identify weed management practices in wheat, paddy, sorghum, maize, pulses, plantation crops, etc. in India.

In a number of cases, crop substitution and adoption of suitable agronomic practices have helped to eliminate the weed competition. Quick-growing crops having quick canopy coverage often suppress weed growth. Likewise, legumes inter-cropped with cereals not only improve soil fertility but also suppress weeds. Also, use of proper inter-row spacing to facilitate inter-cultivation helps to eliminate weeds. For the control of parasitic weed, trap or false crops have been identified.

Use of selective herbicides to eliminate morphologically similar weeds in crops like wheat, paddy, etc., has gained importance in recent years and found useful in increasing the production. Also use of herbicides in control of problematic weeds in several crops including tea is really encouraging.

Future Research Trends in India

Herbicide technology would be an area of continuing concern to us since it has the potential to become an integral part of the ever-changing agro-technological situation in India.

Research in weed biology should probe for a better understanding of survival mechanisms of seed dormancy in annual weeds, dormancy-apical dominance relationships of dormant buds and shoots in perennial weeds, population shifts under the influence of soil, climate and habitat changes. Such research should help identify most vulnerable stage to develop habitat management practices for synchronized germination of weed seeds and to identify chemicals to induce dormancy of weed seeds until they lose viability or prevent the fertilization of weed flowers. Similar work needs to be done on aquatic weeds and plants of forest environment. Studies be made on the effects of vegetation decomposition products in soil on growth of weeds.

Weed competition is maximum during the active growth stage and this critical period varies from crop to crop and from one weed species to another. Identification of these critical periods and economic threshold levels of weed competition helps in choosing appropriate herbicides (in mixtures or in rotations) or weed control practices for economising on the cost of weed control programme. Crop yield losses at different degrees of weed competitions and weed control methods should also be determined.

The whole field of *allelopathy* is coming up. Aim should be to identify allelopathic weed and crop species and chemical products which affect growth of other species in plant communities. Efforts should be made to incorporate the allelopathic compounds into crop plants through breeding so that crops may produce their own natural herbicides.

Weed control is not synonym with chemical control. This concept needs change and research needs to be intensified to find answers to problems which are emerging from intensive and multiple agriculture cropping. Weed control has been worked out hitherto for a specific crop. With the new intensive and diversified cropping patterns such as relay, companion and mixed cropping, the present concept of controlling weeds in a single crop has to give place to integrated weed management for the entire cropping system including appropriate mixes of mechanical, cultural and chemical control methods. Biological methods of weed control can also form a component of such an integrated system wherever possible. In devising integrated strategy for weed control, several elements will have to be suitably adjusted *e.g.* finding ways to short circuit the high reproductive capacity of weed seeds and preventing their reproduction; reducing longevity of weed seeds; interrupting regeneration and movement of weed seeds and to stop reintroduction of weeds. Since multiple and inter-cropping is a unique feature of Indian agriculture, this aspect of weed control research should have the highest priority.

Interest in *bio-control technology* is increasing as the problems arising from indiscriminate use of modern pesticides are becoming more widely appreciated.

Unlike herbicide use, biological weed control method aims not at immediate control but on the long term suppression of weeds. Also, some weed problems are better suited for biological control rather than mechanical or herbicidal control methods, such as weed infested forest areas, commercial plantations, reservoirs, public waterways etc. Integrating natural enemies into a control programme is a relatively new area of study and more attention may be paid to agricultural and aquatic weeds. When properly developed, the integrated programme should provide weed control compatible with ecosystem, besides the method being simple, cheap and easy to adopt.

Equally important are studies on the compatibility of insecticides and weedicides to reduce the operational cost and time required for crop protection.

Our scientists need to stress on the studies on residual and persistent effects of herbicides on soil and food products. There is need to strengthen the work on effects of weedicides on the soil microflora and fauna. Lastly, the use of stimulants and inhibitors for weed seed germination needs to be explored keeping in view the success achieved in stimulating germination of *Striga* seeds with the use of Ethylene gas.

Mention may be made of the possibility of using weeds like water hyacinth for bio-gas production, manufacture of paper pulp, board, mats and house roofs and as a protein source for non-ruminant animals and as a source of nitrogen and potassium for soil and mulching material for weed control and conserving soil moisture. Such research directed to make 'wealth from waste' is highly relevant to countries like India.

Basic research is needed to understand the absorption, translocation and action mechanisms of herbicides as well as transformation and degradation-pathways in plants and soil. Such work requires sophisticated facilities which we must create in the country. We must study how variations in adaptive climatic and biotic factors result in differential modes of action and degradation patterns.

Other areas of research related to herbicidal selectivity are (a) determination of the role of detoxification mechanisms in plants; (b) elucidation of the physiological and morphological differences affecting selectivity; and (c) understanding the interaction effects of adjuvants, surfactants, solubilizers, antidotes and herbicides.

Another area of great importance in basic research is that related to herbicide persistence, residues and residual effects and would require use of techniques such as bioassay, calorimetry, spectrophotometry and chromatography.

Breeding resistant varieties of sorghum, tobacco and millets against parasitic weeds such as *Striga* and *Orobanche* was taken up long back in this country but attempts have not been very successful. Besides, breeding as the cheapest and safest approach, germination-stimulant effects of ethylene have also been tried.

Toxicity of herbicides in field economy of energy through herbicides, conservation tillage and chemical fallows offer possibilities of double cropping.

Most work in the past was limited to insect parasites and predators. We should now explore possibilities with pathogenic micro-organisms and perhaps try combination of insects and pathogens. A proper insect can serve as a disease vector for the pathogens to enter.

Using natural enemies of weed species is the most fascinating area of work which holds out considerable promise for the future but more research is needed to understand the nature of host-plant specificity. We would find out economic feasibility of using snails and herbivorous fish to control aquatic weeds.

Lest the continuous use of herbicides should have harmful side effects, there is need to determine the long term effects of different weed control programmes, of crop production practices and habitat management system on weed problem such as weed persistence, effects of herbicidal use on soil microbial activities and on the physical, chemical and biological characteristics of soils.

There have been instances when second generation problems have appeared leading to shifts in weed flora due to continuous use of the same herbicide. Weed scientists should keep pace with such shifts and should be able to modify weed control programmes suitably. More research needs to be done on the role of micro-organisms in breaking seed dormancy of weeds and vegetative propagules.

Research effort in the past on the development of suitable herbicidal application equipment has been rather feeble in India. Therefore, research needs to be strengthened for the development of suitable sprayers, spray nozzles, and granule applicators. Effort should be directed to enhance durability and reduce cost of spraying equipment. We need nozzles which reduce drift hazards by controlling droplet size, pressure and discharge rate, etc.

We are aware that elsewhere controlled droplet applicators with spinning discs having fluted edges have been developed to produce smaller droplets. Recirculating sprayers have been developed to practically eliminate all drifts so that no herbicide falls on soil directly. Sprayers are also being developed elsewhere which produce electrostatic charges on droplets which when released are attracted to plant surface only. We in India must take note of this advanced technology.

Education and Transfer of Technology Programmes

Weed Science at present forms part of the Agronomy Divisions at the various Agricultural Universities. At both post-graduate and under-graduate levels, a few courses are taught on weed science and there are less students working on weed science for their degree programme. Also, the number of scientists devoting full time to weed science research is extremely limited (about 40 in 1978). In the context of the intensification of Indian agriculture (adopting of high-yielding varieties, package of improved agronomic practices and protection measures), weed control is becoming a serious limiting factor and a matter of national concern. We are accordingly giving serious thought to have a National Weed Research Centre mainly to devote itself to more basic and mission-oriented research and to provide the necessary technical back-stopping to nationwide programmes of applied research on weeds.

It would appear that weed control technology is comparatively more complex, more costly and not as simple as adoption of a variety or use of a fertiliser. The major factor in the way of adoption of modern weed science technology in India seems to be the limited supply of weed scientists and trained weed science extension workers to carry out location-specific research and demonstrations on farmers' fields.

In order to facilitate adoption of weed control technologies, it is absolutely essential to work out the cost-benefit ratio based on a detailed socio-economic analysis.

Ladies and gentlemen, I look forward to very fruitful deliberations in this Conference and wish the conference all success. Once again, I thank the organisers for giving me this opportunity to participate in the Conference. I wish all the distinguished delegates a very pleasant and comfortable stay in India.

PRESIDENTIAL ADDRESS

Dr. H. R. Arakeri,
President, Asian-Pacific Weed Science Society, Agricultural Scientists Recruitment Board, Barakhamba Road, Nirmal Tower, New Delhi - 110 001, India.

His Excellency the Governor of Karnataka Shri Govind Narain, Dr. O. P. Gautam, Dr. N. G. Perur, Dr. S. Matsunaka, Dr. K. Krishnamurthy, Members of the APWSS and ISWS, Distinguished Delegates, Ladies and Gentlemen,

The Asian-Pacific Weed Science Society is 14 years old with its first interchange held at the East-West Centre in Honolulu in 1967. It is actively engaged in its career of service and progress of knowledge in weed science which is of vital importance in modern agriculture. It has endeavoured to further the object of the Society of promoting knowledge through exchange of ideas and information among different scientists involved in weed science, particularly the Asian-Pacific Region. Hitherto 7 interchange biannuals were held earlier at Philippines (2nd), Malaysia (3rd), New Zealand (4th), Japan (5th), Indonesia (6th) and Australia (7th).

I am happy that the 8th conference of the Asian-Pacific Weed Science Society is being held in Bangalore, India. The theme of this conference is 'Perennial weeds in cropped lands and unwanted vegetation in non-cropped lands'. The subjects for discussion include Biology of weeds, Allelopathy of weeds, New herbicides and appliances, Physiology of weeds and herbicides, Herbicide residues and their interactions, Weed control in field and plantation crops, Obnoxious and aquatic weeds and their control, and allied aspects.

I deem it a privilege to extend a cordial welcome to all the visiting foreign delegates and my Indian colleagues who have gathered here to participate in the 7-day long deliberations of the conference. I am confident that their efforts will lead to beneficial exchange of ideas among the scientific fraternity and thus contribute and enlighten on many problems confronting scientists and farmers in weed management.

I thank the Japan Association for the Advancement of Phytoregulators (JAPR) and Indian Council of Agricultural Research for their financial help in organising this 8th conference. In addition, several herbicide firms have helped in various ways and I am thankful to them. Such an interdependent help is essential for proper development of weed science in our region.

APWSS has entered the stage of healthy adolescence and I am sure it will reach very soon vigorous purposeful adulthood. Let us all strive towards strengthening the Society for its legitimate leadership role in the years ahead.

I wish the conference a great success and I am sure worthy recommendations arising out of the various conference deliberations will be useful to farming community.

CROP PRODUCTION IN INDIA

H. R. ARAKERI
President (APWSS) and Chairman,
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Agriculture is said to have its roots in the innovations that took place in different parts of the world about 10,000 years ago. Present day agriculture in India, as elsewhere, has evolved itself through the ages. Agriculture and trade in India, as in other ancient countries, witnessed a boom much earlier than in the developed countries of today. India being a pastoral country before agriculture started, development of crops and animals took place concurrently leading to varying types of mixed farming systems that we see now in different parts of the country. Irrigated agriculture also developed successfully since irrigation has been an ancient art in the country. In some parts, monumental irrigation works were executed as early as 1st century A. D.

The revolution as a result of application of science to agriculture, in the middle of the last century in some parts of the world, however, by-passed many ancient countries including India. The need for "application of research to agricultural problems" was stressed by the successive commissions and committees appointed to examine and report on the recurring famine situations in the country from time to time before the close of the last century. Although initiation of action programmes towards this end can be traced to the events that took place in 1870s in pursuance of various recommendations, Departments of Agriculture, however, were firmly established only in 1901.

Developments leading to the setting up of Agricultural Research Institutes and Colleges took place in the first decade of the century. The significant landmark, however, can be said to be that of the appointment of the Royal Commission on Agriculture in 1926 to examine and report on the conditions of agriculture and rural economy in India. The Commission in its report of 1928, made recommendations of far-reaching consequences. In pursuance of the same the Indian Council of Agricultural Research charged with the responsibility of stimulating, initiating and coordinating agricultural research in the country was set-up in 1929. It also made specific recommendations to bring about improvements in the working of the departments and to create environment enabling farmers to put into practice the new knowledge gained through research and transmit them through extension organisations. In spite of the various efforts made to achieve these objectives of improving the agricultural situation, the production level remained almost stagnant during the first half of the century.

The country which was an exporter of some agricultural commodities in the beginning of the century became a net importer by 1947 when it achieved independence. In spite of increased attention during the planning era initiated since 1950, the situation continued to remain unsatisfactory, until the introduction of new technology consisting of fertilizer responsive varieties in the middle of the de-be identified and removed. Even the forests are not very productive. While forests contribute just about 1.5 per cent to the GNP as against about 45 per cent from ærable land, the contribution from the area put to other uses is almost nil. The scope for increasing the productivity of the 55 per cent of the land not under cultivation is tremendous. The land that is remaining in a degraded condition at present has to be reclaimed and put to better use. In short, it needs to be recognised that at present the yields of various cultivated crops are low and the use of uncultivated land is most inefficient. The endeavour, therefore, has to be to develop an appropriate land use plan for every hectare of land in the country.

The climatic conditions in most parts of the country are such that it is possible to practise multiple cropping wherever water resources are available. In some parts where the rainfall is spread over a longer period, double cropping is a common practice. With the availability of short duration varieties of various crops, the scope for extending the area under double cropping has become increasingly brighter. In the period 1950–51 to 1970–71, the area brought under double cropping has increased from 18 Mha to 26 Mha. With the emphasis at the national level on increase in the area under irrigation, the scope for double cropping would further improve. Thus, the gross sown area is likely to increase continuously although the scope for increasing net sown area is very much limited (Table 1). This would provide good scope for increasing the area under crops like oilseeds and pulses and the production of these has gained paramount importance.

*Table 1 : Land utilisation patterns – A. D. 1985 and A. D. 2000**

Classification	1970–71	1985 (Mha)	A.D. 2000
1) Area under forest	66.0	70.0	70.0
2) Area not available for cultivation	**45.4**	**54.0**	**56.0**
i) Area under non-agricultural uses	16.2	21.5	26.0
ii) Barren and unculturable land	29.2	32.5	30.0
3) Other uncultivated land excluding fallow land	**33.8**	**32.5**	**29.0**
i) Permanent pastures and other grazing land	13.3	14.0	15.0
ii) Land under miscellaneous tree crops and groves not included in net area sown	4.4	5.0	5.0
iii) Culturable waste	16.1	13.5	9.0
4) Fallow land	**19.7**	**16.5**	**13.0**
i) Other than current fallows	8.6	7.0	5.0
ii) Current fallows	11.1	9.5	8.0
5) Net area sown	140.4	145.0	150.0
6) Gross area sown	165.0	180.0	200.0
7) Total reporting area	305.3	318.0	318.0
8) Area for which no returns exist	22.7	10.0	10.0
9) Total geographical area	328.0	328.0	328.0

* As projected by National Commission on Agriculture 1976.

There is a tremendous scope for improving the land use efficiency by bringing about changes in the present cropping patterns. In vast areas there is a misfit in the rhythm of crops and the rhythm of soil moisture supply. Such situations have to be identified and improvements suggested with due regard to agronomic and socio-economic considerations.

India has been an agricultural country in the past and will continue to be so in the future, although its industrial development has been quite spectacular in recent years. Presently, population depending on agriculture has been as high as 70 per cent (Table 2) and situation is likely to be so even in 2000 A.D. The population was 238 m in 1901 and it increased to 361 m in 1952 (Table 3). The growth rate was less than 10 per cent earlier to 1930s and was less than 15 per cent during 1930s and 1940s and in the early part of 1950s, since then, the growth rate has been about 2.5 per cent per annum. As per the 1981 census, the population is 684 m and by 2000 A.D. it may be about 1000 m.

The net area sown was about 100 Mha in 1931 and it has increased to 140 Mha in

Table 2: Classification of workers in India as in 1971.

Class of workers	Total workers million	% to total workers
Cultivators	78.3	43.3
Agricultural labourers	47.5	26.3
Other workers	54.7	30.3
Total workers	180.5	100.0

Table 3: Population growth in India 1901 to 1981.

Year	Undivided India		Indian Union	
	Population (million)	Decennial growth rate (per cent)	Population (million)	Decennial growth rate (per cent)
1901	283.9	–	238.3	–
1911	303.0	(+) 6.73	252.0	(+) 5.75
1921	305.7	(+) 0.89	251.3	(–) 0.31
1931	338.1	(+) 10.60	278.9	(+) 11.00
1941	389.0	(+) 15.05	318.6	(+) 14.22
1951			361.0	(+) 13.31
1961			439.2	(+) 21.51
1971			548.2	(+) 24.80
1981			683.8	(+) 24.75

Census of India Paper 1 of 1981

Table 4 : Population and net area sown – Indian Union.

Year	Population (million)	Net area sown (Mha)	Per capita net area sown (ha)
1931	278.9	97.9	0.35
1941	318.5	98.3	0.31
1951	361.0	118.2	0.33
1961	439.1	133.2	0.30
1965	479.0	138.1	0.29
1966	489.6	136.3	0.28
1967	500.4	137.3	0.27
1968	511.6	139.9	0.27
1969	523.1	137.6	0.26
1970	534.8	138.7	0.26
1971	547.0	140.4	0.26
1972	558.6	139.4	0.25
1981	683.8	140.0*	0.20

* assumed

The net area sown was about 100 Mha in 1931 and it has increased to 140 Mha in 1942 (Table 4). The increase in net area sown has been substantial during the 1940s and 1950s and even in the first half of 1960s. It was during the war and post-war periods that various attempts were made to increase food production to cope with the needs of the increasing population. Increased production came in a large measure due to increase in area and to a small extent due to increase in productivity. Per capita net area sown has come down from 0.35 ha in 1931 to 0.20 ha in 1981.

India is a country of small farmers and it will continue to remain so for a long time to come because of continued pressure of population on land (Table 5).

SOILS

Soils of India vary widely in the fertility status as well as properties (Fig. 2). They have been classified into eight groups, namely, alluvial, black, red, laterites and lateritic types mountainous and

Table 5 : Distribution of agricultural holdings according to size.

Size/Class	No. of holdings (in million)		Percentage		Average size of operation holding		Percentage decrease in 1976-77 over 1970-71
	1970-71	1976-77	1970-71	1976-77	1970-71	1976-77	
Marginal (Below 1 ha)	36.20	44.53	50.9	54.6	0.40	0.39	2.50
Small (Between 1-2 ha)	13.43	14.70	18.9	18.0	1.44	1.42	1.39
Semi-medium (Between 2-4 ha)	10.68	11.64	15.0	14.3	2.81	2.78	1.07
Medium (Between 4-10 ha)	7.93*	8.21	11.2	10.1	6.08	6.04	0.66
Large (10 ha and above)	2.77	2.44	4.0	3.0	18.14	17.53	3.36
Total	71.01	81.52	100.0	100.0	2.30	2.00	13.04

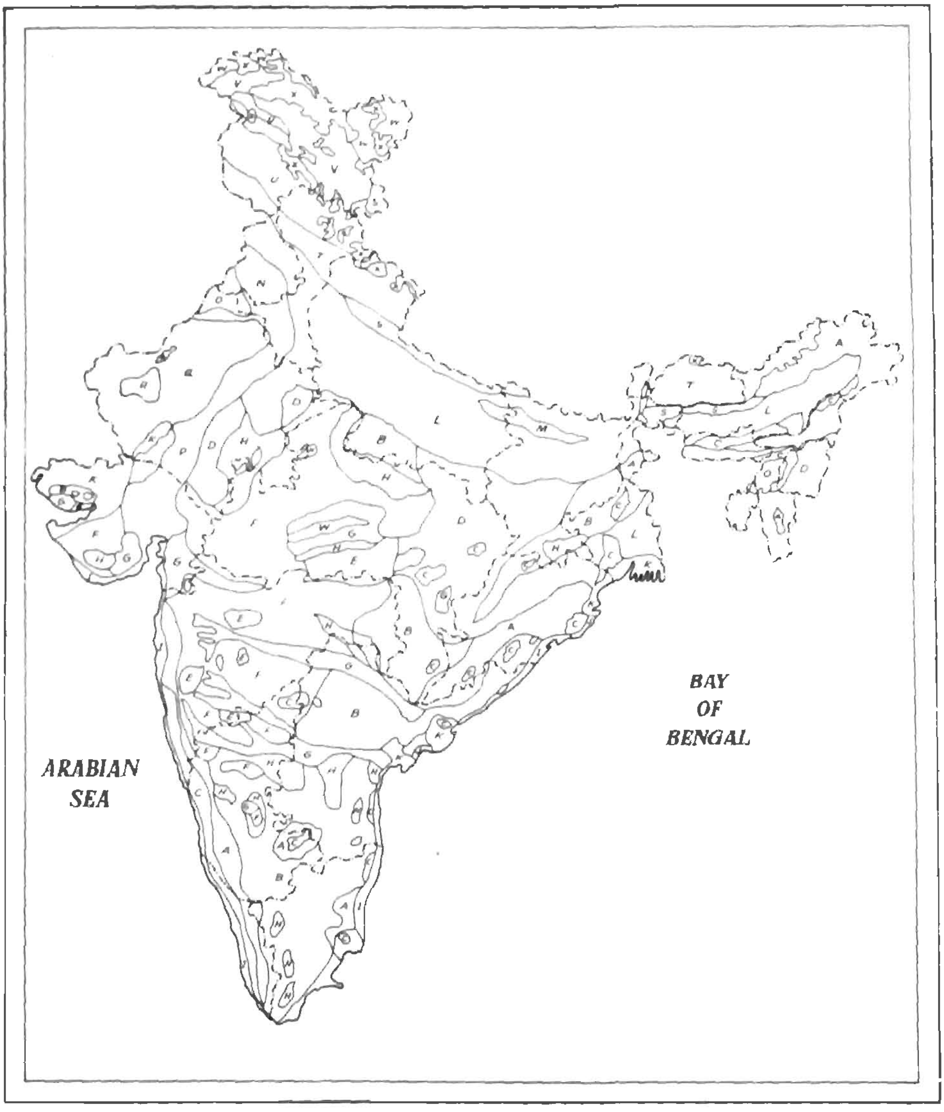

Fig. 2 : Soils of India.

hilly, desert, saline and alkaline and peaty. The areas covered under different kinds of soils is given below:

Major soils	*Area in million ha*
Alluvial	142.5
Black	60.3
Red	49.8
Desert	14.6
Laterites	12.1
Others	49.5
Total	328.8

Alluvial soils include deltaic alluvivum, calcareous alluvial soils and also coastal sands. This forms the most important soil group of the country. The alluvial soils differ greatly in consistency and texture, ranging from sand through silt and loam to heavy clay some with poor drainage. In some places there is accumulation of harmful sodium salts. Vast areas of the northern part of country extending from Rajasthan to West Bengal, are covered by these soils. They occur in parts of Orissa, Assam and Gujarat also. These soils are found in the valleys of major rivers in central and south India too. Alluvial soils are mostly deficient in nitrogen and in some place in phosphorus, zinc and also iron. Wheat, maize, paddy, gram and sugarcane are the important crops grown under rainfed as well as irrigated conditions.

Black cotton soils, which according to present soil taxonomy come under vertisols, are found to occur extensively in Madhya Pradesh, Maharashtra, northern parts of Karnataka and in parts of Andhra Pradesh, Tamil Nadu and Orissa. They are also found in patches in West Bengal, Bihar, Uttar Pradesh and Rajasthan. Owing to considerable variation in their depths, they are called shallow, medium or deep black soils. The fertility status also varies from very poor to rich. Variety of crops are grown both under rainfed and under irrigated conditions. Deep soils are well suited for crops that can efficiently use stored moisture. Cotton, sorghum, wheat and safflower are important crops grown under rainfed conditions. In shallow and medium black soils pulses, oil seeds and cereals predominate.

Red soils occur in the southern parts of the country *i.e.*, in Tamil Nadu, Karnataka and Andhra Pradesh. They appear in parts of Madhya Pradesh, Bihar and Orissa also. They are found in small patches in West Bengal, Uttar Pradesh and Rajasthan. Their depth and fertility varies from place to place. Various kinds of crops are grown mostly in rainy season from June to September. They are ideally suited for cultivation of different crops under irrigation.

Laterite and lateritic soils are found in heavy rainfall areas in Madhya Pradesh, Kerala, Karnataka, Andhra Pradesh, Assam, Bihar and Orissa. They are highly leached soils and are, therefore, deficient in all the three major nutrient elements and also in lime and magnesia. Occurrence of deficiency of some micronutrients is also a common feature. Soils in the valleys are rich where rice and sugarcane are raised. Plantation crops are raised in the elevated areas as well as in valleys (depending on the spread of rainy period and availability of irrigation facilities).

Desert soils are observed mostly in western Rajasthan and in small parts of Haryana, Punjab and Gujarat. They are sandy and poor in fertility. These soils are subject to wind erosion. Salinity and alkalinity are common features of these soils particularly in low lying areas. Water is scarce and salty. These are calcareous and are poor in plant nutrients especially nitrogen.

Other soils include saline and alkaline, peaty and mountainous and hilly soils. Mountainous and hilly soils are rich in organic matter. Peaty soils are obtained in humid regions of West Bengal, north Bihar and in parts of Uttar Pradesh and in Tamil Nadu. They are usually acidic and deficient in bases.

CLIMATE

The climate is diverse and varies greately in different parts of India, especially with regard to magnitude and distribution of rainfall. Although similar variability and diversity is observed in temperature and other elements of climate in winter and summer months, the conditions prevailing during the rainy months from June to September are amazingly uniform. This rainy period known as *kharif* season is the most important from the stand point of crop cultivation. In winter season, known as *rabi*, crops are raised on stored moisture or under irrigation. In summer season cultivation of crops is possible only under irrigation.

The Himalayas and the western and eastern ghats flanking the southern peninsula on both sides, are responsible to a very great extent for rainfall in India. But for these mountain ranges which help in condensation of rain bearing clouds (barriers) India would have been a rainless desert. The south west monsoon rains beginning from June are caused due to depressions and cyclonic storms. These depressions or low pressure areas originate in or pass through the head of bay of Bengal and travel through the sub-continent in a north westerly or westerly direction. Depressions start occurring from June onwards and they may occur three or four times a month during the active monsoon period *i.e.*, in the months of July and August. They may continue to occur but less frequently in the month of September and they are usually weak. The south west monsoon ceases by the end of September. The eastern parts continue to get rains even in October. South west part, however, receives rains primarily from north east monsoon in November and December.

The cyclones formed in the bay of Bengal and Arabian sea between April and June and October and December are responsible for storms in the coastal areas which are quite destructive on some occasions. Snowfall in the hills and light rains in the plains during the winter months from November to April occur because of western depressions. They move in from west and pass through the northern parts of the country right up to Assam. These showers although small in amounts are useful to *rabi* crops in the northern parts of the country. They may be useful or damaging depending upon the period of occurrence. Hailstorms cause heavy damages to standing crops in some parts.

There is considerable variability in the total amounts and distribution of rainfall in different parts of the country. The areas in the extreme east receive heaviest rainfall in the world amounting to as much as 1000 to 1050 cm per annum as against less than 10 cm in the western parts. The contrast is striking not only in total amounts but also in distribution. In some areas rains occur through major part of the year and in some parts they occur only for few days in a year. Major parts of the country however, receives rainfall from June to September. During this period 80 per cent of the total rainfall is received in the country.

It is not the total rainfall but the distribution of rainfall during the periods of growth of different crops that is of primary concern for success in agriculture. The study of rainfall data over a period of more than 50 years indicate that there is considerable variability in the magnitude of annual as well as monthly rainfall. Monthly rainfall variability is as high as 40 to 50 per cent even in the heavy rainfall months of July and August.

The duration of most of the field crops ranges from 100 to 130 days in some cases up to 180–210 days. The following limits for studying the rainfall patterns vis-a-vis cropping patterns have been adopted by the National Commission on Agriculture:

(i) Rainfall greater than 30 cm per month for at least three consecutive months would be suitable for growing paddy.
(ii) 20 to 30 cm per month for at least three consecutive months for crops like maize.
(iii) 10 to 20 cm per month for three consecutive months for crops like pearl millet, sorghum and ragi.
(iv) 5 to 10 cm for crops which are low water requiring, like grasses.
(v) Rainfall of 5 cm per month is not of much significance for crop production.

The monthly amounts over the entire year are codified to analyse and delineate the rainfall regions in the country. The letters, A, B, C, D, E indicate the limits of rainfall given above and the number of months in a year receiving such amounts is indicated by the numerical subscript. A_3 means the rainfall is 30 cm and above for three months. Using the codified formulæ the country has been delineated into 62 rainfall regions having 174 rainfall patterns. The salient features are as given below:

(i) February to May – Only 10 per cent of the geographical area of the country gets more than 10 cm for a month. 75 per cent gets less than 5 cm per month and 15 per cent, 5 to 10 cm during May.
(ii) June to September – This is the principal rainy period. Patterns vary quite a bit and 80 per cent of the rainfall is received during this period.
(iii) October – January – During this period 45 per cent of the area is under E type *i.e.*, no month has even 5 cm of rainfall. 30 per cent mostly in Assam and south, gets 5 to 10 cm during October. Fifteen per cent gets 10 to 20 cm per month mostly in east coast and north eastern States.

The distribution of gross cropped area in different major rainfall zones is given in Table 6. These 32 major patterns each covering more than half a per cent occupy together more than 95 per cent of the gross sown area in the country. The country however can be divided into four broad divisions as given below (Fig. 3):

(1) Heavy	–	'A' type for at least 3 months.
(2) High medium	–	'A' type at least for one month or 'B' type for two months.
(3) Low medium	–	More than 'C' type for at least 3 months
(4) Low	–	'C' type for one or two months only or less.

In spite of the fact that there is considerable variation in amounts and distribution of rainfall throughout the country, a happy feature is that more than 75 per cent of the country's area receives at least 10 to 20 cm of rainfall per month continuously for three months in a year. This pattern of rainfall is more than sufficient

Table 6: Area covered in major rainfall pattern zones.

Rainfall	No. consecutive months	Gross cropped area (percentage of all India)
$E_4 (E_4) E_4$	No. month with 10 cm or more	2.73
June/Sept. C_1	1	5.04
July/Aug. C_2/June/Sept. C_1	1-2	8.94
July B_1 C_1	2	1.87
July B_2	2	0.92
June C_4/C_3	4/3	16.90
July B_2 C_1	3	8.72
June C_1 B_2 C_1	4	3.33
June B_4/B_3	4/3	2.53
July A_1 B_1 C_1	3	1.39
June C_1 A_1 B_1 A_1	4	4.07
July A_2 C_1	3	2.44
June C_1 A_2 C_1	4	3.50
June C_1 A_2 B_1	4	7.57
June B_1 A_2 B_1	4	7.15
October C_2	2	1.34
September C_2	2	0.98
September C_3	3	0.93
August C_4	4	1.86
August C_2 B_1 C_1	5	0.67
June C_4/B_3 Oct. C_1	4/5	2.60
June B_4/B_3 Oct. C_1	4/5	0.88
June B_1 A_2 B_1 C_1	5	0.89
June A_4/A_3 Oct. C_1	5	0.71
May C_1 B_1 A_2 B_1 C_1	6	2.59
May C_1 B_3 C_1	5	1.37
April C_1 A_1 June A_4/A_3 Oct. C_1	7/8	0.66
April C_1 B_1 June A_4/A_3 Oct. A_1 B_1	7/8	0.59
April C_1 A_1 June A_4/A_3 Oct. C_1	7	1.14
May C_1 Sept. C_2	–	0.65
May C_1 August C_3	–	0.50
June C_4	–	0.12

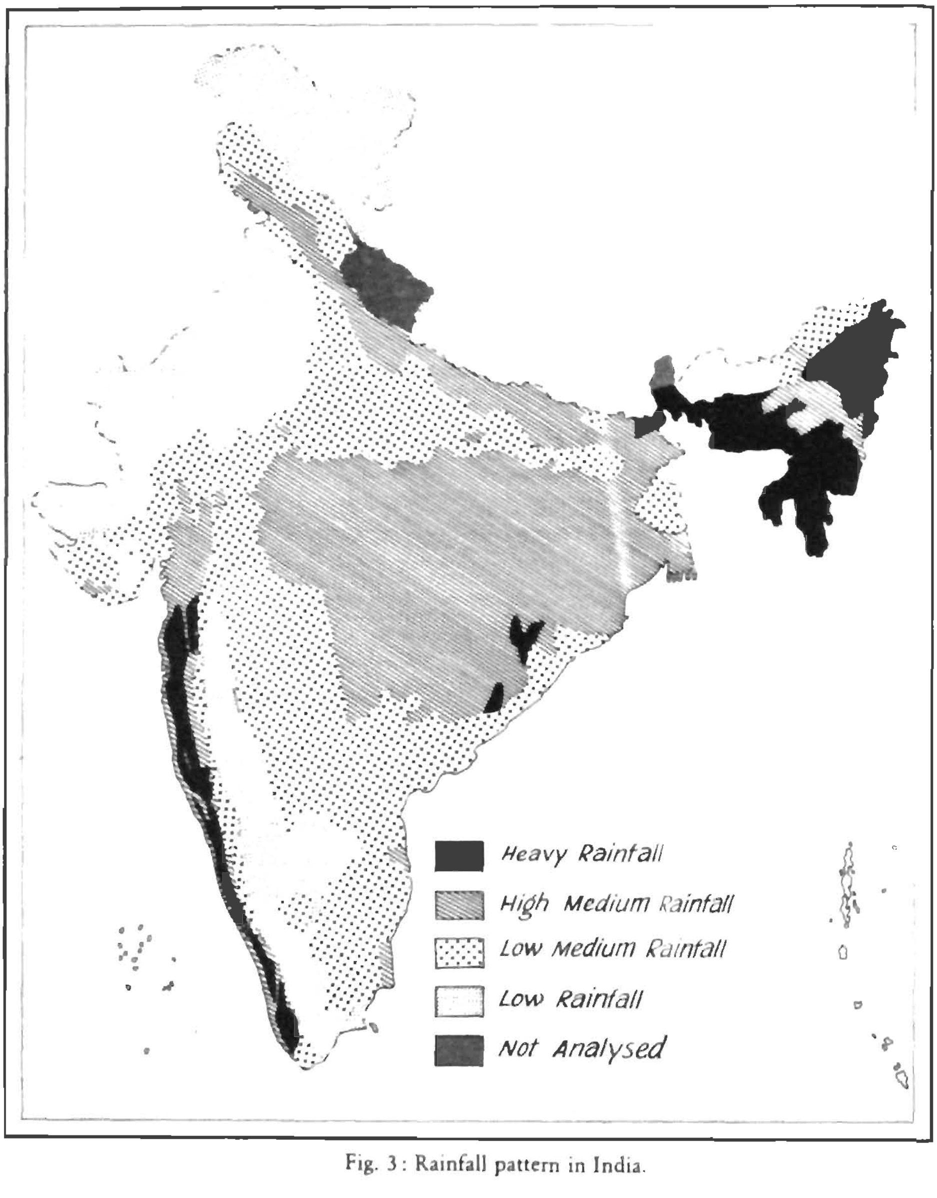

Fig. 3: Rainfall pattern in India.

to support at least one crop in a year. A large measure of stability could be introduced through measures for water conservation and crop planning in relation to possible water availability. In the remaining 25 per cent, major part receives the rainfall sufficient to support millets, grasses and trees. Switch over to fodder and the crops in these areas would be beneficial. It is these areas which need special attention with regard to providing of irrigation facilities.

IRRIGATION

Water is another resource which the country has in good measure. Various estimates have been made to know the water resource of the country. The latest estimate made by the National Commission on Agriculture shows that the country receives about 400 Mham of rain water annually. Out of this, about 125 Mham of water is used directly for transpiration by vegetation. Of the remaining 270 Mham, it is possible to harness only 105 Mham for irrigation – 70 million surface water and 35 million ground water.

Realising the importance of irrigation in Indian agriculture, construction of water storage systems on a range scale began in the second quarter of the last century. The great famines that occurred in succession during the last quarter of the last century led to the development of protective irrigation systems in famine prone areas. Minor irrigation works like small tanks and wells have been in vogue from early times in the private sector. They, however, started receiving attention and support through public sector as part of plan programmes.

The extent of area under irrigation in undivided India in 1947 was 24 per cent of the cultivated area *i.e.*, 28.2 Mha. After partition it came down to 20. During the last three decades irrigation received continuous support. The gross irrigated area which was 23 Mha (16 surface + 7 ground water) in 1951 has now reached the level of 55 Mha. There is scope to bring an additional area of 50 Mha under irrigation. As projected by the National Commission on Agriculture, the gross irrigated area could be 110 Mha (70 surface + 40 ground water) by 2025 A.D.

Ground water resources vary from place to place. While the scope in hilly states like Himachal Pradesh is limited, the same is enormous in the States like Uttar Pradesh, Bihar and Punjab. Ground water is tapped through open wells or tubewells. Tubewells may be deep or shallow. While shallow tubewells are mostly individually owned, the deep ones are constructed and operated by the state. The number of wells dug has risen from 3.64 million in 1956 to 7.78 million in 1978–80 and large number of them are fitted with mechanical water lifting devices. Electrical pumpsets are becoming increasingly popular in recent years. There were 261,000 irrigation tubewells in the country including 15000 State owned in 1971. In 1979–80, the number has risen to 2,146,00 including 36,000 deep ones. State owned tubewells give on an average a discharge of 1,35,000 l/h and irrigate about 80 to 100 ha of gross area. Shallow tubewells give a discharge of 30,000 litres per hour and irrigate about 4 to 8 ha. In some regions of the country there has been over exploitation of ground water, resulting in permanent lowering of water table. This situation has necessitated taking up legal measures to control the exploitation of ground water.

Irrigation projects implemented to supply surface water for crops are classified as major, medium or minor depending on the capital cost and area irrigated. There is considerable scope for developing and utilising the surface water resources in some regions while it is meagre in others. In plains, such projects cost much less initially and are easy to operate as compared to those in hilly terrain. There is considerable possibility for improving the irrigation efficiency by adopting different measures like lining of canals, streamlining distribution and mechanism of application, land shaping and better cropping and cultivation plan. Ultimate percentage of gross irrigated area to gross area sown is estimated to be as high as 85 in Punjab and 84 in Uttar Pradesh as against only 17 in Himachal Pradesh and 26 in Maharashtra (Table 7).

Table 7: Irrigation potential in different States.

State/Union Territory	% of gross irrigated area to gross sown area		
	1970-71	2000*	2025*
Andhra Pradesh	32	44	58
Assam (including Mizoram)	21	43	66
Bihar	24	64	82
Gujarat	13	30	34
Haryana	45	62	64
Himachal Pradesh	7	10	17
Jammu & Kashmir	33	60	70
Karnataka	13	31	41
Kerala	21	50	81
Madhya Pradesh	7	22	32
Maharashtra	9	22	26
Manipur	40	50	60
Meghalaya	20	25	25
Nagaland	12	35	45
Orissa	24	42	64
Punjab	25	83	85
Rajasthan	15	29	31
Tamil Nadu	46	43	42
Tripura	7	25	40
Uttar Pradesh	36	67	84
West Bengal	21	54	61
Union Territory	24	40	43
All India	23	42	52

*As projected by the National Commission on Agriculture (NCA) 1976.

CROPS

The diversity in climatic and soil conditions enable cultivation of a variety of crops in the country. Different types of cropping systems are in vogue in different parts of the country. The mixed cropping systems practised during early periods of agricultural development as an insurance against vagaries of rainfall and incidence of pests and diseases have given place to scientifically evolved inter, companion and relay cropping systems. Multiple cropping practices are becoming widespread all over the country especially in irrigated areas. Ratooning of certain crops is in practice since long. Improvements are being recommended for adoption for many crops with advantage. In general, there has been a gradual shift from crop production as a means of subsistence to commercial production.

The National Commission on Agriculture has made in-depth analysis of the cropping patterns prevalent in different parts of the country. The crop is indicated by letters like Pd, W and G for paddy, wheat and gram and subscript number 1, 2, 3 and 4 indicate the extent of coverage *i.e.*, 70 per cent or more, 50 to 70 per cent, 30 to 50 per cent and 10 to 30 per cent respectively. L1G4 would mean that wheat is grown over more than 70 per cent of the area and gram over 10 to 30 per cent. Similarly, Pd4 W4B4G4 would indicate that all the four crops are grown over an area of 10 to 30 per cent of the gross cropped area. The number of cropping patterns identified by the National Commission on Agriculture are as many as 177 (Table 8).

Foodgrains

Foodgrain crops occupy at present as much as 75 per cent of the total grass cropped area. This group includes cereals like wheat and barley grown in *rabi* season, rice, sorghum, pearl millet and finger millet and a large number of small millets grown in *kharif* and various kinds of pulses grown in different seasons. There is no room for increasing the total area under these crops because of increasing demand for other kinds of crops, but there is considerable possibility for increasing the productivity levels which are quite low at present.

Wheat is an important crop of the north western region of the country although it is grown all over except in eastern and southern parts which are warm and humid. The area and yield-levels have increased from 8.4 Mha and 0.6 t/ha in 1947-48 to 22.2 Mha and 1.6 t/ha in 1978-79. With the introduction of dwarf varieties, cultivation of wheat has spread to non-traditional areas in the east, like West Bengal and Assam with high level of yields. Barley and oats are other important *rabi* crops. Barley gives reasonable yields even under low fertility situations and it is resistant to alkaline and saline conditions.

Rice is the main cereal crop of the country. Despite large area under this, there has been a concern about its self-sufficiency in the country since long. Only in recent years, with increasing popularity rice cultivation in non-traditional areas in the north western parts of the country, that sizeable quantity of rice grain is getting into buffer stock. Rice production has increased from about 23 mt in 1949-50 to 53 mt in 1978-79. Area has also increased from 30 to 40 Mha. The analysis carried out by the National Commission on Agriculture indicates that there is scope and need to reduce the area under rice in the tracts where the rainfall is not sufficient in and irrigation facilities are not adequate. Total reduction in area suggested is about 6 Mha. There is good scope in raising the productivity level by increasing the area under high yielding varieties coupled with more efficient available agro-techniques the ones likely to be developed in future.

Maize, sorghum, pearl millet, finger millet and other small millets accounts for 40 per cent of the area under *kharif* crops and are distributed all over the country. Maize is grown mainly in moderately high rainfall areas. Other millets are grown even in heavy rainfall zones. There is

Table 8 : All India cropping patterns.

Predominating crops	No. of patterns	Predominating crops	No. of patterns
Paddy (Pd)	30	Gram (G)	7
Jowar *kharif* (JK)	17	Other pulses (Pu)	7
Jowar *rabi* (Jr)	13	Groundnut (Gn)	9
Bajra (B)	20	Other oilseeds (O)	1
Maize (M)	12	Cotton (C)	16
Ragi (R)	7	Fodder (F)	2
Small millets (Mt)	7	Fruits (Fr)	2
Wheat (W)	19	Potato (Pt)	1
Barley (Ba)	3	Tobacco (To)	2
		Plantation (L)	2

scope for increasing the area of maize by about 6 Mha in addition to the existing and it can be grown in all seasons. Recent studies have shown that it can be grown successfully as a *rabi* cro in the northern alluvial belt. It is already popular as a *rabi* crop in the Deccan plateau. Neither the need nor the scope for increasing the area under sorghum and pearl millet are limited but productivity has to be enhanced in order to meet the increasing demand for the same as a source of food and animal feed. Sorghum yields can be raised from the present low level of about 1/2 t/ha. Similar scope exists in the case of pearl millet and finger millet. Increasing attention needs to be focussed on other small millets to realise their full potential under varying situations.

Pulses are an important source of protein especially to the vegetarian population. Some of them form important items in livestock feed. Important pulses are pigeonpea, chickpea, cowpea, blackgram, greengram and horsegram. They are grown mainly as mixed crops although some of them are grown as sole crops both in *kharif* and *rabi* seasons. Recent investigations have brought out the possibility of cultivation of these pulses during summer under irrigation country over. Pulses occupy at present an area of 22 Mha and yield level is just about half t/ha. Pigeonpea and chickpea, are the most important pulse crops of the country. While pigeonpea is grown over most part of the country in *kharif*, gram is restricted to cooler regions in *rabi* seasons.

Oilseeds

Oilseed crops have been important in the agricultural economy of our country since long and large quantities of seed were being exported earlier. Even now a sizeable quantity of cakes are exported. Groundnut, brassicas, sesamum, safflower and niger yield edible oils whil linseed and castor yield industrial oil. In recent years, soyabean and sunflower are providing acceptable edible oil in certain parts of the country. There is a good future for these two new oilseed crops since they fit well into the situations where other crops are not profitable.

Groundnut is a major oilseed crop of the country. The national average yield has gone down from 1.2 t/ha in 1920 to 0.78 t/ha. Yield level can be raised to 1.5 t/ha by suitable allocation in the areas of production and adopting of improved practices. Similar scope exists for improving the yield level of other oilseed crops too. Increasing attention is being paid to castor since India happens to be the second largest producer of this oil in the world.

In spite of the fact that there is good scope for increasing the production of oilseeds in the country, it has not been possible to become self-sufficient in this essential commodity so far. The demands at present are being met by resorting to large-scale imports. Even in future, unless earnest efforts are made to improve productivity of existing crops, introduction of new crops like soyabean and sunflower in suitable areas it will be difficult to meet the increasing demand for this important food article. In addition, other sources like different kinds of oil bearing products like cotton-seed, rice bran, maize, products from trees and shrubs, should be exploited to increase over all production of this commodity.

Sugarcane

Sugarcane is the most important sugar yielding crop in the country. It is grown all over the country except in extreme north and high hills. Uttar Pradesh accounts for half the ara but only 40 per cent of the production. Other important states are in the alluvial plains in the north and in the sourthern parts. In contrast, the crop area in southern states is low but the yield levels are quite high. Though the concentration of area under sugarcane is quite high in the northern States, yields are low. The potential for increasing area as also productivity in other parts of the country is tremendous. The area as well as average yield can be doubled and thus obtain fourfold increase in production in the country by 2000 A.D. Scope for cultivation of other sugar yielding crops like sugarbeet and sorghums are limited.

Tobacco

Tobacco is an important commercial crop of the country. India ranks third among the major tobacco growing counries and fourth as far as production of flue-cured tobacco is concerned. Tobacco is one of the major foreign exchange earning commodity. The main States growing this crop are Andhra Pradesh, Karnataka and Gujarat accounting for 80 per cent of area and production. It is also grown in some northern States and in Tamil Nadu in South. It is a rainfed as well as an irrigated crop. There is need and scope for increasing the production of this commodity for export as well as for internal consumption.

Fiber Crops

Cotton is being grown in the country from ancient times. The spurt in cotton production, however, came with the introduction of new world types so as to obtain cotton for export. Although India exported lint and imported textiles for a long period in the past and remained importer of long staple type in the immediate past. In recent years, it has transformed itself into exporter of textiles and also to some extent raw cotton. This took place with the introduction of cotton hybrids. India is probably the only country where interspecific and intra specific hybrids were evolved and are grown commercially. Even then the long range demands show that concerted efforts are necessary to increase production so as to meet the increasing internal demands and also improve export. The percentage area under irrigated cotton has to be increased from present level of 16 to 65 of the total area under cotton. It would be advantageous to replace dryland cotton with some other appropriate crop like safflower in central India where the yields are quite low.

Bast fibre crops grown in India include jute, mesta, sunnhemp, flax and agase. Ramie has been introduced in recent years. More than 90 per cent of jute area is covered in the eastern States like West Bengal, Bihar, Assam, Meghalaya, Mizoram and Tripura. West Bengal accounts for more than 50 per cent of the total area. There is need to improve irrigation facilities for jute to increase and stabilise its production. About 50 per cent of the area under mesta is also concentrated in the eastern States of West Bengal, Bihar, Assam and Orissa. It is possible to step up its yield potential by about 50 per cent at least. Intensified efforts are necessary to raise and stabilise the production of various fibre crops. It is only then that it would be possible to meet increasing national as well as export demands.

HORTICULTURAL AND PLANTATION CROPS

The diverse agro-climatic conditions prevailing in different parts of the country provide ample opportunities for the cultivation of a large variety of fruits, vegetables, plantation crops, spices, medicinal and ornamental plants. It is estimated that these crops cover an area of out, to appropriate localities like hills, plains, river beds, around cities and urban areas, etc. Careful selection of centres of production will go a long way in streamlining the activities concerned with building up needed infrastructure support at least cost and effort.

Tuber crops of the country include potato, sweet-potato, tapioca and yam. These products supplement cereals as they are rich in carbohydrate. Possibilities of putting them to industrial uses are also bright. Some of the products in raw form or in the processed form for industrial uses could be exported.

Potato is grown all over the country except in warm and humid regions. Cultivation of potato is concentrated, however, in Uttar Pradesh, Bihar and West Bengal. Himachal Pradesh is an important producer of seed potato. With the development of new technique of growing the seed crop in plains, in aphid-free season, even combined with cold storage facilities, the area is getting dispersed all over the potato growing regions of the country. The area which was 0.5 Mha in 1970-71 is gradually increasing with the availability of new varieties suited to different agro-climatic conditions prevailing in different parts of the country. The yield level which was at 10 t/ha, is also improving. It is possible to treble the area and double the average productivity by 2000 A.D.

While major area under sweet-potato is to be found in Bihar, Uttar Pradesh and Orissa, it is grown and consumed all over the country on small-scale. Tapioca is concentrated at present in Kerala and it is spreading to other warm and humid areas gradually. Its industrial use is maximum in Tamil Nadu.

Bulb Crops

The peninsula part of the country is the main onion producing region. Maharashtra is the most important in this regard. Garlic is grown in the central parts including Madhya Pradesh and Gujarat. Since these products are consumed all over India the production is required to be increased to meet the rising internal demands and also for export for which there is demand in the neighbouring countries including middle east.

Species and Condiments

Various kinds of spices and condiments like ginger, turmeric and chillies are grown as specialised crops in suitable and concentrated pockets for supplying to other consuming areas within the country. They are grown, however, on small scale all over.

Plantation Crops

Large number of plantation crops are grown in the country. The most important of them are tea, coffee, pepper, rubber, cashewnut, coconut, arecanut and cocoa. There are indications that it is possible to grow oil palm, cloves and nutmeg also.

Total demand for rubber is placed at 1.5 mt in 2000 A.D. Half of it is estimated to be in the form of natural rubber. Kerala accounts for more than 90 per cent of the country's area and production. Remaining area is in Karnataka. Soil and climatic conditions prevailing in north eastern region and eastern coast are also suitable for rubber in addition to west coast. Thus there is scope for extending the area.

India's share of world's total export of cashew ranges from 70 to 90 per cent. India, however, imports as much from African countries as it produces within. With the development of processing facilities in African countries, need for increasing the production within the country has become imminent to feed the processing factories in full. The scope exists for doing so and attempts are under way in this regard through private as well as public sector ventures.

While production and consumption of arecanut is largely confined to Indian subcontinent, coconut is an international crop. Kerala, Karnataka and north eastern States account for more than 90 per cent of arecanut area and production. Coconut, however, is spread over Tamil Nadu, Karnataka and Andhra Pradesh in addition to Kerala which has nearly 70 per cent of the area. Both of them are grown in other States like West Bengal and Orissa also. The need for increasing the area under these crops is not imminent but there is scope for increasing the productivity and thus meet the increasing demands in future years.

Tea and coffee are two important foreign exchange earning products. India is the leading country in tea production and it is exporting to about 80 different countries of the world. Tea production is concentrated in north eastern and southern parts of the country. Tea industry provides employment to about a million persons. The production target set for 1985 is 750 mkg. Coffee is grown in southern States of Karnataka, Kerala and Tamil Nadu. About 60 per cent of the area is in Karnataka. It is grown to a very small extent in Assam, Andhra Pradesh, Maharashtra and Orissa also. About 1.5 to 2 per cent of the world trade is contributed by Indian Coffee and it occupies 12th place. Coffee exports touched an all time record of 30,000 t in 1975-76.

Fodder Crops

Agricultural by-products mainly of cereals and pulses sustain the majority of livestock including cattle and buffaloes in India. The forage material obtained through grazing and harvest from uncultivated areas including forest and from the cultivated areas in the form of weeds has served as a supplement in a big way. Animal population has gone on increasing without any restriction. Only very recently the trend for stabilisation is noticed. Fodder resource being limited, the animals are underfed and they suffer from malnutrition. One of the important measures suggested since the middle of the last century has been the improvement of feeding standards to increase the production of animal products especially that of milk.

With the emphasis on increasing the availability of animal products with a view to improving the nutritional standards of vast majority of population suffering from malnutrition, increased attention is being paid to livestock development in the country. This would become possible only when there is increased availability of fodder and feed material. At present the area put under specific fodder crops is just about 6 to 7 Mha. The area under fodder crops would be required to be increased to at least 16 Mha in addition to improving the supply of feed from forests and other uncultivated areas. This will be in addition to increased quantities of traditional by-products of grain crops. Sufficient quantities of feed in the form of cakes of groundnut and other edible oilseeds would also become available as a result of improvement in the production of these crops because of the measures programmed to be undertaken for the purpose of meeting the increased demands for vegetable oils.

Sericulture

Sericulture is another activity which depends on crops like mulberry and castor. India produces all the four kinds of silks although dominating one is that depending on mulberry. Contribution from

India towards silk is still small. It is just about 10 per cent although the conditions are favourable for its expansion throughout the country. At present Karnataka contributes 82 per cent of mulberry silk. Other important States are West Bengal and Jammu and Kashmir contributing 15 and 2 per cent respectively. While eri and muga silk are concentrated in Assam, tassar is commonly produced in Madhya Pradesh and Bihar. The scope for extending employment opportunities through sericulture is also considerable.

GENERAL

In summary, it can be said that scope for increasing the overall production of various agricultural products is tremendous. High levels of productivity can be achieved provided attempts are made to grow the crops most suited to the locality and adopt appropriate cultivation plan as recommended from time to time based on relevant research. There is a need for large-scale changes in the allocation of areas for different crops. Major changes in the suggested allocation as recommended by the National Commission on Agriculture are given in Tables 9 and 10.

INPUTS

Subsistence farming as practised in India almost until the middle of this cen-

Table 9: Allocation of area (gross) in 2000 A. D.*

Crop	Area (Mha)		Projected irrigated area (Mha)
	present	projected	
1	2	3	4
Rice	37.54	32.00	24.00
Wheat	18.01	17.55	14.90
Other cereals	45.57	48.50	6.99
pulses	22.15	25.00	5.37
Total foodgrains	123.27	123.05	51.26
Oilseeds	16.34	24.50	5.10
Sugarbeet	–	0.50	0.50
Sugarcane	2.59	5.00	5.00
Tobacco	0.45	0.55	0.40
Cotton	7.60	11.50	7.50
Jute	0.78	1.00	0.80
Other bast fibres	0.493	0.525	0.21
Total commercial crops	28.253	43.575	19.51
Vegetables and miscellaneous field crops	3.268	8.798	4.485
fruits	1.80	4.00	1.25
Total plantation crops	2.317	2.876	1.00
Fodders	6.91	16.50	6.50
Grand total	165.818	198.799	84.005

*As projected by National Commission on Agriculture.

tury needed very few inputs from outside. Farmer produced and preserved his own seeds. Farm yard manure helped in maintaining soil fertility at a certain minimum level. Pest and disease control has been through biological sources. Implements and tools were fabricated by the local artisans using the locally available timber. Iron pieces for shodding the implements and some hand tools were the main inputs obtained from outside. The situation was not much different even in the decades of 1920s, 1930s and 1940s. Although steps were initiated for bringing about improvement in the agricultural scene of the country through better seeds, fertilisers, chemicals and improved implements during the 1st half of the century, it is only during the last three decades after the 2nd World War that there has been change in the attitudes and programmes. The real step up took place only in the middle of 1960s when high yielding varieties were introduced.

Seeds

Farmers in India know the value of good seeds since long. Commercial organisations, however, came into existence only during 1960s. In the early period, Government organisations produced and distributed small quantities of seeds of improved varieties. Although there has been tremendous improvement in the situation with regard to production and supply of seeds of various kinds it cannot be said that the structure does match the needs. A redeeming feature, however, is that farmers have learnt the art of seed production and they are in a position to shoulder the responsibility of producing and delivering any kind as required. Mechanism and organisations for procuring, processing, storing and marketing of seed produced by farmers as per plan are still to be built up to the required extent. The task to be performed in this regard is gigantic.

It has been estimated that to cover about 80 per cent of the sown area with

Table 10: Present and projected area allocation to different crops and yield levels.

Crop	Area (Million hectares)		Decrease or Increase	Yield (t/ha)	
	1970–71	2000 A. D.		1970–71	2000 A. D.
Rice	37.54	32.00	− 5.54	1.11	3.04
Barley	2.58	5.50	+ 2.92	1.03	7.97
Maize	5.80	9.00	+ 3.20	1.05	2.65
Small millets	4.68	2.00	− 2.68	0.38	0.75
Pulses	22.15	22.00	+ 2.85	0.32	1.50
Groundnut	7.23	9.00	+ 1.77	0.78	1.50
Safflower	0.59	2.00	+ 1.41	0.24	0.50
Soyabean	–	1.00	+ 1.00	–	1.00
Sunflower	–	1.50	+ 1.50	–	1.00
Sugarcane	2.59	5.00	+ 2.41	49.00	82.00
Cotton	7.60	11.50	+ 3.90	0.12	0.46
Fruits	1.80	4.00	+ 2.20	–	–
Potato	0.49	1.50	+ 1.01	9.00	20.00
Vegetables	0.90	4.00	+ 3.10	–	20.00
Fodder crops	6.91	16.50	+ 9.59	–	–

quality seeds every year it would be necessary to put 2.5 Mha of land under seed crops. The quantity of seeds to be handled would be about 2.5 mt. As many as 30,000 centres would be required to be organised for storage and distribution of seeds. Millions of small farmers will be required to be organised to produce seeds. Some headway has been made with regard to few hybrids of sorghum, maize, cotton, etc. There is still much that is remaining to be done to place the seed industry on sound footing. This industry will provide ample scope for employment in rural areas.

Fertilisers and Chemicals

Other important inputs required for increasing production of various crops are fertilisers and chemicals. It is estimated that fertilisers and chemicals required to support agricultural development programmes by 2000 A.D. would be 16 mt and 300,000 t of various technical materials respectively as against the present level of consumption of 5 mt and 50,000 t.

Weeds cause heavy damage to crops in many parts of the country. Studies to assess the damage caused to different crops in different parts are under way. Weed control is attempted mainly through manual labour using hand tools and with animal drawn implements. Use of chemicals although started since 1950 the quantity of herbicides used in the country at present is as meagre as 1500 t. It is only in recent years that the use of chemicals is becoming inevitable for controlling certain weeds like wild oats and Phalaris species in wheat in northern India. Use of chemicals is also popular in plantation belts. With the increase in wages and scarcity of labour during certain periods use of chemicals would become increasingly popular in future. Even then chemical method may just supplement but not supplant other methods.

The required quantities of fertilisers and chemicals will have to be produced and distributed. At present the production in the country is short of requirement. Organising production and distribution of these inputs is again not a task of small magnitude.

Power, Implements and Tools

Farm power and improved implements are the other important inputs. In spite of large number of animals and human power, timely cultivation is hindered in many parts of the country for want of adequate power. Power availability is so low as 0.1 H.P. to 0.2 H.P. per hectare in many parts as against the optimum requirement of 0.5 to 0.8 H.P. Additional power is required to be provided in a selective manner with care and in such a way that employment opportunities would be enhanced further because of increase in the (a) area under multiple cropping, (b) in the area under irrigation and (c) in the quantity of farm produce to be handle due to increased yields because of timely and proper cultivation. This means that there is no other way but to bring about selective mechanisation. Even in respect of improved implements and tools the position is not much different. Only 10 per cent of the ploughs are of improved type. Vast areas in the northern parts of the country are sown by broadcast method. Use of modern implements and tools in place of traditional ones will reduce drudgery and improve efficiency. In this activity also there is scope for increasing employment opportunities in rural areas.

Finance

Transformation of agriculture from a subsistence level to a commercial proposition, is not possible without increased investment. The credit needs are therefore, increasing continuously. Efforts to introduce institutional financing system through co-operatives in place of age-old source of money lenders began as early as 1904. In 1950 only 3 per cent of the total borrowings of the farmers was through co-operatives. Major commercial banks were nationalised in 1969. Lending by banks which was only Rs. 50 million increased to Rs. 2.36 billion in 1971. The total institutional lending reached a level of Rs. 15.37 billion in 1973-74 and to about Rs. 20 billion in 1980-81. This level would be required to be raised to Rs. 200 billion by the end of the century.

Marketing

It is being increasingly realised that it is not sufficient if attention is paid only to production aspects. Marketing aspects are becoming more and more critical especially to small farmers. Organisations will have to be built for pooling, processing and marketing of various kinds of agricultural produce. About 30 thousand marketing centres will have to be developed suitably with schooling, medical, banking and other social service facilities. This would help in checking the movement of rural population to metropolitan centres in search of employment.

CONCLUSION

The country has vast natural as well as human resources. Agricultural development is a complicated and long drawn out process. It has roots in research laboratories and experimental farms and ends in the application of technology developed on the fields of farmers. Production will increase to the extent farmers are enabled to adopt new technology as and when it becomes available along with the needed supplies and services. This is possible only through building suitable organisations to render the services. Agricultural Research and Educational Institutions set up already will have to be continuously strengthened so that there will be regular flow of trained manpower and relevant research results.

The country has achieved significant progress in increasing production of various commodities during the last 20 years (Table 11). There is still a long way to go in the direction of achieving the national goal of banishing poverty and of providing the minimum needs for bettering the quality of life of a vast population of the country is reached. The levels of production of different commodities required to be achieved as projected by the National Commission on Agriculture are given in Table 12.

The question is not whether the country has the potential and resources for producing what is needed but it is whether it will be possible to build the organisations for serving agriculture with a determination to use the available resources which are more than sufficient to meet the needs. In short, the challenges before the country are those connected with building and using the organisations required for developing and conveying the needed appropriate technology and for servicing agriculture in the matter of management of supply of inputs and outputs along with creations and maintenance of needed climate for encouraging production.

Table 11 : Level of agricultural production 1962–63 to 1978–79

Year	Gross cropped are (million hectares)	Gross irrigated area (million hectares)	Gross area under HYV crops (million hectares)	Fertiliser consumption (all nutrients '000 tonnes)	Weather situation (for purposes of agricultural production)	All India Index Numbers of Agricultural Production (Base-Triennium ending 1969–70 = 100)			
						Food-grains	Oil-seeds	Cotton (Lint)	Sugarcane in terms of Jaggery
1962–63	156.8	29.5	–	452	Average	83.8	94.8	98.0	78.0
1963–64	157.0	29.7	–	544	Average	85.3	91.3	102.4	88.2
1964–65	159.2	30.7	–	773	V. Good	94.3	107.2	107.4	102.9
1965–66	155.3	30.9	–	785	V. Poor	75.8	85.6	86.7	105.3
1966–67	157.4	32.7	1.9	1101	V. Poor	77.1	86.8	91.1	78.5
1967–68	163.7	33.2	6.1	1539	Good	98.7	105.4	103.2	80.7
1968–69	159.5	35.5	9.2	1761	Average	97.3	92.4	97.4	105.7
1969–70	162.3	36.9	11.4	1982	Good	104.0	102.2	99.4	113.6
1970–71	165.8	38.0	15.4	2256	V. Good	112.9	116.1	85.1	106.4
1971-72	165.2	69.4	18.2	2656	Average	111.4	114.3	124.2	95.4
1972–73	162.8	40.8	22.1	2768	V. Poor	102.3	95.3	102.4	104.7
1973–74	169.6	42.2	26.0	2839	Poor	110.3	114.5	112.7	118.3
1974–75	164.6	43.6	27.0	2573	V. Poor	104.3	114.9	127.8	120.7
1975–76	170.3	45.3	31.9	2894	Good	127.2	123.8	106.2	118.3
1976–77	169.1	46.9	33.6	3411	Poor	115.7	103.9	104.2	130.0
1977–78	172.7	48.5	38.0	4286	Good	133.6	117.5	129.3	147.3
1978–79	174.0	52.2	41.1	5117	Good	138.8	127.2	141.5	131.5 Provisional

Source : 1) Annual Review of Fertiliser Consumption and Production 1979–80, Fertiliser Association of India, July, 1980. PP.61.
2) Estimates of Area and Production of Principal Crops in India 1978–79, Ministry of Agriculture, Government of India.

Table 12 : Aggregate gross demand** for selected agricultural commodities
(million tonnes except where otherwise specified)

Items	1971	1985		2000 A.D.	
		Low*	High	Low	High
Foodgrains	107.9	150.3	162.9	205.3	225.1
Sugar & gur	11.5	16.9	21.2	24.0	29.9
Vegetable oils	3.2	5.3	6.6	8.3	10.2
Cotton clothing (million bales) (in terms of raw cotton)	5.9	8.1	12.9	10.4	17.2
Milk	21.7	33.4	44.2	49.4	64.4
Eggs (in million)	6,040.0	10,217.0	15,972.0	17,419.0	28,513.0
Meat	0.7	1.1	1.4	1.6	2.1
Fish	1.8	2.8	3.4	4.6	5.5

As projected by National Commission on Agriculture
These are exclusive of export demand

WEED RESEARCH : A COMPONENT OF ICRISAT'S FARMING SYSTEMS RESEARCH PROGRAM

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ABSTRACT

Weed research is an integral part of ICRISAT's farming systems research that aims to develop improved systems for the small farmer of limited means. Initial studies started in 1975 indicated that in the Indian Semi-Arid Tropics the farmer's level of weed control was usually satisfactory for his traditional systems, but it was concluded that he would respond to better weed control measures if they were part of improved and more remunerative systems. Some aspects of the ICRISAT research are described to illustrate how the cropping system itself may be manipulated to improve weed control. Some evidence is presented on the possible benefits of smother crops, and some examples are given of the role that herbicides could play in improved systems.

INTRODUCTION

ICRISAT was among the first of the international agricultural research centres to give formal recognition in its mandate to the need to supplement research on individual crops with research on farming systems. This research aims to develop technologies that are more productive, more stable and socio-economically viable, and it is primarily committed to helping the small farmer of limited means. It is multidisciplinary in nature and holistic in its approach. It covers a wide range of activities from Base Data Analysis, through On-Center Research to On-Farm Research.

Base Data Analysis consists of the compilation, synthesis and analysis of available data to determine research priorities and strategies and much of this work is carried out as farm surveys. On-Center Research examines those components of research that have important implications in technology development; research on individual components is often carried out in small plots but the integration of components into promising technologies is examined on an operational scale. On-Farm Research involves the further evaluation of promising technologies in a "real-world" farming situation, and it provides important feed back to the On-Center Research. As an integral part of farming systems research, weed research follows this same general pattern and it is within this framework that it is briefly discussed here.

BASE DATA ANALYSIS

From its inception in 1975, the weed research program was initially involved in a series of agro-economic on-farm investigations with the objectives of 1) evaluating the efficiency of farmers' own methods of weed control, 2) investigating whether alternate and improved methods of weed control were feasible and 3) assessing the pay off from additional weed control (Shetty, 1980).

These studies showed that in the Indian Semi-Arid Tropics farmer's weed control practices were based on rational considerations in that the level of his weed control inputs were largely determined by the expected level of returns from those inputs (Binswanger and Shetty, 1977). Thus crops that were likely to give a good yield response were usually well weeded while those likely to give a poor response were often neglected. It was concluded from these studies that the farmer's level of weed control was appropriate for the farming systems that he practised. However, Binswanger and Shetty also considered that the farmer would accept increased weed control measures if these were an integral part of improved and more remunerative farming systems. Thus a primary objective of weed research at ICRISAT is to determine what weed management practices are suited to the improved farming systems being developed, and especially how these practices are best integrated with other components such as crop variety, cropping systems, machinery, tillage practices, fertility level, land and water management practices, and pest and disease management.

ON-CENTER RESEARCH

It is not the objective of this paper to give a detailed description of the On-Center Research, but rather to illustrate the kind of approach that is being used. As examples, some brief comments will be made on the importance of cropping system, on the possible role of herbicides, and on some of the operational research.

Cropping systems: The cropping systems of the small farmer of the Semi-Arid Tropics are complex and varied, and each may have its own weed problem and may require its own solution. This is well illustrated by some studies in millet/groundnut intercropping (Shetty and Rao, 1981). The dominant weeds in this system at ICRISAT center are *Digitaria ciliaris* Pers., *Celosia argentea* L., and *Cyperus rotundus* L., in terms of weed biomass, but their relative importance changes with the relative proportions of the two crops. As the proportion of groundnut increases, *Cyperus* decreases markedly, *Digitaria* increases a little, and *Celosia* increases markedly. The sharp increase in *Celosia* is attributed to the ability of this tall, competitive weed to dominate the groundnut canopy. The decrease in *Cyperus* on the other hand is attributed to the short stature of this weed and the severe shading caused by the groundnut canopy. Supplementary studies conducted with artificial shades also confirmed the extreme shade sensitivity of *Cyperus* compared to several other weeds. These findings emphasise how specific the weed problem may be to a particular cropping system and that in the case of intercropping systems, which are so important for the small farmers of the Semi-Arid Tropics, the problem may be considerably modified by the relative proportions of the component crops.

The intercropping system also serves as a good example of how the cropping system itself may be chosen to improve weed control. Studies have shown that in pigeonpea, a naturally slow-growing crop and a poor competitor against weeds, the weed infestation can be reduced by 50–75% with the introduction of intercrops such as cereals or low-canopy legumes (Rao and Shetty, 1976); indeed this is well known by farmers and the pigeonpea crop is very commonly intercropped. However, it should not be thought that intercropping always improves weed control. In the pigeonpea situation the improved control is brought about by the fact that the intercrop provides an *additional* population of plants so that the total population pressure on weeds is increased; moreover, the intercrop is usually much more competitive than the pigeonpea itself. In other intercropping systems, such as the millet/groundnut one mentioned above, total population pressure is not increased because the introduction or increase in one component crop is offset by an equivalent decrease in the other. Thus the severity of weed problems in these systems is usually intermediate between the problems of the respective sole crops, and largely dependent on the relative proportions of these crops.

The importance of high plant populations has also been exploited in a 'smother-crop' system developed at ICRISAT. Early maturing crops of cowpea [*Vigna unguiculata* (L.) Walp.] or mungbean [V. *radiata* (L.) Wilezek] have been added between the normal-spaced rows of cereal sole crops or cereal/pigeonpea intercrops. Results indicated that this could reduce weeding costs by saving on one hand weeding. Furthermore, the main crop yield was not significantly affected and the smother crop gave a small additional yield (Shetty, 1979).

Another aspect of increased plant population that has been studied is to reduce the within-row weeds by increasing the within-row competition from the crop. For this purpose crops were grown in wider rows but the optimum plant population per unit area was still maintained by decreasing the within-row spacing. In sorghum it was found that the common 45 cm width can be increased to 67.5 cm, and in some seasons to 90 cm without significant loss in grain yield. Widening the rows has an additional advantage that the farmers can intercultivate more effectively with the local implements like blade harrows. It was further observed that in these wider row widths the addition of a smother crop was likely to affect sorghum yields and, as indicated earlier, it could save on the costs of interrow weeding.

Herbicides: On-Farm Studies (Binswanger and Shetty, 1977) showed that there is limited potential for herbicide use on rainfed crops in existing systems of the SAT areas of India because of cost considerations as well as the possible decrease in the income opportunities for the landless female labour. However, in improved systems where the potential returns to improved weed control are high, herbicide use may be feasible in those situations where cultural control methods can be difficult. An example of such a situation is the improved farming system developed at ICRISAT for the deep black soils of the Indian Semi-Arid Tropics in medium to high rainfall areas. In these areas the land is traditionally left fallow during the rainy season and crops are grown during the post-rainy period on stored moisture. These soils have a 50–60% content of montmorillonite clay and their major problem is limited workability during the rainy season; this restricts the opportunity for timely weed control either by cultivation or hand weeding. An alternative system is the use of pre-emergence herbicides and thus a limited screening program has been conducted to identify those most suitable. A further feature of the same farming system is a minimum tillage concept for establishing the post-rainy season crop. Thus by reducing the conventional tillage operations by using a herbicide, soil moisture conservation can be improved and the gap between harvesting of the rainy season crop and sowing of the post-rainy season crop can be minimised; both these features help towards greater assurance of establishment of the post-rainy season crop.

As a general point, ICRISAT experiments with herbicides have shown that while herbicides give good control of susceptible weeds such as *Celosia argentea* L. on the red soils or *Brachiaria eruciformis* Griseb. on the black soils, this can lead to the proliferation of other weeds such as *Cyperus rotundus* L. and *Cynodon dactylon* Pers. The more practical weed management systems have thus been shown to be relatively low doses of herbicides combined with some measure of hand weeding and interculture to ensure the control of both susceptible and resistant weed species (Rao, 1980).

Operational research: An important feature of the ICRISAT weed research program is the testing of promising weed management options on a large scale to determine operational and economic feasibility. Currently, three different management systems are being tested on the operational watersheds on the deep black soils as part of a package of improved land and water management and improved cropping systems. These three systems are 1) a hand weeding system (two weedings in the rainy season crop and one in the post-rainy season crop), 2) a herbicide based system (a pre-emergence herbicide at the beginning of the rainy season crop with one hand weeding in the rainy season crop and one in the post-rainy season one), 3) a smother crop system in the rainy season crop and hand weeding as in 2). Results from the 1980-81 season (Table 1) indicated that for a sequential cropping system of maize followed by chickpea the hand weeding and herbicide based systems gave higher net returns than the smother crop system, largely because this last system reduced maize yields. In a sorghum/pigeonpea intercropping system, however, the herbicide based system and the smother crop system gave highest net returns. In each of the systems, weedy check and weed free treatments were included for comparison. In this year 5 hand weedings were required to keep the plots weed free. Interestingly, the weed free treatment gave the highest net returns indicating that in this particular season, even higher weeding input than used in the treatment was still economic.

Table 1. Effect of different weed management systems on crop yields and net returns from operational scale trials on deep black soils at ICRISAT center 1980–81.

	Sequential cropping system			Intercropping system		
	Maize (kg/ha)	Chickpea (kg/ha)	Net returns (Rs/ha)	Sorghum (kg/ha)	Pigeonpea (kg/ha)	Net return (Rs/ha)
Weedy check	2869	245	3686	1699	654	2974
Weed free	5307	512	6340	3841	1143	5213
Hand weeding system	4142	361	5022	2995	749	3874
Herbicide system	4321	415	5118	3080	936	4274
Smother crop system						
Mung	3411 (132)*	260	4333	2676 (105)	886	4266
Cowpea	3583 (156)	365	4874	2934 (171)	735	4265

* Figures in parentheses indicate the smother crop yields in kg/ha

FUTURE EMPHASIS

With the exception of the farm surveys for Base Data Analysis, weed research at ICRISAT to date has been confined to On-Center studies. These studies will continue to be an important part of the program, especially those that seek to exploit the natural competitiveness of the crop or cropping system. Herbicide use for specific situations will also continue to be explored. However, it is intended that successful testing of weed management systems on an operational scale at ICRISAT center will lead to further testing in the "real-world" situation of the farmer.

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STUDIES ON WEED CONTROL IN RICE IN INDIA

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ABSTRACT

A review of the work done in India in the past 25 years on crop weed competition, chemical and cultural weed control measures for different systems of culture viz., direct sown crop on rainfed upland/low land, puddle seeded and transplanted crops is covered in this paper.

Studies on upland rice reveal that pre-emergent use of butachlor, benthiocarb, nitrofen and piperophos/dimethametryn at 1.5 to 3 kg a.i./ha effectively control weed population. An integrated approach of combining herbicides with manual or mechanical operation is however, imperative to accrue full benefit of these inputs. It may be noted that saturated soil moisture condition, immediately after application of these herbicides leads to considerable reduction in crop stand. However, post-emergent use of propanil does not involve such risk.

Responses of puddle seeded and transplanted rice to these herbicides either as granule or EC formulation, even at half the rate used in upland rice are often comparable to manual weeding. The scope for using phenoxy herbicides like 2,4-D Na or EE and M.C.P.A. at 0.5 kg a.i./ha is however, limited to transplanted rice for controlling sedges and dicots with added advantage of their relative low cost and availability.

Information on the control measures for a broad spectrum weed flora constituting submerged, emerged and floating types in direct sown low land rice is quite inadequate and more efforts are needed in this direction.

INTRODUCTION

Several investigations have been carried out in India in the last 25 years on different aspects of weed control in rice, which lead to an indepth understanding of the problem and recommendations specific to different agro-ecosystems of rice culture. In this paper, these scattered and fragmentary information has been summarised.

DISCUSSION

(a) *Direct sown upland rice*

Severe weed competition is the major constraint limiting the productivity of this crop which occupies about 20% of the total area in this country. Yield losses due to weeds range from 43 to 84% (Pillai and Rao, 1974; Rao *et al.*, 1977). Studies on crop weed competition reveal that the grassy weeds especially *Echinochloa colonum* Link play a predominant role over others causing considerable nutrient depletion to the tune of 24 to 37 kg N, 5.1 kg P and 48.7 kg K/ha (Mukhopadhyay *et al.*, 1972; Kakati and Mani, 1977) during first 30 to 45 days after sowing, which is the most critical period for crop-weed competition (Nair *et al.*, 1975).

i) Influence of agronomic practices on weed incidence: Weed weight increases though number decreases when nitrogen level is increased from 0 to 90 kg N/ha (Kakati and Mani, 1977). Higher weed incidence is recorded under wider inter row spacing of 60 cm (Pillai and Sreedevi, 1980) while a closer spacing of 15 cm is found ideal both for crop growth and weed suppression (Pande *et al.*, 1974).

ii) Mechanical control measures: Mechanical weeding with different tools/implements (such as wheel hoes, hand hoes and paddy weeders) is observed to give promising results (Singh *et al.*, 1976).

iii) Chemical control measures: Pre-sowing application of 2,4-D (2,4-Dichloro-phenoxy-acetic-acid) or M.C.P.A. (4-chloro-2 methyl phenoxy acetic acid) at 2.24 kg a.i./ha followed by one hœing gives 80% control of weeds (Misra and Roy, 1971). While pre-emergence application of butachlor (N-mutoxy methyl – chloro-2'-6'-diethyl acetanilide) at 1.5 to 3 kg a.i./ha gives fair weed control (Bhan *et al.*, 1972; Manna, 1971; Roy and Ram, 1977). Similarly, 69 to 78% weed control is achieved with pre-emergence application of thiobencarb (S-4-chloro-benzyl diethyl thiocarbamate) under Cuttack condition (Rao *et al.*, 1977). Such efficacy has been noted with nitrofen (2,4-dichlor-4' nitro-diphenyl ether) applied at 2 to 4 kg a.i./ha (Dubey *et al.*, 1980).

Other experimental chemicals like avirosan (piperophos + dimethametryn), dinitrimine (N' N' diethyl-2,6-dinitro-4-4 trifluoro methyl-m-phenylenediamine), piperophos/2,4-D IPE and preforan (4-nitrophenyl 2-nitro-4-trifluoro--methyl phenyl ether), molinate (S-ethyl NN-hexa methylinethiocarbamate), oxadiazon (5-tertbutyl-3 (2,4-dichloro-5 isopropoxy phenyl)-1,3,4-oxadiazol-2-one), pendimethalin (N-1-ether propyl) 3,4-dimethyl-2,6-dinitro-benzenamine) and USB 3153 (2,4-dinitro-N^3 – N^3 – dipropyl-6 (trifluoro-methyl)-1,3-benzenediamine) at doses upto 3 kg a.i./ha are found to be effective for control in upland rice.

Post-emergence herbicides like propanil (3,4-dichloropropionilide) and 2,4-D compounds are reported to control weeds reasonably well. Propanil at 2 kg a.i./ha suppressed graminaceous weeds when applied 10 days after rice germination (Manna and Choudhurv, 1966). Post-emergence application of 2,4-D or M.C.P.A. at 2 kg a.i./ha six weeks after sowing (Vacchani and Choudhury, 1955) is observed to be effective against sedges (*Cyperus iria* L.), while their application in combination with propanil effects broad spectrum weed control including grasses (Pande *et al.*, 1966).

Effective control of weeds under this condition has also been achieved through combined pre-sowing application of 2,4-D (1.5 kg a.i./ha) or butachlor (0.5 kg a.i./ha) with post-emergence application of propanil at 2 kg a.i./ha (Patro and Tosh, 1973; Singh *et al.*, 1977).

Efficiency of certain herbicides like propanil (2.2 kg a.i./ha) and M.C.P.B. (4-(4-chloro 2 methyl phenoxy) butyric acid) at 0.5 kg a.i./ha is enhanced when applied with 3 to 4% solution of urea (Tosh, 1977).

iv) Toxicity problems: There exists an adverse interaction effect of pre-emergence herbicides with soil moisture status, Coincidence of heavy rainfall immediately after pre-emergence application of herbicides like dinitramine, butachlor, avirosan, benthiocarb and nitrofen affects the germination of the crop considerably (Rao *et al.*, 1977). Addition of organic matter reduces the toxicity caused by 2,4-D (Pande *et al.*, 1966).

(b) *Puddle seeded rice*

Weed problem in this system is substantially lower than that in dry seeded uplands though higher than that in transplanted crop. An yield loss of 30 to 35% is caused due to weeds under this system (Pillai and Rao, 1974). Weeds such as *Cyperus difformis* L, *Fimbristylis miliacea* Vahl., *Scirpus mucronatus*, *Sphenoclea zeylanica* and *Ludwigia parviflora* are of common occurrence (Moorthy, 1980) and the most critical period of crop weed competition is observed to be the first 3 weeks after sowing (Dubey *et al.*, 1977).

i) Influence of agronomic practices on weed incidence: It is noted that broadcasting more seed (80 kg/ha) or dibbling reduces weeds and nutrient depletion (Rama Moorthy *et al.*, 1974). Based on another report, it is known that a seed rate of 40 kg/ha under chemical weeding and 60 kg/ha under manual weeding are ideal for better yields (Dawood *et al.*, 1974).

ii) Chemical control measures: An effective control of weeds with pre-emergence granular herbicides such as butachlor, nitrofen, avirosan, thiobencarb, piperophos/2,4-D IPE applied at 0.5 to 1.5 kg a.i./ha ha been reported by several workers (Subbaiah and Morachan, 1975; Sreedhar *et al.*, 1976).

However post-emergence control of weed involves spray application of propanil at 3 kg a.i./ha (Manna, 1971). Further work reveals the feasibility of controlling weeds (sedges and dicots) using propanil at 1 to 1.5 kg a.i./ha combined with 2,4-D Na at 0.5 kg a.i./ha or 3% urea solution (Manna and Dubey, 1973; Dubey *et al.*, 1977).

iii) Toxicity problems: Butachlor and oxadiazon are reported to cause 5% crop mortality without affecting the final yield. Dichlormate (3,4-dichlorobenzyl methyl carbamate) caused bleached papery white leaves. There are also reports of toxicity due to other experimental chemicals such as oxadiazon, avirosan, TCE styrene etc tried in various screening trials conducted in the country.

Varietal tolerance to herbicides depends on their morphology, physiology, edaphic and climatic factor, herbicide rate, water absorption after sowing, germination and embryo growth. A number of rice varieties have been classified for their susceptibility and tolerance to butachlor, benthiocarb and propanil (Sankaran and Mohamed Ali, 1974; Mohamed Ali and Sankaran, 1976).

(c) *Transplanted rice*

The minimum weed menace caused in this system as compared to direct seeded rice, may be attributed to the age gap between transplanted and emerging weeds. Based on a large number of multilocational trials, the yield losses turn out to be 15–20% (Pillai and Rao, 1974), while the depletion of nutrients by weeds ranges from 4.2 to 11.8 kg N, 0.8 to 1.3 kg P and 6.9 to 13.6 kg K/ha (Kakati and Mani, 1977). Maintaining weed free condition upto three weeks after planting is observed to be necessary for obtaining economic yield (Mohamed Ali *et al.*, 1977).

i) Preparatory tillage: Minimum tillage is beneficial in heavy soils where puddling is undesirable and in waterlogged fields where ploughing is difficult. Paraquat, when sprayed at 1.5 to 2 kg/ha controls all the vegetation by dessication (Rangiah *et al.*, 1975) and thus forming an essential component of minimum tillage.

ii) Mechanical control measures: In line planted crop working of Japanese rotary weeder which incorporates fertilizer besides uprooting of weeds is considered to be an accepted practice (Vacchani *et al.*, 1963).

iii) Chemical control methods: Herbicides like 2,4-D compounds and propanil when used as post-emergence sprays control weeds effectively. Spray application of 2,4-D at 0.5 kg a.i./ha is found to be quite effective for weed control (especially sedges and dicots) involving least expenditure (Patel and Moorthy, 1980). Besides efficiency of M.C.P.A. at 2 kg a.i./ha applied 4 to 6 weeks after planting is reported (Vacchan *et al.*, 1963). Similarly efficiency of propanil (3 kg a.i./ha) when the weeds are at 2 to 3 leaf stage is observed (Subbaiah and Sree Rangasomy, 1978).

Besides easiness of application, the granular herbicides viz., nitrofen, butachlor and others have been observed to be more effective than spray application of propanil in both weed control and grain yield. Based on a number of studies, granular forms of butachlor, thiobencarb, avirosan, nitrofen, bifenox (methyl 5-(2,4-dichloro phenoxy)-2-nitrobenzoate), molinate and pendimethalin have been identified to be promising. The broad spectrum weed control is also observed with the application of herbicides like butachlor, thiobencarb and piperophos at 50% of their recommended rate when combined with 2,4-D IPE in the formulated granular product (Pillai, 1977).

iv) Synergistic/antagonistic effects of herbicide/fertilizer/insecticide mixtures: Mixed application of propanil and butachlor at 2.5 kg a.i./ha with 3% urea solution enhances the herbicidal efficacy (Sankaran *et al.*, 1974).

The phytotoxicity caused by the use of propanil and parathion seems to be related with the varietal differences (Dubey *et al.*, 1977). An increase with interval of application of propanil and carbaryl helps reduction of the phytotoxicity (Sharma *et al.*, 1980). To the contrary, such adverse interaction is not observed with butachlor, nitrofen and bentazon (3-isopropyl (IH)-benzo-2,1,3-thiadiazin-4-one 2,2-di-oxide) when combined with carbofuran and phorate (Mukhopadhyay and Sen, 1977).

(d) *Direct seeded low land rice*

At the initial stages, the field condition of low land rice resembles that of direct-seeded upland and supports the incidence of grasses, sedges and dicots. Subsequent water logging coupled with impedded drainage leads to the occurrence of typical aquatic weeds like *Chara sp.*, *Nitella sp.*, *Hydrolea zeylanica*, *Monochoria vaginalis*, *Impomœa sp.* etc. posing problem of their control because of the stagnant water.

The research information is inadequate due to the complexity of the agro-ecosystem involved.

i) Cultural methods: The traditional *biasi* system of cultivation involving broadcast dry seeding and subsequent operation of country plough when the seedlings attain a height of about 25 to 30 cm effects partial thinning and reasonable weed control (Bisen and Patel, 1973). However the disadvantage of such traditional system is that the productivity is lowered due to inadequate stand of the crop (Sahu and Bhattacharya, 1964).

ii) Chemical methods: Post-emergence application of propanil at 3 kg a.i./ha, M.C.P.A. or 2,4-D at 1.68 kg a.i./ha control majority of the grasses, sedges and dicots at the initial stages when remains free from standing water (Sahu and Bhattacharya, 1964; Bisen and Patel, 1973). Floating and filamentous algæ and *Chara* sp. are observed to be controlled by copper sulphate 10 to 12 kg a.i./ha (Dutta and Banerjee, 1980). Sodium pentachlorophenate and PCP at 2.5 to 4.4 kg a.i./ha are observed to have controlled *Nitella* sp. and *Chara* sp. effectively (Mukherjee, 1972), while *Najas* sp. by using 2,4-D at 0.5 kg a.i./ha (Manna and Dubey, 1972).

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WEEDS – A MAIN SOURCE OF AYURVEDIC FORMULATIONS

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ABSTRACT

The weeds prevailing in abundance in nature have been since time immemorial, indispensable basic raw material in the preparation of ayurvedic formularies.

By and large, these medicines have been found to be successful in maintaining and restoring the human health in a natural way. These weeds grow under least care and even under extreme and varied climatic conditions. They are on the verge of acute scarcity in the market.

The quantity of the weeds, used as medicine in ayurvedic pharmaceutical industries are increasing constantly and procuring them has become a problem. This is mainly due to the fact that the plant based raw materials cannot be obtained at all places and at all times. Owing to scarcity in the context of heavy demand, substitutes of poorer quality and adulterations are rampant.

INTRODUCTION

The use of herbs as a source of drug in the process of upkeeping health was an integral factor in the indigenous practice of medicine which in the recent years has found a new twist due to the arrival of standard methods in the cultivation, collection, storage and quality control. Due to economic reasons a very large number of weeds have been left out of scientific scrutiny leaving weeds as a problem in the agricultural fields. One can never deny the usefulness of these weeds as a source of medicine. Eradication of weeds can never solve the problem integrally and therefore a systematic understanding of the problem and the application of strategies to regularise cultivation of the weeds may prove very economical. We would at the first instance assess qualitatively the role of weeds as a source of medicine, later, we quantitatively focus the commercial viability, market demand for weeds and finally envisage methods to satisfy the need of weed as raw material in pharmaceutical industries.

(a) *Weeds as a source of medicine-qualitative assessment*

Weeds having popular market whose pharmacological usefulness as medicine known are shown in Table 1. Parts being used vary from the whole plants to seeds, fruits, roots, tubers etc. The pharmacological action of these weeds is a proven research carried out in the universities, national institutes and various national and multinational pharmaceutical companies. Indigenous medical practice identified the usefulness of these weeds in course of experience and as such a very exhaustive list of weeds can be monopoly of a preparation but has a special significance. The originations of the school of Indian medicine had formulated and standardized every prescription basing on their experience. A practitioner or a manufacturer must work within the indications prescribed in the ancient text.

In our survey we found out quite a number of weeds as an ingredient in many such standard preparations. Table 3 gives a list of standard preparations manufactured by the pharmaceutical companies. Weeds like *Boerhaavia diffusa*, *Tribulus terrestris*, *Solanum xanthocarpum* are used extensively.

Systematic investigation of drugs used in Indian medicine in India on modern scientific lines started 30 years ago. A number of important medicinal plants prescribed by Vaidyas and Hakims have been investigated, the constituents have been examined, pharmacological action of the active principles worked out on animal experimentation and preparation made have been tried in hospitals. It is only by thorough enquiry that the merits of these drugs can be proved and a demand created for them not only in India but also in other parts of the world. Table 4 gives a list of weeds used as medicinal plants. It is important to note that quite a variety of activity can be seen among the few selected for presentation. They are being used as cosmetics, insecticides, hypotensive rubificient and even in cardio-vascular diseases. The extraction of active principles from these natural sources involve sophisticated technology.

(b) *Commercial viability of weeds*

In cultivation of drug yielding herbs, weeds have the following advantages:

i) It affords a valuable method of control of the purity of the product,

ii) The process of collection, drying, storage can be adequately controlled in farms and plantations with trained workers,

iii) Improvement of the drug by the control or improvements of certain factors of cultivation,

iv) Production of drug by improvements in cultivation ensures a regular and constant supply and help breakdown monopolies, and

v) Cultivation of drugs in proximity to working place for manufacture of Galenicals is often a distinct advantage especially for making fresh green extracts. The fresh drug can be taken directly from the field into the factory for immediate use preventing deterioration.

It is important to understand that systematic understanding of plant breeding and scientific control of the cultivation, collection, drying and storage of drugs will do much to improve the quality of the medicaments derived from them (Trease and Evans, 1972). The next few decades are going to be the era of natural products. Large number of naturally occurring species are under thorough investigations, both on the traditional and modern methods. The consumption of weeds as raw material for preparation of drugs has been increased by many folds and today it is a million rupees business in the state of Karnataka alone. Tables 5 and 6 give the names of the important pharmaceutical companies who are the potential buyers of these weeds in the state of Karnataka and an anticipated annual consumption of some weeds in Karnataka in 1981. The figures are based on the consumption of these weeds by the State and private enterprises in the yesteryears.

(c) *Methods to regularise weed availability and distribution*

A number of suggestions could be made to solve the problem of scarcity and improper distribution of medicinally useful weeds for ayurvedic physician and pharmaceutical companies. It is important at the outset to launch a programme to educate the farmers about the medicinal properties of weeds and its value as a raw material.

Formation of co-operative society will be the next step whereby every farmer instead of burning or burying the weeds, dumps them in the Society and gets money. The Society in turn is approached by the industries and individuals for their needs. Society shall have adequate staff to identify the weeds, sorth hem, store properly and maintain herbaria of all the weeds available in that particular area.

Thirdly, identification of certain remote areas away from agricultural lands for the cultivation of weeds. As weeds can grow under extreme climatic conditions, the question of adequate water supply, fertilizer does not arise and therefore with minimal availability of resources the object can be achieved. Considering profitability farmers should be adviced to cultivate some weeds as commercial crops on a large scale.

Fourthly, an inter disciplinary platform with ayurvedic scientists is necessary for an integral understanding of the problem and to obtain a knowledge of the importance of weeds.

Finally, intensifying the botanical survey and pharmacognostic study of the weeds in the best possible way enables the identification of newer herbs and newer remedies from natural resources. Plenty of data is already available in indigenous medicine which needs thorough probe and test the validity of the allegations on strict scientific lines.

DISCUSSION

Cultivation of medicinal plants will tend to increase for various reasons mostly economic in character. One important factor is the gradual decrease in the supply of cheap manual labour. The cost of collecting wild plants will therefore tend to increase until a plant is reached at which it becomes more economic to cultivate them. The spread of agriculture in all parts of the world is steadily decreasing the amount of wild untouched vegetation and is also involving the deliberate destruction of medicinal plants, either because of the risk of poisoning resulting from their presence on the agricultural land as in the case of Belledonna or because they are troublesome, easily dissmeated as in the case of Dandelion. The fact that many medicinal plants occur scattered sparcely throughout a mixed vegetation also provides a strong incentive for cultivation which completely removes the difficulty of finding and recognising the correct plants and in most case results in a more economic production of drug.

During recent years chemists have synthesised potent remedies such as Arsenicals and Antimalarial compounds which have proved effective in the treatment of protozoal disease and sulphonamides useful in the treatment of bacterial diseases. Antibiotic drugs have revolutionised the treatment of bacterial and rickettsial diseases. Diseases which were considered incurable a few years ago are now cured by their use. But then why indigenous drugs? British Journal 'The Practitioner' answers this question saying "the wise and experienced clinician never spurrs an old wife's tale until he has good evidence in doing so". The lore of the countryment is built upon the experience of generation, often of centuries and the data upon which it is based have often been obtained at a price in human lives which no modern research worker would ever dream of considering. It is particularly appropriate at the present moment when the pharmaceutical companies of the world are emitting an uneasing flow of new synthetic drugs, that attention should be turned to the possible remedies that may be found among indigenous weeds of this and other countries. We could cite a number of such interesting results based on indigenous drug research like, Ammi Vasaaga, Rauwolfia serpentina, Cootis coinensia, Ruta graveolens etc.

The idea of launching a co-operative society for weed collection and distribution would help solve the problem of acute scarcity of those weeds. Presently practising physicians and small companies depend on the forest contractors for weeds. The procedure is as follows:

The contractor who gets a part of the forest for lease from the Government sells the items like wood etc., to the concerning industries. The weeds are collected and sold in the market at a very high price and it is difficult to get a regular supply of weeds of a standard quality at reasonable price. Formation of a society as suggested in the paper may help and solve this problem.

We finally embark on the idea that a systematic understanding and research on medicinally useful weeds is the need of the hour. Any attempt to eradicate species can only cause ecological imbalance which can aggravate and not alleviate the problem.

CONCLUSION

The weeds are a very good source of raw material, hence a systematic understanding of the problem of weeds can only help to solve the shortage of weeds which as we have seen is being used in almost all the ayurvedic pharmaceutical preparations and are a good source of active ingredients for the needs of a modern pharmaceutical industry. Traditionally weeds played an important role as medicine but in the latter part of the history it ran into oblivion for very obvious economic reasons. It is important to launch rural programmes to educate farmers not to treat weeds as a menace but as a source of income.

ACKNOWLEDGEMENTS

Authors are thankful to M/s. Deccan Ayurvedashram Pharmacy Ltd., Hyderabad, for having sponsored this study and presentation at this conference in Bangalore.

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Table 1: List of weeds considered as medicines in Ayurveda.

Sl. No.	Latin name	Family	Sanskrit name (Ayurvedic term)	Part used	Important uses
1	2	3	4	5	6
1.	*Phyllanthus niruri*	Euphorbiaceæ	Bhoomyamalaki (Sweta)	Plant	Used as a diuretic, dropsy, jaundice, gonorrhœa, genito-urinary tract diseases
2.	*Phyllanthus urinaria*	- ditto -	Tamravalli	Plant	- ditto -
3.	*Eclipta alba*	Asteraceæ	Bhrungaraja	Plant	Jaundice, tonic, deobstruent, hepatic & spleen enlargement
4.	*Tribulus terrestris*	Zygophyllaceæ	Gokshura	Fruit	Cooling, diuretic, aphrodisiac, painful and burning micturition kidney disorders
5.	*Cyperus rotundus*	Cyperaceæ	Musta	Tubers	Diuretic, anthelmentic, cough, bronchial asthma, fever, diaphoretic
6.	*Solanum xanthocarpum*	Solanaceæ	Kantakari	Root	Cough, asthma, fever, sorethroat, rheumatism
7.	*Solandum nigrum*	- ditto -	Kakamachi	Plant	Fever, cough, hepatic disorders, expectorant
8.	*Solanum indicum*	- ditto -	Brihati	Plant	Carminative, expectorant, bronchial asthma
9.	*Boehaavia diffusa*	Nyctaginaceæ	Punarnava	Root	Diuretic, laxative, oedema, anaemia, jaundice, dropsy
10.	*Datura alba (D.metal)*	Solanaceæ	Kanaka	Plant	Insanity, fever, skin diseases, antispasmodic
11.	Datura stramonium (*D. tatula*)	- ditto -	Dhattura	Plant	Antispasmodic, sedative, analgesic, narootic
12.	*Sida rhombifolia*	Malvaceæ	Antibala	Root	Tonic, rheumatism
13.	*Sida cordifolia*	- ditto -	Bala	Root	Tonic, rheumatism, nervous disorders
14.	*Sida veronicaefolia*	Malvaceæ	Bhumibala	Root	Diarrhœa, burning micturition
15.	*Centella asiatica (Hydrocotyle asiatica)*	Umbelliferæ	Mandukaparni, Brahmi	Plant	Tonic, for improving memory, skin diseases, nervous disorders
16.	*Vetiveria zizanioides*	Poaceæ	Usheera	Root	Febrifuge, diaphoretic, stimulant, stomachic
17.	*Aalyha indica*	Euphorbiaceæ	Haritamanjari	Plant	Cold, cough, bronchial asthma, scabies, pneumonia
18.	*Abutilan indicum*	Malvaceæ	Nagabala	Root	Fever, aphrodisiac, laxative, demulcent

(Table 1 Contd.)

Sl. No.	Latin name	Family	Sanskrit name (Ayurvedic term)	Part used	Important uses
1	2	3	4	5	6
19.	*Argemone mexicana*	Papaveraceæ	Swarnaksheeri	Plant	Chronic skin diseases, laxative, emetic, cough
20.	*Achyranthes aspera*	Amaranthaceæ	Apamarga	Plant	Purgative, diuretic, dropsy, piles, boils, skin eruptions
21.	*Tephrosia purpurea*	Leguminosæ	Sharapuneha	Plant	Tonic, anthelmentic, blood purifier, carminative
22.	*Cassia tora*	Leguminosæ	Chakramarda	Plant	Laxative, skin diseases
23.	*Cassia accidentalis*	Leguminosæ	Kasamarda	Plant	Purgative, diuretic, expectorant, fever
24.	*Andrographis paniculada* (*Justicea panniculata*)	Acanthaceæ	Bhoonimba	Plant	Fever, tonic, dysentery, febrifuge, anthelmentic
25.	*Convolvulus arvensis*	Convolvulaceæ	Bhadrabala	Root	Purgative
26.	*Cuscuta reflexa*	- ditto -	Amaravela	Plant	Carminative, anthelmentic, purgative
27.	*Evolvulus alsinoides*	- ditto -	Vishnugandhi	Plant	Tonic, vermifuge, dysentery, asthma
28.	*Ipomœa hispida*	- ditto -	Nakhari	Root	Antirheumatic, epilepsy, leprosy, headache
29.	*Ipomœa reptans*	Convolvulaceæ	Kalambi	Plant	Emetic, purgative, antidote to opium & arsenical poisonic nervous disorders
30.	*Ipomœa hederacea*	- ditto -	Krishnabeeja	Seeds	Purgative, substitute for crotantiglium
31.	*Leucas aspera*				
32.	*Leucas cephalotes*	Labiatæ	Dronapushpi	Plant	Stimulant, diaphoretic, scabies, skin eruptions, cold cough, fever, rheumatism
33.	*Leucas linifolia*				
34.	*Blumea lacera*	Asteraceæ	Kukuradru	Plant	Antipyretic, anthelmentic, stimulant, diuretic, cholera
35.	*Centipeda orbicularis* (*Centipeda minima*)	- ditto -	Chhikika	Plant	Cold, headache, ophthalmia, toothache, vermifuge
36.	*Vernomia cinerea*	- ditto -	Sahadevi	Plant	Diaphoretic, conjuctivitis, dropsy, anthelmentic, urinary disorders
37.	*Xanthium strumarium*	- ditto -	Aristha	Plant	Diaphoretic, sedative, chronic malaria, tonic, small-pox, cancer

(Table 1 Contd.)

1	2	3	4	5	6
38.	*Aerva lanata*	Amaranthaceæ	Astmabayda	Plant	Anthelmentic, diuretic, demulcent, headache
39.	*Amaranthus spinosus*	- ditto -	Tanduliva	Root & leaves	Menorrhagia, gonorrhœa, eczema, colic lactagogue
40.	*Oxalis corniculata*	Oxalidaceæ	Amlika	Plant	Cooling, stomachic, refrigerent in scurvy
41.	*Fumaria parviflora*	Fumariaceæ	Parpataka	Plant	Anthelmentic, diuretic, diaphoretic, aperient, fever
42.	*Cucumis trigonus* (*C. pseudocolocynthis*)	Cucurbitaceæ	Visbala	Seeds	Carminative, anthelementic, rubefacient
43.	*Euphorbia hypericifolia*	Euphorbiaceæ	Dugdhika	Leaves	Astringent, dysentery, diarrhœa, leucorrhœa
44.	*Euphorbia thymifolia*	- ditto -	Laghudhika (Rakta-vinda-chada)	Plant	Astringent, amenorrhœa, snake bite, aromatic, stimulant, laxative, skin diseases
45.	*Cannabis sativa* (***Cannabis indica***)	Cannabinaceæ	Bhanga	Plant	Tonic, intoxicant, stomachic, antispasmodic, analgesic, narcotic, sedative & anodyne
46.	*Biophytum sensitivum*	Geraniaceæ	Lajjaluka	Root	Gonorrhœa & lithiasis
47.	*Euphorbia hirta (Euphorbia pilulifera)*	Euphorbiaceæ	Pusitoa	Plant	For worms in children, asthma, cough, colic, dysentery, bowel complaints
48.	*Chrosophora rottleri*	Euphorbiaceæ	Suryavarta	Plant	Emetic, cathartic
49.	*Chrosophora prostrata*	- ditto -	Suryavarta	Plant	For cough in children, depurative, purgative
50.	*Urena lobata*	Malvaceæ	Vana bhenda	Root	Diuretic, external application in rheumatism
51.	*Triumfetta rhomboidea* (***T. bartramia***)	Tiliaceæ	Hinjhirita	Plant	Mucilaginous, demulcent, gonorrhœa, diuretic, diarrhœa, dysentery, bitter & astringent
52.	*Phaseolus trilobus*	Leguminosæ	Mudgaparni	Leaves	Tonic, sedative, fever, catoplasms for weak eyes
53.	*Passiflora fœtida*	Passifloraceæ	Mukkopeera	Fruit & Leaves	Biliousness, asthma, giddiness & headache
54.	*Opentia dillenii*	Cactaceæ	Vidara	Fruit	Gonorrhœa, whooping cough & spasmodic cough
55.	*Mollugo lotoides*	Passifloraceæ	Bhiṣsata	Plant	Diarrhœa, boils, bilious attacks, tonic for children
56.	*Trianthema monogyna* (*T. portulacastrum*)	Ficoidaceæ	Punarnavi	Leaves & Root	Diuretic, œdema, peritoneal & kidney disorders, cathartic, abortifacient, amenorrhœa

(Table 1 Contd.)

Sl. No.	Latin name	Family	Sanskrit name (Ayurvedic term)	Part used	Important uses
1	2	3	4	5	6
57.	*Celosia argentea* (*Celosia cristata*)	Amaranthaceæ	Mayurashikha	Flowers Seeds	Astringent, diarrhœa, excessive menstrual discharge demulcent, painful micturition, cough & cysentery.
58.	*Amaranthus viridis*	- ditto -	Tanduliya	Leaves	Emollient, scorpion sting, snake bite
59.	*Chenopodium album*	Chenopodiaceæ	Vastuk	Plant	Laxative, anthelmentic
60.	*Portulaca oleracea*	Portulacaceæ	Lonika	Plant	Refrigerant, alterative, liver diseases, scurvy
61.	*Cleome icosandra* (*Cleome viscosa*)	Capparidaceæ	Arkakanta	Leaves & Seeds	Rubefacient, vesicant, sudorific in ulcers & earache, carminative, anthelmentic
62.	*Vitis trifolia*	Vitaceæ	Surasa	Plant	Anenorrhœa, fever, catarrh, sprain & rheumatism
63.	*Zizyphus nummularia*	Rhamnaceæ	Bhubadari	Fruit	Cooling, astringent
64.	*Seseli indicum*	umbelliferæ	Vanayavani	Seeds	Stimulant, carminative, stomachic, anthelmentic
65.	*Melilotus indica*	Leguminosæ	Vanamethika	Seeds	Useful in bowel complaints, infantile diarrhœa
66.	*Sesbania aculeata*	- ditto -	Jayanti	Seeds	Ringworm and skin diseases
67.	*Ammannia baccifera*	Lythraceæ	Agnigarva	Leaves	Rheumatic pains, fevers & skin diseases
68.	*Calotropis gigantea*	Asclepiadaceæ	Arka	Leaves, Root, Bark Latex	Root bark in dysentary, tincture of leaves in intermittent fever, latex as purgative
69.	*Trichodesma indicum*	Boraginaceæ	Surasa	Plant	Diuretic, paste of the root applied to swelling in the joints
70.	*Rungia repens*	Acanthaceæ	Parpatha	Plant	Fever & cough & as vermifuge
71.	*Celsia coromandeliana*	Scrophulariaceæ	Bhutakeshi	Leaves	Sedative, useful in diarrhœa & dysentery
72.	*Physatis minima*	Solanaceæ	Lakshmipriya	Plant	Tonic, diuretic, purgative
73.	*Lippia nodiflora*	Verbenaceæ	Vashira	Plant	Ferbrifuge, diuretic
74.	*Spermacœ hispida*	Rubiaceæ	Madanaghanti	Seeds	Stimulant
75.	*Blumea lacera*	Asteraceæ	Kukuradru	Plant	Bitter, Antipyretic

(Table 1 Contd.)

1	2 3	4	5		6
76.	*Sphraeranthus indicus*	Asteraceæ	Mundirika	Root & Seed	Tonic, aphrodisiac
77.	*Kyllinga monocephala*	Cyperaceæ	Nirvisha	Root	Fever, antidote to poisons
78.	*Cynodon dactylon*	Poaceæ	Dhurva	Plant	Dropsy, secondary syphilis, bleeding piles
79.	*Echinochloa crusgalli*	- ditto -	Jalsamoka	Plant	Diseases of spleen & to check haemorrhage
80.	*Paspalum scrobiculatum*	- ditto -	Kodrava	Plant	Scorpion stinge, as narcotic
81.	*Sachharum spontaneum*	- ditto -	Kasha	Plant	Laxative, aphrodisiac, useful in burning sensation
82.	*Commelina bengalensis*	Commelinaceæ	Kanchata	Plant	Bitter, refringerent, laxative, demulcent
83.	*Commelina nudiflorum*	- ditto -	Koshapushpi	Plant	Burns, itches & boils
84.	*Pistia stratiotes*	Araceæ	Kumbhika	Plant	Dysurea, laxative, diuretic.

Table 2 : List of exclusive preparations of the selected popular weeds used as medicine in ayurveda.

Sl. No.	Name of the weed	Name of the important preparations	Uses	Nature of preparation	Prepared by physician	Prepared in industry
1	2	3	4	5	6	7
1.	*Phyllanthus niruri & Phyllanthus urinaria*	Bhoomyamalaki churna	Used in jaundice, diuretic	Powder	+	–
		Bhoomyamalaki swarasa	- ditto -	Fresh extract	+	–
2.	*Eclipta alba*	Bhrungaraja taila	Used in hair falling	Oil	+	–
		Bhringaraja swarasa	Anaemia, jaundice, tonic, hepatic & spleen enlargement	Fresh extract	+	–
3.	*Tribulus terrestris*	Gokshura churna	Aphrodisiac, kidney diseases, tonic	Powder	+	–
		Gokshura kashaya	Diuretic, impotence calculus affections	Liquid	+	–

(Table 2 Contd.)

Sl. No.	Name of the weed	Name of the important preparations	Uses	Nature of preparation	Prepared by physician	Prepared in industry
1	2	3	4	5	6	7
		Gokshura swarasa	Diuretic, cooling	Fresh extract	+	
		Gokshura ksheerapaka	Diuretic, cooling painful micturition, kidney diseases	Milk extract	+	–
4.	*Solanum indicum &*	Kantakari kashaya	Carminative, expectorant	Liquid	+	–
	Solanum xanthocarpum	Bruhati kashaya	Bronchial asthma, rheumatism			
		Kantakari & Bruhati churna	ditto	Powder	+	–
5.	*Cyperus rotundus*	Musta churna	Diuretic, cooling, fever	Powder	+	–
		Musta himakashaya	Fever, anthelmentic, emmenagogue	Liquid	+	–
6.	*Boerhaavia diffusa*	Punarnava churna	Diuretic, anaemia	Powder	+	–
		Punarnava kashaya	Oedema, jaundice	Liquid	+	–
		Punarnava ksheerapaka	Diuretic, laxative	Milk extract	+	–
7.	*Datura alba &*	Kanaka lepa	Anti-inflamatory	Paste	+	–
	Datura stramonium	Kanaka taila	Anti-inflamatory, rheumatism	Oil	+	–
8.	*Sida rhombifolia &*	Bala churna	Rheumatism	Powder	+	–
	Sida cordifolia	Bala kashaya	Rheumatism	Liquid	+	–
		Bala taila	Rheumatism, nervous disorders	Oil	+	–
		Bala ksheerapaka	Tonic, rheumatism, diarrhœa, burning micturition	Milk extract	+	–
9.	*Vetiveria zizanioides*	Usheera churna	Febrifuge, diaphoretic stimulent, stomachic, cooling	Powder	+	–

(Table 2 Contd.)

1	2	3	4	5	6	7
		Usheera ksheerapaka	Febrifuge, diaphoretic stiumulent, stomachic, cooling	Milk extract	+	–
		Usheera himakashaya	- ditto -	Liquid	+	–
10.	*Centella asiatica*	Brahmi swarasa	Tonic, for improving memory, Skin diseases & nervous disorders	Fresh extract	+	–
		Mandukaparni tablets		Tablets	–	+
		Brahmi churna		Powder	+	+
		Brahmi ghrita		Ghee	+	+
11.	*Leucas cephalotes* *Leucas aspera* & *Leucas linifolia*	Dronapushpi swarasa	Rheumatism, cold, cough	Fresh extract	+	–
		Dronapushpi churna	Skin eruptions, fever, jaundice	Powder	+	–
12.	*Acalypha indica*	Haritamanjari swarasa	Expectorant, bronchial asthma	Fresh extract	+	–
		Haritamanjari churna	Pneumonia	Powder	+	–
13.	*Euphorbia hypericifolia*	Dugdhika kashaya	Used in dysentery, diarrhœa	Liquid	+	–
		Dugdhika kalka	Galactogog, leucorrhœa, memorrhagia	Bolus	+	+
14.	*Fumaria parviflora*	Parpastika churna Parpastaka himakashaya	Low fever, diuretic anthelmentic, blood purifier	Liquid	+	+
15.	*Achyranthes aspera*	Apamarga kashaya	Diuretic, piles, boils in dropsy	Powder	+	+
		Apamarga kalka	Skin eruptions, warts	Bolus	+	–
16.	*Argemone mexicana*	Swarnaksheeri swarasa	Emetic, expectorant, laxative	Fresh extract	+	–
		Swarnaksheeri beeja churna	Chronic skin diseases	Powder	+	–
		Swarnaksheeri beeja taila	Chronic skin diseases	Oil	+	–
17.	*Tephrosia purpurea*	Swaraphunka chura	Tonic, anthelmentic, hepatic	Powder	+	–
		Swaraphunka kashaya	Disorders, carminative blood disorders	Liquid	+	–

NOTE : + = Prepared by Physician/Industry; — = Not prepared by Physician/Industry

Table 3 : List of important standard ayurvedic preparations incorporating weeds.

Sl. No.	Name of the weed	Name of the standard formulation	Nature of the formulation	Name of some of the pharmacutical companies
1	2	3	4	5
1.	*Bœrhaavia diffusa*	Punarnavarishta	Liquid	D.A.P., D.P., IMPCOPS, G.C.P. IMI
		Punarnavasava	Liquid	D.A.P., K.A.V.P., I.M.I., T.R.W.,
		Punarnavasataka churna	Powder	IMPCOPS, G.C.P., D.A.P., Z.P.
		Punarnava mandoora	Pill	D.A.P.
		Punarnava churna	Powder	G.C.P.
2.	*Solanum xanthocarpum*	Dashamoolaristha	Liquid	D.A.P., G.C.P., S.N.P.M.A.P., Z.P., I.M.I, IMPCOPS, D.P.
3.	*Tribulus terrestris*	Dashamularistha	Liquid	D.A.P., G.C.P., S.N.P.M.A.P., IMI, IMPCOPS, D.P.
		Gokshura churna	Powder	G.C.P., IMPCOPS
		Gokshuradi guggulu	Pills	G.C.P., IMPCOPS, D.H.P., Z.P.
4.	*Solanum xanthocarpum*	Kantakaryavaleha	Linctus	IMPCOPS
5.	*Eclipta alba*	Bhringarajasava	Liquid	D.A.P., IMPCOPS, T.R.W.
		Bhringaraja taila	Oil	IMPCOPS, D.A.P., T.R.W.
6.	*Cyperus rotundus*	Mustakaristha	Liquid	D.A.P., B.A.B.
		Shadanga Paneeya quatha Churna	Powder	G.C.P.
		Amrutharistha	Liquid	G.C.P., D.A.P., IMPCOPS, K.A.V.P I.M.I., N.K.C.A., Z.P., Z.P., B.A.B.
7.	*Sida cordifolia & Sida rhombifolia*	Ralaristha	Liquid	D.A.P., I.M.I., IMPCOPS, K.A.V.P., Z.P., D.P., N.K.C.A., B.A.B.
		Bala taila	Oil	D.A.P., I.M.I., IMPCOPS, K.A.V.P. Z.P., D.P., N.K.C.A., B.A.B.
		Bala churna	Powder	K.A.V.P.
8.	*Tephrosia purpurea*	Tefroli	Liquid	O.P.

(Table 3 Conted.)

1	2	3	4	5
9.	*Datura alba & Datura stranamonium*	Kanakasava	Liquid	D.A.P., IMPCOPS, D.P., Z.P., B.A.B.
		Kanaka taila	Oil	D.A.P., IMPCOPS, D.P., Z.P., B.A.B., S.N.P.M.A.P., G.C.P.
		Kanakalepa	Ointment	G.C.P.
10.	*Centella asiatica*	Bramhi ghritha	Ghee	G.C.P., Z.P., D.A.P., N.K.C.A., B.A.B.
		Kalyana ghritha	Ghee	G.C.P., Z.P., D.A.P., N.K.C.A., B.A.B.
		Sarasvataristha	Liquid	D.A.P., B.A.B., IMPCOPS, M.P., D.P.
		Saravata churna	Powder	IMPCOPS, B.A.B.
		Brahmi taila	Oil	D.A.P., B.A.B., N.K.C.A., G.C.P., IMPCOPS.
		Mandookaparni tablets	Tablet	IMPCOPS.
11.	*Phyllanthus niruri & Phyllanthus urinaria*	Salovine	Liquid	P.N.V.P.
		Livozone	Liquid	M.P.
		Hexaliv	Liquid	H.P.
		Stimliv	Liquid	A.P.
		Vimliv	Liquid	D.P.
12.	*Vetiveria zizanioides*	Usheerasava	Liquid	D.A.P., IMPCOPS, Z.P., T.R.W., K.A.V.P.,N.K.C.A., B.A.B., I.M.I.
		Amrutarishta	Liquid	D.A.P., IMPCOPS, Z.P., T.R.W., K.A.V.P., N.K.C.A., B.A.B., I.M.I.

D.A.P.	= Deccan Ayurvedashram Pharmacy Ltd.	H.P.	= Hexapharma
G.C.P.	= Government Central Pharmacy	T.R.W.	= Taranatha Rasoushadi works
Z.P.	= Zandu Pharmaceuticals	N.K.C.A.	= Nikila Karnataka Central Ayurvedic Pharmacy Ltd.
P.N.V.P.	= P.N. Vedas Pharmaceutical Works	A.P.	= Aphali Pharmaceuticals
IMPCOPS	= Indian Medical Practitioners Cooperative Pharmacy Society	M.P.	= Makswel Pharmaceuticals
I.M.I	= Indian Medicine Industries	K.A.V.P.	= Karnataka Ayurveda Vidyapeetha Pharmacy
S.N.P.M.A.P.	= S. N. Pandit Mysore Ayurvedic Pharmacy	B.A.B.	= Baidhyanath Ayurveda Bhandar
O.P.	= Orient Pharma	D.P	= Dhootapapeshwar

Table 4: Weeds as medicinal plants in western system of medicine.

Sl. No.	Name of the weed	Part used	Pharmacological property/uses
1.	*Veratrum viride*	Root stocks	Alkaloids are hypotensive seeds as insecticide
2.	*Myrica asplenifolia*	Leaves & tops	Triterpenes
3.	*Rumex crispus*	Roots	Anthroquinonues glycosides
4.	*Chenopodium ambrosoides*	Fruits & tops	Anthelmentic
5.	*Phytolacca americana*	Roots & berries	For dyeing, contain saponins
6.	*Chelidonium major*	Entire plant	Alkaloid sparteine analgesic
7.	*Brassica alba*	Seeds & roots	Rubifecients & counter irritent
8.	*Brassica nigra*		
9.	*Geranium maculatum*	Roots	Geranium oil, perfumery, counter irritent
10.	*Passiflora incarnata*	Tops	Flavone-C-Glycosides, alkaloids
11.	*Conium maculatum*	Fruits	Indigenous poison
12.	*Apocynum cannabinum*	Roots	Cardiac tonic
13.	*Apocynum androsaemifolium*	Roots	Cardiac toic
14.	*Asclepia syriaca*	Roots	Carenolides, cardioactive
15.	*Asclepias tuberosa*	Roots	Cardioactive
16.	*Symphytum officinalis*	Roots	Ganglion stimulant (ureide allontoin)
17.	*Verbena hastata*	Tops	Harmone like, parasympathetic action
18.	*Marrubium vulgare*	Leaves & tops	Volatile oils, counter irritant
19.	*Mentha piperetta*	Leaves & flowering tops	Counter irritant
20.	*Mentha spicata*	- ditto -	Carminative
21.	*Datura stramonium*	Leaves & seeds	Skeletal muscle relaxant
22.	*Solanum carolinense*	Ripe berries	- ditto -
23.	*Solanum dulcamane*	Young branchlets	- ditto -
24.	*Digitalis purpurea*	Leaves	Cardio tonic
25.	*Verbaseum thobsus*	Flowers & leaves	Cardio tonic
26.	*Achillea millefolium*	Tops	Volatile oils, perfume & cosmetic
27.	*Grindelia squrrossa*	Leaves & flowering tops	For bronchitis & asthma
28.	*Inula helenium*	Roots	Stimulant
29.	*Lactuca scariola*	*Leaves*	Treatment of molta fever
30.	*Lactuca virosa*	*Leaves*	- ditto -
31.	*Tanacotium vulgare*	Leaves & flowering tops	Volatile oils, counter irritant
32.	*Taraxacum officinale*	Roots	Treatment of molta fever, antibiotic
33.	*Tussilago farfare*	Leaves & roots	Treatment of cancer

Table 5 : Names of the important pharmaceutical industries in Karnataka incorporating different weeds in their formulations.

Sl. No.	Name of the company	Place
1.	The Himalaya Drug Company	Bangalore
2.	Dhootpapeshwar Limited	Bangalore
3.	The Sadvaidyashala Private Limited	Nanjangud
4.	The Nutan Ayurveda Karyalaya Private Limited	Bijapur
5.	The Taranatha Rasoushadhi Works Private Limited	Chikmagalur
6.	Seetharaghava Vaidyashala	Mysore
7.	Government Central Pharmacy	Bangalore
8.	Amrut Pharmaceuticals	Belgaum
9.	S. N. Pandit's The Mysore Ayurvedic Pharmacy	Mysore
10.	Indomed Laboratories	Mysore
11.	The Nikila Karnataka Central Ayurvedic Pharmacy Limited	Mysore
12.	Swadeshi Oushadha Bhandar	Kunjal
13.	Indian Pharmaceutical Company	Udupi
14.	Bharat Pharmacy	South Canara
15.	Makswel Pharmaceuticals	Bangalore
16.	Sagar Pharmaceuticals	Bangalore
17.	Ideal Indigenous Pharmaceuticals Private Limited	Bangalore
18.	Pharmaceutical Division of Charities International	Mysore
19.	Geetha Company	Mysore
20.	Friends Pharmaceuticals	Bangalore
21.	Karnataka Ayurved Vidyapeetha Pharmacy	Belgaum
22.	Sanjeevini Pharmaceuticals	Bangalore

Table 6 : Annual consumption of some weeds by the ayurvedic pharmaceutical industries of Karnataka

Sl. No.	Name of the weed	Approximate consumption in kg	Market rate Rs./kg in 1981
1.	*Phyllanthus niruri* & *Phyllanthus urinaria*	30,000	5.00
2.	*Datura alba* & *Datura stramonium*	20,000	5.00
3.	*Bœrhaavia diffusa*	20,000	12.00
4.	*Centella asiatica*	20,000	10.00
5.	*Eclipta alba*	10,000	5.00
6.	*Sida cardifolia* & *Sida rhombifolia*	15,000	12.00
7.	*Vetiveria zizanioides*	10,000	10.00
8.	*Solanum indicum* & *Solanum xanthocarpum*	10,000	10.00
9.	*Tribulus terrestris*	5,000	8.00
10.	*Cyperus rotundus*	4,500	8.00
11.	*Fumaria parviflora*	500	8.00
12.	*Seseli indicum*	500	4.00

* Excludes regular consumption by the indigenous medical practitioners

WEED RESEARCH IN AUSTRALIA RELATED TO PROBLEMS IN THE ASIAN-PACIFIC REGION

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Australia with an area of 7.7 million ha is about two and a third times as big as India but its population is only 15 millions, a mere 2.2 per cent of the population of India. The diversity of the climate throughout Australia, from tropical and sub-tropical to extremely arid, with annual rainfall varying from more than 2500 mm to less than 200 mm, of essentially summer or winter or erratic distribution, leads to a great diversity of weeds many of which are important in other parts of the Asian-Pacific region.

Research on weeds began in last century as in most countries, with identification. This work was done essentially by Government Botanists and amateurs, often churchmen who interested themselves in natural history. The early journals of the various State Departments of Agriculture provide much descriptive information on weeds. In the first Australia-wide scientific journal devoted to agricultural problems – "Science and Industry", the official journal of the Institute of Science and Industry, which later grew into the Commonwealth Scientific and Research Organisation (C.S.I.R.O), there were reports on prickly pear (*Opuntia stricta* Haw.) (Cleland, 1919) and water hyacinth (*Eichhornia crassipes* Solms.) (Mackinnon, 1919). The early interest in prickly pear, which occupied millions of ha led to the exciting story of control by the moth *Cactoblastis cactorum*. The great success of biological control of prickly pear has led to a great emphasis on biological control of weeds in Australia. Work done in Australia is of decided relevance to the whole Asian-Pacific region. Other examples of successful control include:

(1) the control of a form of skeleton weed (*Chondrilla juncea* Ledeb) by a rust fungus, *Puccinia chondrillina*. Unfortunately other forms of skeleton weed resistant to the particular race of the fungus used are now increasing.

(2) the control of Harrisia cactus (*Eriocereus martinii*), after release of three insects, a stem-boring beetle, *Alcidion cereicola*, a mealy bug, *Hypogeococcus festerianus* and a stem-boring weevil, *Eriocereophaga humeridens*.

Attempts at control of various weeds using insects successful elsewhere in the world – for example, Chrysomelid beetles for the control of St. John's wort (*Hypericum perforatum*) have often been ineffective due to different environmental conditions and/or inappropriate species of insects.

Current interest in biological control includes work against the aquatic weeds, alligator weed (*Alternanthera philoxeroides*), water hyacinth and *Salvinia molesta* and parthenium weed (*Parthenium hysterophorus* L.) important in Queensland and so abundant here in Karnataka.

Much of the emphasis on research in weed control in Australia has been on weeds of pastures used for sheep and cattle. The principles of control of such weeds developed in Australia should be easily applicable elsewhere. In many cases the best weapons we have for control of pasture weeds are successful pasture species – for example the annual subterranean clover (*Trifolium subterraneum* L.) for the control of St. John's wort (Stening, 1933; Moore and Cashmore, 1942), perennial grasses and lucerne for the control of thistles (Michael 1968a, 1968b) and the sub-tropical species *Desmodium* spp. and *Macroptilium atropurpureum* for the control of *Ageratina adenophora*.

Since the development of 2,4-D (2,4-dichloro phenoxy acetic acid) and MCPA (4-chloro-2 methyl phenoxy acetic acid) after the second World War there has been much emphasis in Australian weed research on the control of crop and other weeds by herbicides. But such work is essentially of a regional nature. The long use of herbicides has led to changing patterns in weed populations as elsewhere. Some attention is being given to problems of herbicidal resistance of weeds and to differential susceptibility of crop cultivars. Because of the great use of herbicides over wide areas much attention has been directed in Australia to techniques of spraying, with much emphasis on aerial spraying.

Detailed work on the mode of action of herbicides and mechanisms of selectivity have been very much neglected in Australian research. Recent work done in the Department of Agronomy and Horticultural Science, University of Sydney on interactions of the herbicides diclofop-methyl (methyl 2-[4-(2,4-dichloro phenoxy)-phenoxy] propionate) and prometryn (2,4-bis (isopropylamino)-6-methyl thio-1,3,5 triazine) is of special interest. Combinations of these two herbicides, applied separately, have given better yields of pigeon pea (*Cajanus cajan* L.) and carrots (*Daucus carota* L.) than either herbicide used alone. The better yields cannot be attributed solely to the effect of both herbicides on weed control. Much work has been done at the University of Sydney using a very simple technique for testing the selectivity of different herbicides, using different concentrations of herbicides applied to seeds in Petri dishes and measuring their effect on root and shoot growth of seedlings. The findings of such simple experiments have been confirmed in pot studies in the glasshouse and in field studies with a range of crop species. This technique is certainly worthy of serious attention in other parts of the Asian-Pacific region where facilities are limited.

Recent studies, largely theoretical, on the spread of weeds (Auld and Coote, 1980; Menz *et al.*, 1980–81) and bioeconomic models (Auld *et al.*, 1979) may lead to a much better understanding of the potential and significance of weeds in the general agricultural economy of any country. Crop-weed density studies are also under current review.

Until recent years, by far the greater emphasis in weed-research in Australia was on weeds of the more temperate parts of Australia, relevant only to limited areas of the Asian-Pacific region, notably New Zealand and Japan and perhaps parts of Northern India. But today more and more emphasis is being directed towards problems in the sub-tropical and tropical areas.

Overall, too little emphasis has been placed on biological studies on the common weeds of cropping, especially of summer crops, whether irrigated or rainfed. As mentioned at the beginning of my paper there is a great diversity of weed species in Australia and it is to be hoped that further studies on identification, distribution and biology of weedy genera are occurring in Australia and common to many parts of the Asian-Pacific region may be rewarding.

My special interest in weeds research is in problems of identification. It is pleasing to note that recently more interest is being shown by taxonomists in weed genera. A notable contribution is an account of the important weedy genus *Solanum* in Australia by Symon (1981). I presented a paper on the taxonomy and distribution of *Echinochloa* at the International Rice Research Institute/International Weed Science Society Rice Weed Control Conference in September this year and trust that the Proceedings of the Conference will soon be available for general distribution. Forthe Seventh APWSS Conference in Sydney in 1979 I prepared, with financial support from Japan Association for the Advancement of Phyto-Regulators (JAPR), a working list of weeds of the Asian-Pacific Region. It is to be hoped that with further constructive criticism, a more satisfying list will be prepared, which would be of great use to weeds workers anywhere in the Asian-Pacific region. Without proper identification of weeds, real communication between weeds workers in the region, is difficult indeed.

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THE STATUS OF WEEDS IN NEW ZEALAND AGRICULTURE

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ABSTRACT

New Zealand agriculture can be characterised as predominantly pastoral but with a diversity of arable and horticultural crops suited to a temperate climate with a sub-tropical northern fringe. Weed problems are correspondingly wide-ranging and usually the worst weeds are adventive species which have adapted easily to local soils and climate. Pastoral land is being continuously improved by techniques which include vegetation management and direct chemical control of weeds although much of the large area involved is inaccessible and difficult to treat. Established cultivated cropping areas are generally subject to regular herbicide treatments and in some specialist crops very sophisticated spray programmes are used. A number of annual and perennial crops are expanding to take advantage of export markets and the preparation of new land brings new weed problems, usually perennial species associated with the previous pasture.

As the trend of crop diversification continues so the weed control requirement becomes more complex. A continuing reliance on herbicides is inevitable but there is also a growing appreciation of the need to integrate chemical weed control with sound cultural practice in order to maintain robust and cost-efficient cropping systems.

INTRODUCTION

The main islands of New Zealand lie between 34° and 47° S in the South Pacific, just south of the sub-tropical high pressure belt. The climate is temperate but local variations are considerable since the combined length of the North and the South Islands is over 1,600 km and a chain of high mountains from south-west to north-east through the length of the country produces marked climatic contrasts from east to west.

Average precipitation in the main agricultural areas is between 600 and 2,000 mm. Mean temperatures at sea level range between 9.4°C in the South and 15°C in the North, but there is considerable variation according to season and altitude. The winters are mild enough to allow sheep and cattle to graze outside all year round. Much of the country has at least 2,000 hr of sunshine a year, with a range of 1,700 hr in Southland to 2,400 hr in the Nelson, Hawkes Bay and Bay of Plenty regions.

About three-quarters of the land is mountainous or steep and broken hill country and much of the remainder consists of elevated plateaux or gravelly river terraces. Nearly 85% of the land is more than 200 m above sea-level.

For its size, New Zealand has an unusually wide range of soil types with a high proportion of allophane clays in the North Island. Soil organic matter content is often 5% or higher (Burney *et al.*, 1975). Fertilisers, especially phosphatic and potassic, are widely used. In 1977–78 about six million ha of pasture was top-dressed with nearly half of the total amount applied by air.

In a climate of few temperature extremes, generally adequate rainfall although topography is a major limiting factor. Two thirds of the total land area of 27 million ha are farmed and about 95% of these are devoted to grazing sheep and cattle. About 3.2 million ha are flat enough for cultivation and provide most of the dairy production, cereals, arable and horticultural crops as well as some meat and wool; field and horticultural crops occupy approximately 0.9 million ha. Productive exotic forests on land of varying topography, occupy about 0.74 million ha (New Zealand Official Yearbook, 1979).

Pastoral products provide about 71% of New Zealand's total export earnings. The pastoral economy is based on year round grazing of sheep and cattle, with a minimum of supplementary feeding. Most improved pastures are sown with perennial ryegrass and white clover which produce their best yields in spring, early summer and autumn. Cocksfoot and red and subterranean clovers are also sown. After the first year or so, sown pastures usually develop into mixed associations of several species.

Most of the cropping is undertaken to provide supplementary fodder for animals. Only 1% of the total cultivated area is used for food crops for direct human consumption (Claridge, 1972). Apart from market gardens, few farms are used solely for cropping. Two thirds of field crops are grown in the South Island. The main crops are wheat (96,300 ha), barley (74,400 ha), oats (16,800 ha), peas (16,800 ha) and potatoes (10,000 ha). Maize (28,600 ha) for grain production, is restricted by climate to the North Island. Lucerne and fodder crops are grown principally to supplement pastures during summer and winter, respectively.

A diverse range of horticultural crops is grown, usually on smallholdings. The pattern is changing as those with good export or processing prospects – such as kiwifruit, asparagus and grapes – expand into new areas. Areas of process cropping, market gardens, orchards and nurseries occupy an estimated 70,000 ha, with vegetable crops (vining peas, beans, sweetcorn, brassicas and onions) and pip and stone fruits occupying the largest areas.

ORIGIN AND DEVELOPMENT OF WEED FLORA

There are about 1,100 plant species regarded as weeds in New Zealand (Healy, 1969) and these are mostly adventive. The very few native or endemic species of importance are largely restricted to low fertility grasslands under high rainfall, indigenous tussock grassland and aquatic habitats. Thus, the development of weed floras of arable land and improved pastures has been a direct result of European settlement during the last century and a half.

A wide range of herbaceous and woody plants of diverse botanical relationship and geographical origin has been introduced. New species have established in many different ways but there is little doubt that most have been introduced as impurities in commercial seed lots and spread by farm machinery (Healy, 1952, 1969). It is remarkable that in the short history of New Zealand agriculture species representative of many regions of the world have become established, often in as great abundance as in their country of origin. A large proportion of the introduced weeds are of European origin and whilst many have arrived directly from Europe, others have been introduced indirectly via North and South America, Africa, Australia and Asia, along with other weeds originating in these continents.

A comprehensive summary of weed species according to land use in New Zealand was presented at the 4th Asian Pacific Weed Science Society Conference (Healy, 1973).

WEEDS OF PASTURE LAND

Plants which occur in pastures are regarded as weeds for various reasons and are hard to define adequately. They may cause physical damage or be toxic or unpalatable to animals (Connor, 1977) or they may compete with other pasture species. They are often grasses or legumes which provide useful food for stock in particular climates, soils and management systems but can be replaced by better species if soil fertility and grazing management are improved.

Scrub weeds are particularly serious as they are unpalatable and can form dense cover and thus render land totally unproductive. The main species involved are *Pteridium aquilinum* var. *esculentum*, *Leptospermum* spp, *Discaria toumatou**, *Cytisus scoparius*, *Ulex europaeus*, *Rosa rubiginosa* and *Rubus fruticosus*. In the South Island it is estimated that c. 12% of farmable land is covered in scrub weeds, with consequent lost carrying capacity of 3.5 million stock units.

Once scrub weeds have become established they must be cleared before the land can become productive again. Scrub clearing is expensive. Herbicides are used extensively, often sprayed by aircraft, and mechanical and manual methods are also employed. Once the land is cleared, it is very important that vigorous pasture is established quickly and that regular, controlled grazing is carried out. Grazing not only helps to maintain a competitive pasture but also provides control of new scrub weed seedlings, which are usually palatable when young. Even if the pasture management is adequate, herbicides may still be needed to kill regrowing stumps and new plants which have escaped grazing.

* Limited to the South Island

Some scrub weeds, notably *Coriaria* sp, are poisonous to stock; others form thorny thickets in which sheep can become entangled.

Herbaceous weed species in pastures vary according to climate, pasture fertility and grazing management. Control of poisonous species, for example *Homeria collina* and *Senecio jacobaea* is often subsidised by the government. *Ranunculus* spp and *Coronopus didymus* which are common on pastures can cause taint in dairy products. *Hordeum* spp. and some species of *Bromus* produce seeds which can seriously affect pelt quality and growth rates of stock and it has been estimated that the growth of 10% of the country's lamb population is depressed by *H. murinum* infestations (Hartley and Atkinson, 1972).

Many weed species do little direct harm to stock but, being unpalatable, occupy valuable pasture space. Among these are several thistles (*Cirsium arvense*, *C. vulgare*, *Carduus nutans*, *C. pycnocephalus*, *C. tenuifloris* and *Silybum marianum*), rushes (*Juncus* spp), sedges (*Carex* spp, *Cyperus* spp) and docks (*Rumex* spp). Of these only *Cirsium arvense* has been shown to reduce stock production (Hartley and James, 1979) but there is considerable scope for detailed investigations of the effects of other weeds.

It is not easy for annual or biennial weeds to establish in a dense, vigorous sward and invasion of many weeds occurs as a result of weakness in grazing management – over-grazing in dry summers or treading damage during wet winter conditions. Management techniques often reduce the incidence of herbaceous weeds but the herbicides commonly used, MCPA and 2,4-D, are also damaging to clovers. As a result, their use sometimes harms the pasture while controlling the weeds.

Table 1: Estimated costs of weeds to New Zealand agriculture, as lost productive opportunity.

	Gross Output* $m	Cost of weeds $m	Cost as % of gross output
Pastoral farming	1,454	32.0	2.2
		(scrub 23.3)	
		(herbaceous 8.7)	
Arable farming	146	10.8	7.4
Horticulture	103	5.1	5.0
Total	1,703	47.9	2.8

* From Agricultural Statistics 1975-76, Official Report of New Zealand Department of Statistics.

Estimates of lost agricultural production caused by pasture weeds are shown in Table 1.

WEEDS OF CULTIVATED LAND

Common annual weeds of cultivated land include *Amaranthus powellii, Avenua fatua, Capsella bursa-pastoris, Chenopodium album, Coronopus didymus, Crepis capillaris, Fumaria muralis, Plantago lanceolata, Poa annua, Polygonum aviculare, P. convolvulus, P. persicaria, Portulaca oleracea, Senecio vulgaris, Silene officinalis, Solanum nigrum, Spergula arvensis, Stellaria media* and *Veronica arvensis.*

In warmer northern areas particularly, a group of grasses are troublesome, including *Bromus unioloides, Digitaria sanguinalis, Echinochloa crus-galli, Eleusine indica, Panicum dichotomiflorum, Paspalum dilatatum, P. paspaloides* and *Setaria verticillata.*

Recent studies of annual weed germination in cultivated seedbeds (Cox, 1977) have shown how populations vary during the months of spring and early summer. Weed population peaks of 19×10^6 seedlings per ha have been recorded on regularly cropped land at Levin where it has been estimated that the total viable seed population is about 250×10^6 per ha. The highest number of weeds between twenty and thirty species germinated in early spring seedbeds but greater total weights were obtained from fewer species in mid to late spring seedbeds.

When cultivation occurs in late spring and early summer, especially in warmer northern areas, annual grasses become more important (Matthews, 1975). In general, when weed populations are very high only a few species dominate at any time. If these are removed by cultivation or chemical means other species may take over if better suited to the prevailing conditions. The sequential emergence of weeds continues well into the summer in most parts of the country.

Perennial species such as *Achillea millefolium, Agropyron repens, Cirsium arvense, Rumex* spp and *Trifolium repens* can be troublesome weeds in annual crops and are also common in perennial crops, such as apples, bush and cane fruit, and asparagus. The incidence of these species is often a consequence of poor land preparation from previous pasture. *Convolvulus arvensis* often invades perennial crops from waste areas.

Although there are herbicide recommendations for all commonly grown crops, new weed problems constantly arise and it is difficult to predict which species are going to become future problems; the control of 'new' problem weeds can also be expensive. It is estimated that weed control measures are effective in 75–80% of maize and potato crops but only in 20% of oats, ryegrass seed and oilseed rape crops. The total costs, in terms of potential yield not realised is probably more than $ 10 million a year (Table 1).

With few exceptions commercially-grown annual horticultural crops rely heavily on chemical weed control programmes. Much of the vegetable cropping is small-scale and diverse and, as with arable crops, weed control efficiency tends to be variable. However, in the hands of specialist growers some crops, for example onions and garlic, are grown very successfully under chemical weed control regimes of five or more separate herbicide applications.

The proportionate cost of weed control in the production of vegetable crops is estimated to range between about 10% (peas) and 20% (tomatoes or asparagus). Früit cropping usually implies limited soil disturbance and a low incidence of annual weeds, with perennial weeds spot-treated. The proportionate cost of weed control may be around 3% of the total production cost.

The complexity of crop types and production systems makes it difficult to estimate lost yield potential but even set very conservatively, it represents a loss of $ 5.1 million (Table 1).

ACKNOWLEDGEMENTS

Our thanks are due to W. F. A. Meeklah and J. H. B. Butler and other weed science colleagues for help in the collection of data for this paper.

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WEED CONTROL IN MALAYSIA

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ABSTRACT

Production of rubber and palm oil in Malaysia is being assisted by herbicides. Herbicides worth M $ 110M (US $ 48M) accounted for 85% of the total pesticides used in the country and have enabled 72% of the cultivated acreage to be planted with rubber and oil palm. *Imperata cylindrica*, a noxious grass is controlled by dalapon and glyphosate. *Paspalum conjugatum*, *Ottochloa nodosa* and *Mikania cordata* are major weeds. Constant and repeated usage of the same herbicides has resulted in the succession of the flora by new weeds often more difficult to control economically. Paraquat, 2,4-D and their mixtures with other herbicides are widely used against the wide variety of weeds present. Triclopyr, a broadleaf herbicide, selective to oil palm is to be introduced. End-users often do not have adequate knowledge about the chemical, its usage and safe handling. Labels are seldom consulted. More efficient application methods are envisaged for the future.

INTRODUCTION

In Malaysia, particularly in rubber and oil palm cultivation, herbicides have replaced manual weed control method. Rubber and oil palm (3.3M ha) comprise 71% of the area utilized for agriculture and consume 80 to 90% of the herbicides used annually. In fact, without the use of herbicides, much of the efforts invested into developing improved varieties would not have been translated into higher yields.

Rice is the third major crop and the only field crop grown extensively. Grown mainly for local consumption, the common method of weed control is handweeding. Herbicides, mainly 2,4-D, however, are gradually becoming more widely used. Other crops grown on a substantial scale in the country are cocoa, pepper and coconut but usage of herbicides on these crops is limited at present.

WEEDS IN PLANTATIONS

The climate of Malaysia while being good for perennial crop cultivation is also ideal for weed growth. Unlike intensive agriculture, perennial crops in the early stages occupy very little of the cultivated area. Rubber in its first two years of planting occupy about 10% of the land. Thus, in the early years, perennial crops offer insignificant competition against the weeds. Even after maturity, the crop occupies only 25 to 35% of the land leaving a large proportion of the area exposed to weeds. Keeping the ground totally free of weeds is not normal practice. Areas usually kept free of weeds are the tapping paths alongside rubber trees and the circles and harvester's paths of oil palm. Inter-row weed control is required only when legume covers need to be maintained during the early phase of the crop and when noxious weeds or very dense weed growth occur.

Imperata cylindrica or lalang is the worst weed. Its vigorous growth makes it a very difficult grass to eradicate. Its presence is never tolerated in well-managed estates but is still frequently found in small holdings. The lalang problem can be especially acute in land cleared from secondary jungles for new planting. If left unchecked, it will thrive and recolonise eliminating all other vegetation. Being shade tolerant, it can also be found under mature crops with closing canopies. In a year, M $ 30 to 40M is spent on herbicides to control this weed.

Paspalum conjugatum, *Ottochloa nodosa* and *Mikania cordata* are the key inter-row weeds of the plantation crops. *P. conjugatum* is common on inland light soils while *O. nodosa* is confined on heavier soils near the coast. Single stands of these weeds can be found on exposed land. More often one of these will be dominant weed in association with other common weeds, the type and composition being dependent on the crop phase and the level of management. *Axonopus compressus*, *Paspalum commersonii*, *Cynodon dactylon*, *Digitaria marginata*, *Eleusine indica*, *Borreria latifolia*, *Ageratum conyzoides*, *Passiflora fœtida* and sedges are common components under the mature crops. In the mature crops with closing canopies, ferns like *Nephrolepis biserrota* and *Stenochlæna palustris* and other shade tolerant weeds predominate. Herbicides costing M $ 70 to 80M is spent on controlling these general weeds annually and the cost is increasing.

The constant and repeated application of the same herbicides has caused the regeneration of new weeds flora often more difficult to control. *Ishæmum muticum* and *Brachiaria mutica* are two such grasses which have taken over from *Ottochloa* in some low-lying soils on the coast. Similarly, introduced exotic plants such as *Cleidemia hirta* and *Asystasia coromandeliana* are now widespread in south Malaysia where the indigenous flora once dominated. *Cordia curassavica* a popular hedge plant now colonises vast acreages under coconut. Some members of the *Zingiberaceæ* and *Caladium* spp. are acknowledged economic weeds in some estates.

Pueraria phaseoloides and *Calopogonium cœruleum* which are maintained as legume cover crops need to be confined to the inter-rows. Their vigorous growth especially *Pueraria* encroaching into the planting rows and circles, compete and strangle the crop. *Eupatorium odoratum*, *Melastoma malabathricum*, *Cleidemia hirta*, *Ficus grossularioades*, *Bridelia monoica* and *Lantana camara* are some of the shrub vegetation which compete and obstruct field operations in plantations. Although not widespread, these can become obnoxious when left unchecked. Control is attained from phenoxy herbicides unless when found under sensitive crops where manual methods is resorted to.

HERBICIDES USED IN PLANTATIONS

Smallholders cultivating 2.1 ha of land or less are now the major users of herbicides. In a 1978/79 survey, there were 235,410 smallholders, 1,261 small estates and 797 larger estates using chemicals for weed control. The use of herbicides is expected to increase as industrial developments in the country compete with agriculture for labour availability.

A wide range of herbicides is available. Realising that no single herbicide will control all weeds, two or three herbicides are usually used together. Both tank mixtures and premixed formulations are common.

Dalapon and glyphosate are both broad spectrum grass herbicides, but in view of their cost, are utilised almost exclusively for lalang control. Paraquat is the most widely used dessicant against general weeds. Properly used, it is tolerated by most crops. Although used alone against grasses, its most popular use is in mixtures with Diuron (which is reported to enhance its activity), MSMA, sodium chlorate 2,4-D and picloram.

Triclopyr (3, 5, 6-trichloro-2-pyridinyl oxy-acetic acid) is the latest herbicide to be introduced into the country. The only broadleaf herbicide selective on oil palm of all ages, it controls a wider variety of weeds than 2,4-D. *Cleidemia hirta* and *Tetracera scandens* which have been found difficult to control economically by phenoxy herbicides easily succumb to triclopyr.

Ametryn, atrazine, dicamba, metolachlor and oxyfluorfen are utilised for pre-emergent weed control during legume cover establishment. Efficacy of these pre-emergence herbicides generally do not extend beyond 16 weeks following application and to maintain the legumes in the weed free condition, manual labour is necessary. Glyphosate, paraquat and paraquat-diuron mixtures are now beginning to substitute the manual weeding.

The choice of which herbicide to use is guided foremost by cost, weed flora and control duration expected. In relatively open conditions where weed growth is most vigorous, control periods in excess of 3 to 4 months are seldom obtained from a single application of any herbicide at economic rates. Thus during the early stages of the crop, 3 to 4 applications of herbicide annually are necessary. As the control period lengthens with increasing shade provided by the growing crop, the number of applications made each year reduces until the crop reaches the replanting stage.

PROBLEMS WITH HERBICIDES

Chemical weed control in Malaysia began when sodium arsenite was introduced in the early 1930s. Until 1976 when it was banned, sodium arsenite was the most economical herbicide and a panacea for all weed problems encountered in rubber and oil palm. The herbicides currently available are expensive and more selective by comparison.

Ignorance of the activity of these newer herbicides is prevalent among end-users, especially the smallholders. Despite the detailed product labelling required by recently introduced Malaysian registration laws, herbicide abuse by end-users remains. Thus, it is not surprising to find an end-user using a concoction of contact and translocated herbicide such as paraquat and dalapon to control lalang when only dalapon on its own gives better control at a cheaper cost.

The importance of nozzles in determining the spray quality needs no emphasis but is frequently disregarded by end-users.

Planters in general are also not too aware of the changing weed population. Given a particular recommendation for a particular weed situation and being convinced by the results, they will continue with the practice. This often results in the regeneration of resistant weeds which could be more expensive to eradicate than the earlier population.

Lables on the products are very often not consulted prior to usage. Complaints of poor performances by the herbicides are frequently traced to under dosage. This is quite rampant with commodity products such as 2,4-D amine which is sold under several labels, each containing different levels of active ingredient. Similarly, the safe handling precautions given on the labels are seldom enforced.

Herbicides in Malaysia are a very lucarative \$ 130M business. This has attracted many dubious manufacturers producing imitation and adulterated products. Unsuspecting purchasers, attracted by the cheaper prices of such herbicides usually end up paying more for their weed control costs. Stringent laws regulating import and registration of pesticides have been introduced to curb this practice.

RESEARCH AND FUTURE OUTLOOK

Labour shortage will be the most important factor limiting weed control in Malaysia. Already, power sprayers, ULV techniques and more efficient herbicides are being investigated to overcome this constraint. The successful adaptation of these methods for weed control and their acceptance by planters and smallholders will be the challenge of weed researchers in Malaysia.

ACKNOWLEDGEMENTS

The author is grateful to Dow Chemical Pacific Ltd., for permission and support to present this paper at this conference.

HIGHLIGHTS OF WEED SCIENCE RESEARCH IN THE UNITED STATES

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ABSTRACT

Some highlights of weed science research in the U.S. are presented to illustrate the range of investigations being conducted. These include new herbicides, triazine resistance and its mechanism of action, triazine resistance as a basis for selection and breeding, biological control of weeds using insects and plant pathogens, new equipment such as the rope-wick applicator, EPTC (S-ethyl dipropylthiocarbamate) coated seeds for weed control, ethylene stimulated germination of *Striga asiatica* (L.) O. Kuntze, witchweed, seeds, and some results of a long-term agroecosystems study.

INTRODUCTION

This paper highlights the weed science research in the U.S. In deference to limited time and space, only a few of many highlights which I consider interesting can be presented. This does not imply that other important discoveries not mentioned here are considered less significant.

NEW HERBICIDES

New herbicides have provided the basis for modern weed control technology in the U.S. during the last 30 years. Effective herbicide use patterns allow the use of modified row spacings, planting configurations and plant populations. Diverse agroecosystems are developing as a result of herbicide technology. Systems like minimum and no-tillage have increased because of the effectiveness of certain kinds of herbicides.

New herbicide chemistry with its different uses and selectivities continues to be an extremely important part of weed research programs of private industries and institutions in the U.S. Probably every state in the U.S. devotes part of their weed research program to identify appropriate herbicides, rates, timing, and combinations to obtain control of weeds in their respective cropping systems.

Increased government regulation of agricultural chemicals in the U.S. has resulted in fewer uses as well as limiting the number of new herbicides. Further, industry efforts for new herbicides has been mainly directed to large-acreage crops; minor crops receive relatively little attention from industry. In states like Hawaii where these minor crops are the important crops, the university does much of the developmental research.

Several of the new herbicides now being developed have new modes of action or selectivities. These include acifluorfen [5-(2-chloro-4-(trifluoromethyl) phenoxy)-2-nitrobenzoic acid], oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene], diclofop [2-(4-(2,4-dichlorophenoxy)phenoxy) propanoic acid], sethoxydim [2-(1-(ethoxyimino) butyl)-5-[2(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one], 3,6-dichloropicolinic acid, etc. It is expected that these materials and others still to be discovered will solve many of our difficult weed control problems.

TRIAZINE RESISTANCE AND ITS MECHANISM OF ACTION

Variability in response of population of a crop species to triazine herbicides has been known for many years. Although *Zea mays* L., corn, is known to be generally tolerant to atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine] and simazine [2-chloro-4,6-bis(ethylamino)-*s*-triazine], some inbreds respond differently (Andersen, 1964), and a Mississippi selection of the inbred line GT 112 was susceptible (Eastin, 1971; Grogan *et al.*, 1963). Differences in biotype susceptibilities to triazines have been noted for *Linum usitatissimum* L., flax (Andersen and Behrens, 1967), *Glycine max* (L.) Merr., soybean (Andersen, 1969), *Sorghum bicolor* (L.) Moench, sorghum (Wiese and Quinby, 1969), *Saccharum* L. hybrids, sugarcane (Osgood *et al.*, 1969), and *Cucumis sativus* L., cucumber (Werner and Putnam, 1979).

Resistance characteristics in populations of weed species to triazines or other herbicides might be expected to occur in normal populations of weeds; continued use of a herbicide selects for the resistant strains. Ryan (1970) in Washington found *Senecio vulgaris* L., common groundsel, to tolerate atrazine or simazine in a nursery where atrazine was used once or twice a year for 10 years. *S. vulgaris* from a source where triazines were not continuously used was susceptible.

Other species found to be resistant to the triazines were *Amaranthus retroflexus* L., redroot pigweed, *Chenopodium album* L., lambsquarters, *Ambrosia artemisiifolia* L., common ragweed, *Brassica campestris* L., wild turnip, and *Chenopodium strictum* Roth var. *glaucophyllum* (Allen) Wahl., late-flowering goosefoot (Bandeen *et al.*, 1979). However, some or all of the *A. retroflexus* indicated to be resistant were *Amaranthus hybridus* L., smooth pigweed, and/or *Amaranthus powelii* S. Wats., Powell amaranth (Ahrens *et al.*, 1981).

Susceptible biotypes of *S. vulgaris* and *Amaranthus* spp. were more competitive than the resistant biotypes as manifested in lower dry matter production by resistant biotypes (Radosevich, 1979). This reduced capacity for carbon fixation by the resistant biotype may be due to a less efficient electron transport system resulting from a modification of the herbicide binding site on the thylakoid membrane (Sims *et al.*, 1981).

In investigating the nature of resistance, Radosevich and Appleby (1973) found that both biotypes of *S. vulgaris* absorbed simazine equally well and did not metabolize it; 80 to 90% of the C^{14} activity was identified as simazine. Differences in response to simazine could not be attributed to differences in uptake or metabolism. Later, similar conclusions were obtained with triazine resistant and susceptible *C. album* (Jensen *et al.*, 1979). This mechanism of resistance is different than previously found for triazine resistance in grasses, where the following mechanisms are recognized: a) benzoxazinone (2,4-dihydroxy-7-methoxy-1, 4-benzoxazine-3-one) catalyzed non-enzymatic dechlorination accompanied by substitution of a hydroxyl group in the 2-position (Hamilton and Moreland, 1962; Hamilton, 1964), b) production of a peptide (glutathione) conjugate (Shimabukuro *et al.*, 1971).

When chloroplasts were isolated from *S. vulgaris, Amaranthus* spp. and *C. album*, Hill reaction activity of resistant-type chloroplasts was not inhibited by atrazine, but was inhibited in susceptible-type chloroplasts (Radosevich, 1979). A structural or conformational change associated with the thylakoid membrane could be responsible for the differences in susceptible and resistant types (Radosevich, 1979).

Arntzen *et al.*, (1981) proposed that a specific polypeptide creates the binding site for the triazines and is located on the reducing side of photosystem II. The polypeptide is currently being characterized.

TRIAZINE RESISTANCE AS A BASIS FOR SELECTION AND BREEDING

Considerable research has been conducted on species resistance to triazine herbicides by a number of investigators in the U.S. and elsewhere. Some had suggested that this resistance may be a source for selection and breeding long before resistance of weeds to triazine herbicides was documented in the literature.

Presently, scientists in Ontario, Canada have transferred triazine resistance from *Brassica napus* L., annual rapeseed, to *Brassica napus* L. (Napobrassica group), biennial rutabaga, using the triazine resistant *B. napus* as the female parent and crossing it with *B. napus* (Napobrassica group) commercial cultivars. Several backcrosses have been made resulting in biennial *B. napus* (Napobrassica group) genotypes that are triazine resistant. Further backcrosses are needed to produce a commercially acceptable cultivars with triazine resistance.

In other Canadian studies, triazine resistance was transferred from *B. campestris* to *B. campestris* cv. Candle, thus permitting the use of atrazine at 0.74 kg ha^{-1} to provide excellent control of *Thlaspi arvense* L., field pennycress, previously not controlled by other herbicides (Kirkland, 1980). However, atrazine at these rates caused residual carryover to succeeding cereals; studies are continuing.

Breeding and selection for triazine resistance may now be intensified as a result of these studies. Some breeding and selection programs have long considered herbicide tolerance as an integral part of their selection pressure. The Hawaii Sugar Planters Association recognized that *Saccharum* hybrids responded differently to ametryne [2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-*s*-triazine] (Osgood *et al.*, 1969), and now they routinely screen all new seedlings and clones to ametryne as part of their selection pressure. They have noted that tolerance to ametryne is correlated with tolerance to other triazines, ureas and uracils.

Their current screening procedure is to apply ametryne at 9 kg ha^{-1} without surfactant or at 4.5 kg ha^{-1} with surfactant 2 mth after planting (R. V. Osgood, personal communication, 1981). Plots are evaluated 3 wk after application and observed later for recovery. Since some cultivars recover rapidly from ametryne injury, more emphasis is placed on chronic deleterious effects in the variety selection process.

BIOLOGICAL CONTROL

In recent years, greater attention has been focussed on biological control of weeds. Despite past successes, breakthroughs in this area appear less frequently than in other control areas. A recent important development is the use of *Ctenopharyngodon idella* Val., Chinese grass carp, for control of aquatic weed vegetation.

Another aquatic weed, *Alternanthera philoxeroides* (Mart.) Griseb., alligatorweed, has been partially controlled by the introduction of a fleabeetle *Agesicles hygrophila* Selman & Vogt, and a moth *Vogtia malloi* Pastrana (Maddox *et al.*, 1971).

There appears to be increased interest in the use of plant pathogenic organisms for biological control of weeds. In Hawaii, Trujillo (1976) introduced *Cercosporella ageritinae* n.s. for the control of *Ageritina riparia* (Regel) K. & R., Hamakua pamakani. The organism was released during late 1975 and early 1976. Excellent control of this weed resulted from about 450 to 2000 m elevation, where conditions for pathogenicity were appropriate. This introduction apparently resulted in a self-perpetuating pathogen population as in classical control interactions between insect introductions and weeds.

Researchers in Florida have demonstrated that a race of *Phytophthora citrophthora* (Sm. and Sm.) Leon effectively controlled *Morrenia odorata* Lindl., milkweed vine, in citrus (Burnett *et al.*, 1973). The organism was originally isolated from a dying *M. odorata* plant in Florida. It appears that this *P. citrophthora – M. odorata* relationship may also be self-perpetuating.

The use of plant pathogens as a mycoherbicide also appear to be a promising area. For example, scientists in Arkansas have obtained excellent control of *Aeschynomene virginica* (L.) B.S.P., northern jointvetch, in *Oryza sativa* L., rice, by aerial applications of an anthracnose fungus *Colletotrichum gloeosporiodes* f. sp. *aeschynomene* (Daniel *et al.*, 1973). This organism was originally found infecting *A. virginica* in the *O. sativa* fields of Arkansas. A commercial company in the U.S. is developing the commercial use of this fungus for *A. virginica* control.

NEW EQUIPMENT

Perhaps the discovery of glyphosate [*N*-(phosphonomethyl)-glycine] has spurred innovative developments in equipment. The excellent translocation of glyphosate coupled with the broad spectrum of species susceptibility provided opportunities for control of problem weed species, if glyphosate could be applied to the weed and not to the crop.

The recirculating sprayer developed by McWhorter (1970) was highly effective in applying glyphosate to tall weeds growing above crop canopies, resulting in excellent control and little to no crop injury. This applicator disperses horizontal streams of spray solution above the crop canopy to tall-growing weeds and catches spray solution not intercepted by the weeds and recirculates it through the spray tank. Thus, this mechanism minimizes loss of spray material in the application process, and has rapidly adopted by farmers in the U.S.

Some years later, Dale (1978) of the same laboratory reported on a ropewick applicator to apply systemic herbicides to weeds growing either above or below the canopy of row-crops.

The rope-wick consists of braided nylon strands which transfer herbicide solution to the weeds by physical contact as the wick is moved through the field. Herbicide solution on the wick is replenished by capillarity from a reservoir. Since only emerged weeds receive the herbicide solution, very little herbicide is used unless a dense population of weeds exist. Reports from farmers indicate that it is not uncommon to cover 60 ha of *G. max* with 1 kg a.e. of glyphosate and obtain excellent control.

The rope-wick applicator can be mounted on tractors or can be hand-carried. Several designs have been made and many individual growers construct their own rope wicks. Fields were first treated with rope-wick applicators in 1978, and by 1980 an estimated 8 to 10 million ha in the U.S. were treated with rope-wick applicators.

Many other modifications to the rope wick concept developed. For example, roller wipers constructed with an absorbing pad of carpet move counter-clockwise to the direction of the tractor movement (Wyse and Habstritt, 1977). This results in better wetting than the rope wick, but less than the recirculating sprayer.

The principle behind these wick and wiper applications is not new, as farmers previously wrapped their spray booms with burlap or sponge rubber and wiped their tall-growing weeds with this system using 2,4-D((2,4-dichlorophenoxy) acetic acid) as the herbicide. However, dripping often caused crop injury with this practice. 2,4-D wax bars were constructed to eliminate dripping and other problems; but these wax bars are no longer marketed for row crops.

The simplicity of the rope-wick applicator and appropriate herbicides to go with it should result in many opportunities for controlling weeds that previously did not exist.

AN INNOVATIVE TECHNIQUE

Some innovative techniques of improving crop selectivity to herbicides have been established with localized applications of activated carbon and by plug planting. Also, chemical antagonists for EPTC (*S*-ethyl dipropylthiocarbamate) and butylate (*S*-ethyl diisobutylthiocarbamate) for *Z. mays* and chloroacetamides for *S. bicolor* have been developed.

Dawson developed an innovative technique where he coated seeds of *Medicago sativa* L., alfalfa, (1981a) and *Phaseolus vulgaris* L., bean, (1981b) with EPTC in lime or gypsum. These materials are common carriers for *Rhizobium* inoculum. When 0.2 mg of EPTC was applied per *M. sativa* seed and these sown in rows 1 cm apart, control of susceptible species was obtained in a band approximately 5 cm wide. These treated seeds could be stored in closed containers for 1 yr and the same result was obtained. When seeds were evenly sown by hand at 14 to 25 kg ha^{-1}, complete control of *Lolium perenne* L., ryegrass, was obtained. However, because of the difficulty in achieving even distribution and a uniform depth of 1 cm in practice, weed control was usually incomplete.

By estimating the area of *M. sativa* seed at 2 mm^2, Dawson calculated that the rate of EPTC that the *M. sativa* seed was exposed to at seeding time was about 250 times the normal rate of application. In his experiments at 4 kg ha^{-1}, seeds were exposed to 1000 kg ha^{-1} if applied uniformly and incorporated in the field.

Further studies indicated that emerging seedlings of *M. sativa* are extremely tolerant to EPTC, nongerminated *M. sativa* seed is practically immune to EPTC, and EPTC diffuses rapidly from the seed to the band of soil where weeds are controlled. All these factors contribute to the extremely high tolerance of *M. sativa* to EPTC.

EPTC was also applied to *P. vulgaris* seeds which were seeded 4 cm deep and 3 cm apart in the row. Under these conditions, *Echinochloa crus-galli* (L.) Beauv., barnyardgrass, was controlled in bands 10 to 12 cm wide. The deeper seeding with *P. vulgaris* probably caused better distribution of EPTC laterally and hence a wider band of weeds was controlled.

This technique appears to have much promise for use of herbicides where equipment, water, and other necessary items may be unavailable. It could be used as an aid to subsequent hand-weeding or perhaps with wiper or rope-wick applications as discussed earlier.

APPLICATION OF WEED BIOLOGY

Studies on weed biology have provided the basis for more effective control of weed species. For example, Egley and Dale

(1970) discovered that ethylene stimulated germination of *Striga asiatica* (L.) O. Kuntze, witchweed seeds. Following germination, *S. asiatica* must attach to a host or starve.

Ethylene applied at 0.4 to 1.1 kg ha^{-1} induced *S. asiatica* seed germination in the field (Eplee, 1975). One application of ethylene was delivered approximately 20 cm below the soil surface by a field injector resulting in 90% germination of *S. asiatica* seeds and their subsequent starvation. This program is now part of the *S. asiatica* eradication program; several thousand ha in North and South Carolina have been treated with ethylene gas.

AGROECOSYSTEMS STUDY

Long-term studies dealing with herbicide and cultural controls for several cropping systems are being conducted (Slife and Wax, 1975). Weed seed populations are monitored; in several cropping systems only 12 of 30 weed species remained after 6 yr of cropping. Regardless of the weed control measure used, best yields of *Z. mays*, *G. max*, and *Triticum aestivum* L., wheat, were obtained when grown in rotation rather than continuously. Of the weed control measures used, rotational herbicide use resulted in the highest yields. No herbicide residue buildup was noted with any of the herbicide treatments after 6 years. Other studies on soil organisms are being conducted on these plots (Chio and Sanborn, 1978).

These are just a few highlights of the many accomplishments in weed science and technology in the U.S. Though many interesting aspects such as allelopathic relationships, modelling weed and crop growth dynamics, relationships of weeds with other pest organisms, weed competition studies, mechanisms of herbicidal action, translocation and metabolism, herbicide-soil and interactions, have not been discussed here. It is hoped that this presents a broad perspective of weed science research in the country.

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HIGHLIGHT OF WEED SCIENCE WORK IN INDONESIA

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ABSTRACT

The highlights of weed science work in Indonesia are briefly reviewed to cover the history of weed science and recent developments in education and training, research, collaboration, publication, extension work, regulation and agrochemical development. The prospect of future trends of weed science development is also briefly presented. Weed science has been officially offered in some universities since the 1970's, while training in weed science has been conducted by some universities, research institutes, and by the Weed Science Society of Indonesia. Weed science research still emphasizes chemical control, the study of weed flora in various areas, the ecophysiology of the crop-weed system, biological control and utilization of weeds for various purposes.

INTRODUCTION

Several review articles concerning weed science development have already been published (Soerjani *et al.*, 1971; Soerjani, 1973, 1977 and 1978), while prospects of weed (including aquatic weed) management in Indonesia have also been discussed (Soerjani and Tirtarahardja 1971; Soerjani and Azis, 1979; Soerjani *et al.*, 1976, 1977; Kasno *et al.*, 1979; Widyanto and Soerjani, 1980; Soerjani, 1979, 1980 and 1981). This paper attempts to briefly highlight more recent weed science work in Indonesia.

RESEARCH

Taxonomy and inventory

The extreme importance of correct identification of weed species was first realised by Koorders (1890), and resulted in a very few publications, e.g. weed flora in tea (Backer and van Slooten (1924) and in sugarcane (Backer, 1928–1934). This book in fact covers almost all weeds in Java, and is still considered as a rich source of information pertaining to weed taxonomy and identification.

Other modern up-to-date general floras are Flora of Java (Backer and Bakhuizen van den Brink 1963–1968) and Flora Malesiana which irregularly appears in separate volumes (van Steenis, 1951).

Illustrated weed floras recently published, include weeds in plantations with colour photographs by Sudarsan and Rifai (1975), weeds in rice fields with attractive drawings by Sundaru *et al.* (1976), a more extensive book on aquatic weeds in Southeast Asia by Pancho and Soerjani (1978) and weed flora of highland horticulture in Java by Everaarts (1981).

The latest work on weed flora in Indonesian rice cultivation will cover 250 illustrated weed flora, including information on their ecophysiology, agricultural importance and control, and will be published jointly by BIOTROP and the Royal Tropical Institute as a result of BIOTROP-NUFFIC five years of collaboration. The work reported by Wicaksana (1979) described the possibly more easy and accurate method of Cyperaceae seedling identification by examining the remaining pericarps still attached to the seedlings.

BIOTROP also plans to produce Weed Species Identification Sheets (weed SIS): loose sheets of illustration and description of important weed species in four languages (English, Indonesian/Malaysian, Tagalog and Thai).

Weed ecophysiology

Weed ecophysiology forms an area of study which may yield valuable information for the selection and the performance of justified practices in weed management. The recent work in the biology of weeds includes ecophysiology of important weed species and the systems in which they occur. Factors taken into account in this studies e.g. growth requirements of crops and weeds, the relationships between the degree of occurrence and the degree of the effect of weeds on crop yield, generative and vegetative reproduction, and dispersal of the propagules as well as their establishment.

Much attention has also been paid to the biology of alang-alang *Imperata cylindrica* (soerjani loc. cit; Eussen, 1981; de Groot, 1979), *Salvinia molesta* (Nguyen, 1979), and purple nutsedge *Cyperus rotundus* (Sierra, 1979; Mangunsukardjo, 1979). Information on various aspects have been gathered, e.g. reproduction of this species, its growth under various conditions, its impact on the associated plant species, allelopathic mechanisms, and the effect of control practices. Other species of weeds much studied are waterhyacinth (Djalil, 1979; Talatala and Soerjani, 1975; Sastroutomo *et al.*, 1978), *Panicum repens, Paspalum conjugatum, Pennisetum polystachion,* water lettuce (*Pistia stratiotes*), *Striga lutea* and *Ageratum conyzoides* (Sastroutomo, 1979; Eussen, 1981). The degree of competitiveness of the following species was studied and reported by Pons (1979) i.e. *Echinochloa crusgalli, E. colona, C. iria, C. difformis, C. pilosus, Fimbristylis littoralis, Scirpus juncoides,* and *Eleocharis congesta.*

Chemical control

Although most weed control practices are done manually, the recent activities in weed science research have emphasized on chemical control. Research on chemical control in rice fields and other food crops are done mainly to select herbicides suitable for certain agro-ecosystem in particular areas, due to differences of cultural practices, crop varieties planted and problems of weeds (Sundaru, 1979; Utomo and Mercado, 1979; Pane and Sundaru, 1981; Utomo, 1981). At present the farmers are practising the use of 2,4-D amine, 2,4-D butylester, MCPA, thiobencarb + 2,4-D, oxadiazon, and butachlor for inundated rice fields.

In controlling weeds in corn the common practice is to use atrazine, paraquat, and glyphosate. Paraquat and glyphosate are limitedly used also for cassava, while alachlor and oxadiazon are used for soybean. Herbicides still under further investigation by various researchers, e.g. butachlor for upland rice and soybean and diclofop methyl soybean.

Following the past herbicide selection trials, the present commonly used herbicides for plantation crops are dalapon, paraquat, paracol, glyphosate and 2,4-D, mainly for rubber and oilpalm. Glyphosate and dalapon are used in controlling alang-alang in several plantation crops of rubber, cocoa and oilpalm (Tjitrosudirdjo *et al.*, 1980; Uswandi and Angudi, 1980; Arief and Sutomo, 1980). The current widely studied new herbicide is fusilade 25 EC for post-emergence application to control grass weeds in inter-row crops of rubber and other perennial plantation crops.

Cultivation methods

The cultivation methods are based on the modification of environmental conditions, in which the modified environmental conditions are suitable for the crops and not for the unwanted naturally occurring plants. This may consist of soil preparation, irrigation, type of crop planting, maintenance of the crops, rotation, multiple cropping, inter-row cropping and the use of annual cash crop or ground covers in plantation crops. These methods may effectively contribute to the proper management of weeds in any crop planted. In rice fields, the most important cultivation method to control weed seed germination and growth is the continuous inundation through irrigation. Therefore, in rice field areas with lack of irrigation, the weed problem is more severe than in irrigated fields.

In some localities the farmers convert the rice field into sugarcane plantation periodically. With this rotation, the presence of certain weed species, e.g. *Monochoria vaginalis*, *Fimbristylis* spp., *Marsilea crenata* and *Limnocharis flava* may be reduced.

The use of ground covers like *Centrosema pubescens, Calopogonium mucunoides, Psophocarpus palustris* which can be fed to livestock constitutes a good weed control practice in some plantation in addition to preventing the harmful effects of a clean culture. In young rubber and other young plantation crops the cash cropping system using maize, cassava, peanut, etc. is used. There are two reasons for employing this method. One is to optimise land utilization and the other is to reduce weed infestation.

Recent investigation to develop the best techniques for controlling weeds through agricultural methods has been done in various transmigration sites. Two cropping systems have been investigated, i.e. the perennial crop (coffee) based cropping system, in which after the third year no more food inter-row crops are planted, and the food crop based cropping system. The food crops, namely corn, upland rice, cassava, sorghum, peanut, and ricebean are mixed planted, intercropped or sequentially planted (Suryatna and McIntosh, 1980). Another similar method using mechanized cultivation methods is currently being investigated which is aimed mainly at the control of alang-alang in the area (Sembiring and Supardja, 1981).

Biological control

Research into biological control methods of weeds in Indonesia was reviewed by Mangundihardjo (1975) and Kasno *et al.* (1979).

Efforts in the biological control of weeds are still in their initial stage in Indonesia. The introduction of *Dactylopius tomentosus* from Australia into Sulawesi in 1935 to control *Opuntia* spp brought results in four years. It was the first attempt at this type of control. Other efforts were the introduction of lace bug (*Teleonemia scrupulosa*), grass carp (*Ctenopharyngodon idella*), and the mottled waterhyacinth weevil (*Neochetina eichhorniae*), in the integrated effort to control *Lantana camara, Hydrilla verticillata* as well as other aquatic weeds and waterhyacinth respectively. Efforts to find out indigenous insects and fungi have also been carried out for several years, however, till recently there have been no promising agents that have the potential to control important weeds in Indonesia. Most of them are species with a wide host range. *Proxenus hennia* is considered as a specific feeder on *Pistia stratiotes* but it only has a low damaging potential. To maximize this low potential it is advisable to integrate biological control with other agents or other control efforts such as mechanical and chemical methods. Preliminary studies done under laboratory condition showed interesting results, e.g. the combination of the use of a fungus *Myrothecium roridum* and *N. eichhorniae* to control waterhyacinth demonstrated a better result than the use of any one of them alone.

Utilization

The attitude toward the utilization of weeds is *how can we benefit from a problem*. Although this is not always feasible, there is, however, a need to consider appropriate approaches to problem solving, since *all problems should be*, in the first instance, *viewed as opportunities*.

So far, species of weeds investigated for their possible utilization are: waterhyacinth, *Salvinia molesta* and alang-alang.

The recent approach is to make use of the plant material for mushroom culture, biogas production, paper pulp production, water purification, and also as fertilizer, animal feed and handicrafts.

The petioles of waterhyacinth can be properly used as a bedding material for tropical mushroom, *Volvariella volvacea*, yielding approximately 25% (250 g of mushroom out of 1 kg dried petioles) (Soerjani, 1980, 1981; Widyanto and Soerjani, 1980).

Biogas can be produced from fresh material of waterhyacinth, i.e. 370 l of biogas with 69% methane gas can be produced (Soerjani, 1980, 1981).

Potential uses of waterhyacinth, alang-alang, *Panicum repens* and *Scirpus grossus* as paper pulp material have been investigated. The results showed that alang-alang material is the best source for paper pulp (Judodibroto *et al.*, 1979; Soerjani, 1980, 1981).

Polluted water may be purified to some extent by the high absorption capability of waterhyacinth. The plants are able to absorb heavy metals such as Cd, Hg, Ni, and other materials, e.g. NO_3, NH_4, PO_4, Na, SiO_2 and S (Widyanto, 1979).

HERBICIDE MANAGEMENT

Regulation

Aiming at the most desirable and optimal use of herbicides with a minimal risk to the human health and the environment, the distribution, storage and usage of pesticide have been regulated by the Government Regulation no. 7-1973. The registered pesticides following the procedure set forth by the regulation will be announced through a "white list" issued regularly by the Ministry of Agriculture. In the present book published by the Pesticide Commission, there is a list of 286 formulations of pesticides, 57 (or 19.9%) are formulations of herbicides (Table 1).

As compared to the earlier figure, there were only 20 herbicides registered in Indonesia in 1977 (Soerjani *et al.*, 1977).

Industrial development

Herbicide industrial development in Indonesia is still in its early stage. The first steps towards producing herbicides in Indonesia were taken some ten years ago, but production until now has remained only at the formulation stages.

Table 1: List of registered formulations of pesticides in Indonesia (1980)

Pesticides	Number of registered formulations	Per cent
Insecticides	124	43.4
Herbicides	57	19.9
Fungicides	57	19.9
Others	38	13.3
Surfactant, etc.	10	3.5
	286	100

Table 2 : Permitted formulated pesticides (1979-80 and 1980-81).

Pesticides	Number of permitted formulations (1979-1980)	Per cent	New permitted formulations (1980-1981)
Insecticides	75	58.6	5
Fungicides	21	16.4	–
Herbicides	15	11.7	1
Surfactants, etc.	–	–	–
Others	17	13.3	1
	128	100	7

The permitted formulated herbicides in 1979-80 constitute only 15 formulations, or 11.7% of the total 128 formulated pesticides (Table 2). Permission to manufacture these herbicides was granted to 13 companies.

The number of new permitted formulations accepted in the 1980-1981 period was limited to only seven new formulations and production licenses were given to four companies.

FUTURE TRENDS AND CONCLUSION

In Indonesia agricultural practices are still labour intensive, therefore weed control efforts are mainly performed manually. However, since the labour distribution is imbalanced, there are areas with less labour for manual weeding. This is true in plantation crops, but it also occurs in some areas of annual crops, e.g. rice fields. Therefore, the solution of the weed problem may vary from region to region and from time to time.

Considering the fact that agriculture only covers 8% of the total land area, the present burden, already approaching 70% of the carrying capacity of the agricultural land, is somewhat on the critical side. Therefore, if the overall welfare of the farmers (which is 70% of the total population) is to be steadily enhanced, the most important options are:

a. To increase the carrying capacity of the present agricultural land area. This will require a lot of energy, including herbicides.
b. To open new agricultural land and redistribute the population. This requires efficiency which may in turn also require the use of more energy, including herbicides.

Therefore, in future national development, the role of weed science is expected to increase. This is a prerequisite to the balancing of the development of all components in agricultural production, in particular agricultural education and training.

There is also an increasing concern for the critical situation of the quality of the environment. The future increase in the use of energy for weed management, including the use of more herbicides or any other methods of weed control, will require increasing wisdom by all concerned. This places the role of education in the forefront of future development of weed sciences.

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WEED COMPETITION IN UPLAND RICE

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ABSTRACT

In order to obtain the information of weed competition in upland rice, some experiments were carried out at BIOTROP, Bogor, Indonesia. The "space occupation" and "replacement series" concept developed from de Witt were used to describe the complex of environmental factors that affect to the plant growth performances and interaction between weed species and upland rice crop.

INTRODUCTION

Agricultural fields may be regarded as artificially established and maintained ecosystems in which man tries to adapt the environment as much as possible to the benefit of the crop plant in order to attain a maximum yield of the crop (Soerjani *et al.*, 1981). Further the requirement of the established and maintained ecosystem will depend on the growth requirement of crops. To establish such an ecosystem, the site of conditions are first made suitable for crops. This may be in the forms of removing of the existing vegetation, site preparation, establishment of irrigation and application of chemicals.

After planting period, the crops then grow together with non-crop species.

In upland rice ecosystem the crop is introduced as soon as the environmental condition with respect to available soil moisture are favourable during the period of rice growth. After soil preparation rice seeds are directly planted, broadcasted or drilled in hills or rows. Since in upland rice culture there is no rice transplanting system therefore heavy weed infestations occur. Both crop and weeds are living organisms, capable of establishing a community. In this connection this paper is intended to discuss their response, and interactions.

COMPETITION

The main factor of competition is actually based on the ecological manipulation by both crop and weeds. According to Aspinall and Milthorpe (Zimdahl, 1980), plant (weed and crop) during growth will modify the environment around them and the modified environment in turn influences the growth of constituent plants.

The condition established of such area after land preparation apparently suitable for both the crop and many non-crop plant species and the vegetation will be composed of a crop and a non-crop plant (Soerjani *et al.*, 1981). The non-crop plant species are classified as weeds as soon as indication exits that they hamper crop germination, development, growth and yield in one way or the other.

The kind and number of weed species, which establish in an ecosystem, depends on the composition of the previous existing vegetation on that site and on the composition of the surrounding vegetation. During and after site preparation, weed species will start to inhabit the site. When the crop is introduced both components of the vegetation, the weed and crop component, are utilizing mainly the same environmental factors for their growth performances. As soon as these factors are not sufficient to support their optimal growth performances, the competition starts.

The degree of competition will vary according to the plant species, plant densities, distribution and duration of plant existing in that ecosystem (Bleasdale, *in* Zimdahl, 1980), while climatic and edaphic condition serve as modifiers.

To determine the competition between plants (crop and weed) all environmental factors contributing to the growth performances of plants may be involved. The term "space" embraces all environmental factors, e.g. light, water and nutrient for which the species compete; and furthermore it can describe the difficulty to evaluate the individual significance of these factors in the process of competition.

In a certain environment, the yield of a plant growing may be represented by:

$$0 = \frac{B.Z.}{B.Z. + 1} \; OM$$

where

0 is the actual yield, Z is the density of sowing; OM is the maximum yield which is obtained at high plant densities and B is the space occupation occupied by a single plant growing alone (de Witt, 1960).

The yield OM is attained when the available space is completely occupied by the population. At lower densities the population occupies a relative space.

$$RS = \frac{0}{OM} = \frac{B.Z.}{B.Z. + 1} \; ;$$

where RS is relative space occupation.

FACTORS AFFECTING WEED COMPETITION IN UPLAND RICE

Some factors affecting plant competition have been studied intensively by several researchers. One of the more substantive recent explanations of the sum of the factors encountered by an individual plant has been schematically outlined by Bleasdale (Zimdahl, 1980) (Fig. 1).

Some environmental factors in connection with the weed competition in upland rice at BIOTROP, Bogor, Indonesia. They deal with the densities of plant (both crop and weeds), species of weed and ecological factors such as nutrient status in the soil or level of nitrogen added to the soil.

Effect of plant density

Based on the plant density, weed competition that affect crop yield, can be re-

- Species
- Densities
- Distribution → Weeds
- Duration (weeding)

- Densities
- Other crop
- Distribution → Plants of some species
- Duration (thinning)

Modified by edaphic and climatic conditions → The degree of competition encountered by an individual plant

Fig. 1 : Schematic diagram depicting the competition encountered by an individual plant.

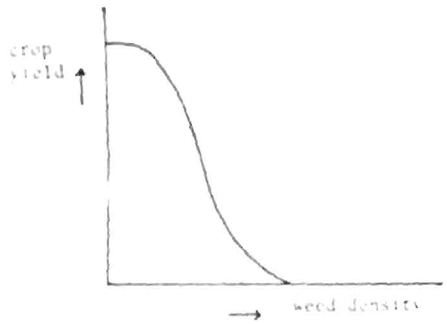

Fig. 2: A schematic sigmoidal relationship depicting the effect of increasing weed density on crop yield.

presented by a schematic sigmoidal reltionship (Fig. 2). However in the same species, like in upland rice itself, the intracompetition may occur according to the densities applied. Eussen (1981a) has tried to obtain information on a possible negative effect of high plant densities on grain yield of upland rice. The studies were made under glasshouse condition at BIOTROP, Bogor, Indonesia. It was found that no negative effect of plant densities on grain yield could be observed in the broadcast situation up to seed rates of 280 kg/ha. But when situated in hill seeded rice the grain yield decreased when seed rates exceeded values equalling to 140 kg/ha.

Considering the value of space occupied by plant, the conclusion is almost the same. Eussen and Utomo (1981) observed same space occupation by rice under both hill seeded and broadcast seeded conditions at two plant densities (3 and 15 plants/pot, equal to 60 and 200 kg/ha with the same planting patterns (Fig. 3).

In a replacement experiment done at BIOTROP, Eussen (1981b) reported that a series of densities of *Ageratum conyzoides* L., ranging from 1 to 32 plants/pot re-

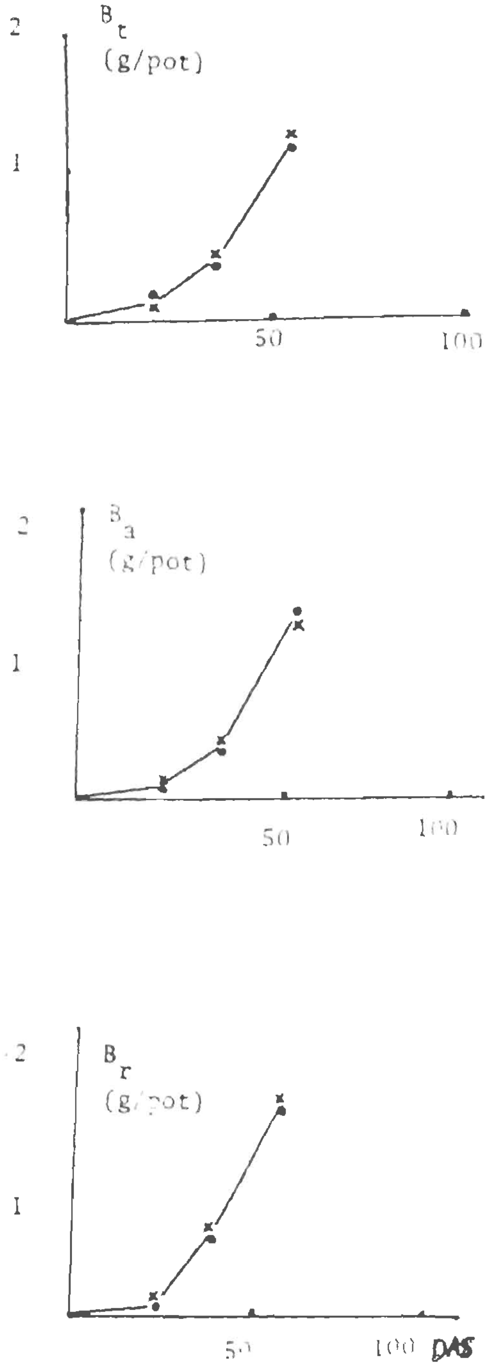

Fig. 3: Space occupied by the plant as function of time for hill seeded (.) and broadcast seeded (x) rice.

Table 1 : Effect of *A. conyzoides* densities on yield of upland rice.

A. conyzoides densities (Plants/pot)	Yield g/pot	Per cent reduction
0	16.0	0
1	13.0	18.7
2	11.5	28.1
4	10.3	40.6
8	7.5	53.1
16	5.5	71.8
32	5.5	71.8

Note : 1 plant/pot is equivalent to 32 plants/m^2

duced the grain yield of upland rice var. Bicol by 19 to 72% (Table 1).

Eussen and Hadi (1981) showed an effect of *Digitaria ciliaris* Pers. to rice grain yield. When *D. ciliaris* present at a density of 1 plant/pot the grain yield of rice grown at a density of 2 plants/pot was reduced by 62%.

b. *Weed species*

Some competition studies were carried-out at BIOTROP with some important species of weed e.g. *Digitaria* spp., *Porophyllum ruderale* Cass., *Croton hirtus*, *Dactyloctenium aegyptium* L., *Cyperus rotundus* L., etc.

The competition varied according to the species and it was determined by calculating the space occupied by the species based on de Witt method.

Digitaria ciliaris displayed higher rate of space occupation than *D. fuscencens* and *D. ternata* when grown from the seed When grown from the cutting, space occupation of *D. ciliaris* was delayed until 55 DAS (Eussen and Balen, 1981). In a replacement series the competition was also determined under greenhouse condition. It showed that rice grown later than *D. ciliaris* started to grow at the same time as one plant of rice appeared about equally competitive to one plant of *Digitaria*.

Porophyllum ruderale a common species in upland area, was also studied to know the ability in occupying the space. It was found that the rate of space occupation of this plant species was low plant densities. At these low densities, some effect of the soil nitrogen level on root dry matter was observed (Eussen and Madenan, 1981). At a density of 2 plants/pot this species retarded the tiller formation of rice at 60 DAS and afterwards reduced the grain yield by 50%. When the density of this species was 32 plants/pot, the effect appeared at 30 DAS and reduced the grain yield of rice by 91% (Eussen and Martoyo, 1981).

Holm *et al.* (1977) considered *Dactyloctenium aegyptium* as a weed of secondary importance on a world basis. An effect of *P. ægyptium* on rice started to become visible on rice tiller production from 30 DAS itself (at density of 1 plant/pot). The reduction of the grain yield was recorded at 75% and 10% by the densities of 32 and 1 plant/pot.

The species like *C. rotundus*, which is recognized as the world worst weed (Holm *et al.*, 1977), reduced the grain yield of rice by 33% and 93% at soil without fertilizer of 1 and 32 plants/pot. At 100 kg N/ha this reduction was 43% and 93% respectively. The reduction in grain yield was mainly caused by a decrease in the number of grain, due to a reduction in panicle numbers.

c. *Duration of weeds present in the ecosystem*

The duration of weeds present on the field, often considered as the maximum period of weeds that can be tolerated without affecting the yield of crops. Therefore, it is dealing with critical period of weed control in a certain crop cultivation.

In upland rice conditions, Mercado (1979) stated that the critical period for weed control in upland rice is 40 days after planting. A field experiment was carried out at BIOTROP experimental station to obtain information on the effect of weeding time on the competition between weeds and upland rice (Sebayang, 1980).

The weed composition found in the field were: *Mimosa pudica, M. invisa, Ageratum conyzoides, Porophyllum ruderale* Cass., *Digitaria* spp. and other grasses.

At the levels of 100 kg N/ha the grain yield of rice grown with weeding at 20, 40, 60 and 80 DAS, and without weeding were compared to no weeds plot. The reduction of rice grain yield over no weeds plot were 19, 16, 39, 5 and 99%, respectively. In a greenhouse condition Eussen and Zulfadli (1981) also carried out an experiment for the same purpose to obtain information on the effect of time and duration of competition between weeds and upland rice. The weed species used were *Mimosa invisa, Ageratum conyzoides, Porophyllum ruderale* and *Digitaria fuscencens*.

When no nitrogen was applied, reduction of grain yield due to weeds started at 0 and 40 or more DAS or when started before 20 DAS and left until 110 days. When nitrogen was applied, weeds which started at 0 DAS decreased grain yield when they were allowed to stay for 40 DAS or longer, or when they started at 40 DAS or early and are left until 110 DAS (Fig. 4).

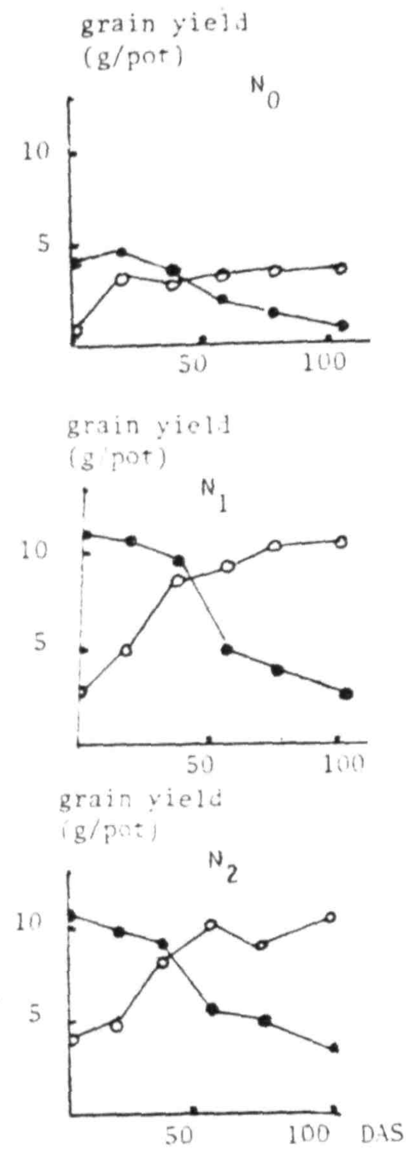

Fig. 4 : Grain yield of rice as affected by the treatments. ● weed present from 0 DAS until time indicated, ○ weed present from indicated time until 110 DAS.

d. *Environmental condition factors*

There are many environmental factors that will serve as modifier in the process of competition. However, the levels of nutrition in the soil can be the most important factors.

In an experiment conducted in glass house at BIOTROP by using water culture solution, Eussen and Utomo (1981) found that nitrogen should be present between 30 and 70 DAS in order to assure a grain yield not deviating from plants grown continuously on nitrogen containing culture solution. The weed control, therefore, can be based on this matter. It is in-line with Sebayang (1980), that two time of weeding in field condition of upland rice at 20 and 40 DAS was satisfactory to control weed.

The N levels in the soil will affect the degree of weed competition. In upland rice, increase in N fertilizer will cause increased N uptake by *Cyperus rotundus* (Okafor in Mercado, 1979). Weeds grow better under adequate levels of nutrients thus making them more competitive against the crop.

In other experiment Eussen and Zulfadli (1981) have proved that in the rate of 100 to 300 kg N/ha the reduction of rice grain yield due to weed was 75%. This reduction appeared to be independent on the levels of nitrogen. Therefore it can be noted that weed control becomes more imperative when fertilization is practiced.

CONCLUSION

Grain yield reduction due to weed in upland rice has been quite enormous, being 78% in Philippines (Mercado, 1979) and 70 to 80% in Indonesia (Syam and Effendi, 1977).

Further it is imperative that space occupation of the weed should be as low as possible therefore it will be beneficial for the crop. According to Soeprapto (1980) to get the maximum production appeared to be a seed rate of 100 kg/ha. The species of plant, either crop plant or weed, will influence the competition occurred in the crop-weed system. Morphologically, the crop plant with tall vigorous and faster rate in growth will have ability to compete with the weed.

Duration of weed occurred in the weed-crop system plays an important role. Sometimes the farmers believe that removing weed any time during the growing season of crops solves the problem. This is not correct, since the correct time of weed removal produces a comparable yield of crop. As proved by Eussen and Zulfadli (1981) that two weeding at 35–40 DAS and 50–60 DAS are necessary to avoid the grain yield loss at 100 kg N/ha.

Principally, the application of fertilizer should be directed to the benefit of the crops. However, weeds in crop-weed system will take advantage in uptaking the nutrient, and in certain condition become more competitive to the crops. Therefore, to make the fertilizer application efficient, weeds should be controlled.

ACKNOWLEDGEMENTS

Thanks are due to Weed Science Society of Indonesia for appointing the author to participate in the Conference at Bangalore and CIBA-GEIGY Rep. Indonesia for financial support.

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STUDIES ON RICE WEED COMPETITION UNDER DIFFERENT METHODS OF RICE CULTIVATION AND WEED CONTROL

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ABSTRACT

Field experiments were conducted in monsoon 1979 and 1980 at Banaras Hindu University, Varanasi, India, with three methods of rice cultivation and ten weed control treatments.

The maximum grain yield was recorded under transplanted method followed by direct seeded (puddled) and significantly lower in direct seeded dry condition owing to corresponding increase in weed dry matter, more depletion of nutrients by weeds and less uptake by the crop. Butachalor 1 to 2 kg/ha, propanil 2.0 kg/ha and thiobencarb 2 kg/ha were the most effective herbicides in checking the weed growth and nutrient depletion. These treatments produced grain yield comparable to hand weeded treatment. Weed dry matter and nutient removal by weeds showed positive relationship.

INTRODUCTION

Among the various factors responsible for low yield of upland rice, weeds are important. Gopalakrishna Pillai and Rao (1974) reported that the per cent yield losses due to weeds in direct seeding under dry condition, direct seeding under puddled condition and transplanting methods are 50%, 30-35% and 20%, respectively. The timely removal of weeds, through hand weeding which is largely adopted by farmers, is rather difficult due to unavailability and high cost of labour. Therefore, the present experiment was planned to study the rice-weed competition under different methods of rice cultivation and to find out suitable herbicide to subdue weed growth.

MATERIAL AND METHODS

Field experiments were carried out with rice cultivar Cauvery at the Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India for monsoon seasons of 1979 and 1980. The experiment was laid out in split plot design keeping the three sowing methods in main plots and ten weed control treatments in sub plots (Table 1).

Crop was sown in lines 25 cm apart using 100 kg seed/ha. The direct sowing under dry and puddled conditions was done on July 12 and July 14 during 1979 and on July 2 and July 4 in 1980, respectively. Transplanting was done on August 8 and July 22 in the year 1979 and 1980, respectively. At last ploughing/puddling fertilizer was applied at the rate of 60 N, 60 P_2O_5 and 60 K_2O kg/ha. The remaining 60 kg N/ha was top dressed in two equal splits, viz., at tillering and at panicle initiation stage. The liquid formulations were applied with a foot sprayer while the granules were broadcasted uniformly mixing with dry soil. Nutrients uptake by weeds and crop was estimated at harvest stage.

RESULTS AND DISCUSSION

The prominent weed species were *Cynodon dactylon* (L.) Pers., *Echinochloa colo-*

Table 1 : Effect of planting methods and weed control on weed dry matter production and N, P, K depletion by weeds.

Treatments	Dry matter weeds (g m⁻²)		Nutrients depletion by weeds (kg ha⁻¹) N		P		K	
	1979	1980	1979	1980	1979	1980	1979	1980
Sowing methods								
Direct sowing (dry)	216.2	179.9	29.30	22.8	9.0	7.1	27.9	23.8
Direct sowing (puddled)	160.9	135.8	23.20	17.8	6.3	4.5	17.5	15.6
Transplanted	100.8	84.6	12.20	9.6	3.1	2.1	10.3	8.2
C. D. (P=0.05)	10.9	6.7	1.80	1.3	0.1	0.2	1.0	1.5
Weed control treatments kg/ha								
+ Butachlor (EC) 2	116.0	96.2	17.90	13.6	5.0	3.3	15.2	12.6
+ Butachlor (G) 1	107.9	92.5	16.60	13.1	4.8	3.1	13.3	10.7
+ Nitrogen 2	147.3	119.7	20.30	15.8	5.5	3.9	17.1	14.1
+ 2,4-D (G) 1	223.2	187.5	23.40	19.1	7.8	6.2	22.5	19.9
† 2,4-D (EC) 1	215.7	184.4	24.00	18.6	8.0	6.4	22.9	20.4
† MCPA 1	219.0	182.8	24.25	18.7	8.0	6.5	22.9	20.5
† Thiobencarb 2	129.4	108.2	17.80	13.8	5.4	3.8	16.1	13.8
† Propanil 2	113.7	100.1	18.60	13.9	4.8	3.1	15.0	12.6
Handweeded	43.5	36.7	8.40	6.3	2.9	1.2	5.9	3.8
Unweeded control	277.1	326.3	44.30	34.3	9.5	7.9	35.0	31.6
(C. D (P=0.05)	10.3	12.6	1.10	1.3	0.3	0.5	0.9	0.9

+ Pre-emergence, 4-DAS/DAP † Post-emergence, 20-DAS/DAP

num (L.) Link, *Cyperus rotundus* (L.) Pers., *Fimbristylis miliacea* Vahl., *Euphorbia hirta* L., *Corchorus acutangulus* L., *Eclipta alba* Hassak., *Phyllanthus niruri* L., *Ammania baccifera* L. and *Commelina benghalensis* L. The direct sown crop had maximum weed dry matter, while it was minimum in transplanted crop (Table 1). Puddling reduced the weeds. Thus transplanted crop produced maximum grain, followed by direct sown with puddling and lower in direct sown under dry conditions (Table 2).

All the herbicides and handweeding treatments significantly lowered weeds dry matter and gave yields more than unchecked control. Butachlor (EC or G) was superior to other herbicides. The next best herbicides both in yields and weed control were thiobencarb and propanil. The phenoxy group of herbicides were less effective in controlling the weeds and gave yields slightly superior to unweeded control.

Methods of planting had significant variation in N, P and K depletion by weeds. The maximum depletion of N, P and K was recorded in direct sown crop under dry condition, while minimum was in transplanting. The direct sowing under puddled condition was intermediate. Nutrients depletion corresponded to the dry matter of weeds indicating the positive relationship between them.

Among the weed control treatments, the maximum depletion of nutrients was observed in unweeded control and minimum in hand weeded control. It was fur-

Table 2: Effect of planting methods and weed control on grain yield and N, P, K uptake by rice

Treatments		Grain yield (kg/ha)		Nutrients uptake (kg/ha) N		P		K	
		1979	1980	1979	1980	1979	1980	1979	1980
Sowing methods									
Direct sown (dry)		936	2012	26.4	63.4	8.3	19.00	26.7	72.0
Direct sown (puddled)		2655	3000	74.2	91.9	18.6	24.60	73.7	100.8
Transplanted		3640	4175	96.0	104.3	24.5	32.00	94.4	113.1
C. D. (P=0.05)		436	323	5.3	0.3	0.8	0.70	5.0	3.3
Weed control treatments, kg/ha									
Butachlor (EC)	2	2775	3412	74.4	98.7	19.0	29.42	78.7	109.0
Butachlor (G)	1	2769	3575	71.0	97.0	18.7	28.60	75.6	109.0
Nitrofen	2	2400	3050	64.0	81.0	16.5	24.80	64.2	88.6
2,4-D (G)	1	1910	2425	54.3	70.5	14.3	21.00	56.8	79.3
2,4-D (EC)	1	1950	2575	54.7	74.7	14.1	22.50	58.0	82.8
MCPA	1	1939	2537	55.6	70.4	14.7	20.50	58.1	77.5
Thiobencarb	2	2674	3325	70.8	94.4	18.3	27.30	73.6	108.3
Propanil	2	2924	3562	75.3	101.6	19.6	29.40	78.9	106.2
Handweeded		3065	4050	86.2	110.5	21.3	31.80	88.9	122.3
Unweeded control		1702	2137	49.0	66.3	14.8	17.00	48.9	73.2
C. D. (P=0.05)		252	260	1.7	6.4	0.6	1.20	2.8	3.0

ther observed that the application of butachlor (EC or G) and propanil were superior to others in reducing depletion of nutrients. The nitrofen and thiobencarb were on par and superior to phenoxy group of herbicides.

Uptake pattern of N, P and K in crop under the treatments was just reverse to the depletion of these nutrients in weeds (Table 2). Transplanting and weed control treatments, viz., hand weeding, butachlor, propanil and thiobencarb resulted in maximum uptake of these nutrients by rice, as observed by Rethinam and Sankaran (1974).

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EVALUATION OF TRADITIONAL AND INTEGRATED WEED CONTROL APPROACHES IN UPLAND RICE IN THE PHILIPPINES

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ABSTRACT

One trial, comparing farmers' weed control practices and integrated weed control practices in upland rice was conducted at four locations in the Philippines. Treatments consisted of weedy and weed free checks, butachlor [N-(butoxymethyl)-2-chloro 2', 6'-diethylacetanilide] at 2.0 kg a.i./ha^{-1} alone, butachlor at 2.0 and 1.0 kg a.i./ha^{-1} plus one handweeding, and the farmers' practice. Generally, significant yield differences did not exist between any treatments in which handweeding was used. The higher rate of butachlor without handweeding reduced populations of grass species but resulted in a weed population shift towards broadleaf species. Butachlor at either the higher or low rate plus one handweeding yields were not significantly lower than weed free check. It appears that high yields can be achieved when using a labour intensive weed control practice of several cultivations and handweedings. If time and labour are constraints, an application of butachlor could eliminate all post-plant cultivations and substantially reduce handweeding times or frequencies for upland rice farmers.

INTRODUCTION

Yield losses in upland rice constituting 11% of the total area under rice due to weeds have been reported as high as 70 to 83% (Vega *et al.*, 1967; Madrid *et al.*, 1972). Upland rice farmers cannot take advantage of important weed control practices such as puddling and flooding which are used by lowland farmers. Post-plant cultivations and handweeding are the most common weed control practices used by upland rice growers in the Philippines. A single handweeding has been reported to take about 300 man hours ha^{-1} (DeDatta and Ross, 1975) and many upland farmers weed their fields two or three times. If labour costs continue to increase or labour availability decreases, weeds may become the major constraint to upland rice farmers. Herbicide use has gained little acceptance by upland farmers, the major reasons being the high costs, the irregular market supply of herbicides and the lack of information on how to correctly use them.

The increasing use of drought tolerant varieties with higher yield potential focuses attention on the effectiveness of weed management practices as a serious factor in upland rice areas. In the 1980 wet season trials were established to test a package of alternative weed control practices in upland rice that may provide upland rice farmers with options of weed control methods suited to their specific constraints.

MATERIAL AND METHODS

One trial was established on farmers' fields in two provinces of the Philippines.

Three trials were located in Batangas at Tanauan, Cuenca and Bauan. The other was located in Camarines Sur at Sta. Elena.

Traditional land preparation, which consisted of two to three animal plowings and several animal harrowings prior to planting was practiced at all locations. Seed of UPL-Ri-5, a newly-released upland variety, was broadcasted at the rate of 100 kg/ha^{-1}. At all three Batangas sites the seed was broadcast and then harrowed into furrows previously formed by a lithao, an animal-drawn cultivator. In Camarines Sur, the broadcast seed was plowed under with a moldboard plow.

Fertilizer was applied at the rate of 60 N, 20 P_2O_5 kg/ha with 16 N, 20 P_2O_5 applied basally, 21 kg N topdressed at 21 days seeding (DAS) and 23 kg N topdressed at panicle initation. The experimental plots were arranged in a randomized complete block design with four replications. Plot size was 3 by 10 m. Butachlor was sprayed as a blanket pre-emergence application within 5 DAS. A knapsack sprayer, fitted with a 3-nozzle 1.5 meter boom, delivering approximately 280 l/ha was used. Weed counts and weed control ratings by specie and crop injury ratings were taken 2 to 3 times during the course of the experiment. Weed weights were taken at harvest.

The farmers' weed control practices varied from one location to another (Table 1).

The six weed control treatments were included at each location (Table 2). In weed free check, 2 to 3 handweedings were made.

RESULTS AND DISCUSSION

The highest yield was obtained by the Batangas farmers, where seed was broadcast and harrowed into rows, allowing for post-plant cultivations (Table 2). By comparison, at Sta. Elena, where the seed was not harrowed into rows, and post-plant cultivations were not done, yields were lower, weed populations and weed weights at harvest were higher and perennial weeds, such as *Cyperacea* species and *Cynodon dactylon* (L.) Pers. were more prevalent.

At two locations, Bauan and Sta. Elena, significant differences in crop yields did not exist between treatments in which handweeding was practiced. At three locations, butachlor plus one handweeding gave yields comparable to weed free checks.

Table 1 : Farmers' weed control practices at four locations.

Location	Post-plant weed control practices
Bauan, Batangas	one harrowing followed by three cultivations during 14-35 DAS plus one handweeding at 21 DAS.
Cuenca, Batangas	two harrowings and two lithao cultivations during 14-41 DAS with three handweedings at 31, 53 and 80 DAS.
Tanauan, Batangas	one lithao cultivation at 14 DAS followed by two handweedings at 27 and 39 DAS.
Sta. Elena, Camarines Sur	2,4-D application at 23 DAS and two handweedings at 14 and 29 DAS.

Table 2: Grain yields at 14% moisture (kg ha^{-1}) of rice at four locations.

Treatment	Location			
	Bauan	Cuenca	Tanauan	Sta. Elena
1. Weed free check	3186 a	3956 a	4605 ab	3482 a
2. Butachlor 2.0 kg a.i./ha	2112 ab	1927 c	3600 bcd	2146 b
3. Butachlor 2.0 kg a.i./ha + handweeding	3361 a	3863 a	4600 ab	3457 a
4. Butachlor 1.0 kg a.i./ha + handweeding	3103 a	3302 b	4765 a	3137 a
5. Farmer's practice	3650 a	3989 a	3528 cd	2961 a
6. Weedy check	1450 b	344 d	2753 d	842 c

Means in a column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range test.

Butachlor at 2.0 kg/ha alone resulted in a weed population shift towards broadleaf species, mainly *Celosia argentia* L., *Ipomœa triloba* L., Cleome rutidosperma DC. and *Commelinaceæ* species. At two locations, Bauan and Tanauan, yields from these plots were not significantly higher than the weedy check. In Cuenca and Sta. Elena, where grass and sedge populations were high, the rice yields from the weedy check were significantly lower than butachlor alone.

Except at Sta. Elena, the total number of grass species in the weedy check were significantly higher than the number of grass species in the butachlor-treated plots (Table 3). Handweeding in butachlor plots did not significantly decrease the grass weeds. In Cuenca, plots with the low rate of butachlor had a significantly higher number of grass species due to a large population of *Echinochloa colona* (L.) Link as compared to plots with a high rate of bu-

Table 3: Total number of grass weeds (G) and predominant broadleaf weeds (D) per 0.5 m^2 prior to handweeding of butachlor plots.

Treatment	Bauan		Cuenca		Tanauan		Sta. Elena	
	31 DAS		55 DAS		40 DAS		42 DAS	
	G	D	G	D	G	D	G	D
1. Weed free check	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
2. Butachlor 2.0 kg a.i./ha	10 b	43 c	11 b	11 bc	1 ab	16 b	9 b	28 cd
3. Butachlor 2.0 kg a.i./ha + hand weeding	10 b	34 c	17 bc	14 c	2 ab	12 b	6 b	11 b
4. Butachlor 1.0 kg a.i./ha + hand weeding	11 b	51 c	28 c	13 c	6 b	36 b	5 b	21 c
5. Farmer's practice	4 b	12 b	1 a	0 a	24 c	25 b	7 b	44 de
6. Weedy check	20 c	132 d	97 d	7 b	31 c	25 b	9 b	47 e

Analysis of variance and mean separation done on data transformed to Log (X + 1).

tachlor. The dominant grass species found at all Batangas locations were *E. colona* and *Eleusine indica* L. Gærtn.

Generally, rates of butachlor application did not affect the number of broadleaf species. Only in Bauan and Sta. Elena there were significant differences between the broadleaf populations of the weedy checks and the other treatments. The farmer-cooperator in Sta. Elena contracted for an outside custom application of 2,4-D at 21 DAS. The weed control results were poor, the differences in the broadleaf populations in the farmers' practice plots and the weedy check were not significant. Butachlor at 2.0 kg/ha reduced the handweeding time from one-third to almost one-half of the time required when butachlor was applied at 1.0 kg/ha. At two locations, Cuenca and Tanauan, the handweeding times for the high rate of butachlor were significantly lower (31.3 and 36.8 hrs/ha respectively than the handweeding times for the low rate (61.1 and 57.6 hrs/ha). The higher rate of butachlor, though, may not result in substantial savings to the farmer, would double the cost of the chemical inputs from P 114.52 to P 229.04/ ha (US $ 14.32 to $ 28.63) but resulted in only an average saving of 44.5 man hrs/ha in handweeding time. Crop injury was not found at either rate of butachlor.

CONCLUSION

The 1980 results indicate that at the present time herbicide use by the upland rice farmer may be an economically risky alternative. Farmers' practices which include several post-plant mechanical cultivations and at least two handweedings gave yields that were not significantly lower than the weed free checks or the butachlor plots plus one handweeding. These high yields were obtained at the expense of two post-plant cultivations and two or three handweedings. It appears that the labour-intensive farmers' practices will continue to predominate until the scarcity or cost of labour becomes more expensive than alternative integrated or chemical control measures. The risk associated with using herbicides would decrease if time and labour become major constraints to the farmer and his usual cultivations and handweedings would be either delayed or impossible to complete.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the excellent technical assistance provided by Mr. Felix Villa. This research was a cooperative effort of the National Crop Protection Center, Los Baños, Laguna; the Ministry of Agriculture, Regional Crop Protection Center, Pili, Camarines Sur; the International Plant Protection Center (IPPC), Corvallis, Oregon; and the United States Agency for International Development (USAID). Funding was obtained primarily from the IPPC through a contract with USAID.

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CROP WEED COMPETITION STUDIES IN SORGHUM UNDER DIFFERENT MANAGEMENT PRACTICES

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ABSTRACT

Two experiments were conducted at P.K.V. Campus, Akola during monsoon 1975 and 1976 to know critical stage of weed control in sorghum cultivars under different agronomic practices. The first experiment consisted of different weed free and no weeding periods in CSH-5 and CSV-3 of sorghum crop and the second experiment also of similar type compared in relation to four fertility levels under rainfed as well as under irrigated conditions.

Critical period of crop weed competition of the sorghum was between 15 to 30 days from sowing. The grain obtained was 82 and 76 per cent of the weed free period till harvest in 1975 and 1976 seasons respectively. The CSH-5 cultivar was found to be superior to CSV-3 in grain yield and weed competition. The dry matter production of weeds was several times higher than that of crop upto 60 days and later on reverse trend was observed.

The weed dry matter increased with increase in fertility level which indicated that the higher yields of sorghum could not be maintained by simply increasing the nitrogen level in the presence of weeds. The weeds were found to be good absorbers of moisture than the crop thus affecting the crop yield.

INTRODUCTION

Weeds have always been associated with sorghum and the damage they cause depends upon species, duration and density. Incidence of striga alone caused a reduction in the grain of sorghum by 75% (Nagur *et al.*, 1962; Rao, 1978) and milk weed (*Asclepias sysica*) (Evetts and Burnside, 1973). Sankaran and Damodaran (1974) recorded that sorghum crop require 30 days weed free period from sowing for getting optimum yield. Srivastava and Gosh (1973) found positive correlation between weed growth with increase in row spacing and nitrogen level in hybrid sorghum.

MATERIAL AND METHODS

The experiments were conducted at C.R.S., Punjabrao Krishi Vidyapeeth Campus, Akola during monsoon 1975 and 1976. This study comprised of 2 field trials one main and the second subsidiary.

1. Studies on the critical period of crop weed competition in sorghum with two different cultivars (Main).
2. Studies on the effects of different weeding intervals on sorghum grain yield in relation to different fertility levels under rainfed and irrigated conditions (subsidiary).

Both the experiments were laid out in a split plot design with 4 and 3 replications in 1st and 2nd experiments respectively. Treatment details are given in Table (1 & 3).

RESULTS AND DISCUSSION

Main experiment

In the first experiment in 1975 season, 22 species belonging to 12 families were

1 : Dry matter production of weeds (g/m^2) at different stages of crop growth

ients	1975						1976					
	15	30	45	60	75	90	15	30	45	60	75	90
	(days)						(days)					
g intervals												
ree for												
5 days (W_1)	–	8.80	17.45	94.95	179.63	218.93	–	7.64	16.02	100.89	159.99	194.49
0 days (W_2)	–	–	4.67	7.32	17.74	29.04	–	–	4.24	6.22	15.28	23.58
5 days (W_3)	–	–	–	3.19	7.02	17.18	–	–	–	4.25	7.76	13.25
0 days (W_4)	–	–	–	–	2.69	4.37	–	–	–	–	3.07	4.16
ırvest (W_5)	–	–	–	–	–	–	–	–	–	–	–	–
eding for												
rs (W_6)	24.24	–	–	–	–	–	21.11	–	–	–	–	–
rs (W_7)	25.69	132.16	–	–	–	–	23.07	131.84	–	–	–	–
rs (W_8)	25.16	136.75	401.02	–	–	–	23.28	129.92	344.23	–	–	–
rs (W_9)	23.54	127.91	368.07	498.33	–	–	25.24	121.95	349.99	416.17	–	–
ırvest (W_{10})	24.90	132.20	378.75	502.33	486.64	446.97	24.74	138.66	402.29	495.26	471.69	409.54
ars												
-5 (V_1)	25.56	109.43	227.96	220.06	140.98	143.56	23.67	105.20	207.73	199.26	130.72	130.32
-3 (V_2)	23.85	105.70	240.08	222.39	136.50	143.03	23.30	106.85	238.98	209.86	132.39	127.69

found, out of which 7 were monocots and rest of them (15) were dicot, whereas in 1976 season 23 species belonging to same 12 families were observed. Amongst them 8 and 15 were belonging to monocot and dicot families respectively.

Amongst the 22 species found in 1975 season, eight species viz., *Cyanotis axillaris*, *Commelina benghalensis*, *Cynodon dactylon*, *Celosia argentea*, *Euphorbia hirta*, *Striga lutea* and *Lagasca mollis* contributed the major weed population with density of 67.5, 30.4, 14.5, 90.4, 23.3, 16.8, 10.8 and 50.1/m^2 respectively. Whereas in 1976 season, 11 species viz., *C. axillaris*, *C. benghalensis*, *Brachiaria eruciformis*, *Digitaria sanguinanlis*, *C. argentea*, *E. hirta*, *S. Lutea* and *L. mollis* were dominant weeds with population density of 59.5, 37.4, 15.8, 17.2 12.6, 11.6, 48.4, 22.1, 14.6/m^2 respectively.

The total dry matter production of weeds increased gradually with the advance in age upto 60-75 days after sowing in the no weeding treatment series and then it declined gradually on 60th day in W_{10}. This may be due to the early maturity of some of the weeds or by shedding of leaves etc. by 60th day. However in weed free treatment series like W_1, W_2, W_3 and W_4 the dry matter production of weeds continued to increase till 90th day. The rate of dry matter production was maximum between 30th and 45th day of the crop-age in no weeding treatment series whereas in weed free series treatments like W_1 it was between 6oth and 75th and in W_2 and W_3 it was between 75th and 90th day. These trends were common in both the seasons.

The ratio of the dry matter produced by the weeds to that produced by crop was five times greater on 30th day.

In 1975, the differences in dry matter production of weeds in relation to cultivar was not found to be consistent. However, in the second year (1976), the dry matter production of weeds was higher in CSV-3 than the CSH-5 at all stages except on 90th day (Table 1). This indicates the smothering effect of CSH-5 on weeds.

During 1975, when the plots were kept weed free upto first 15, 30, 45 and 60 days, reduction in grain yield of 30.5, 18.0, 5.0 and 3.2% respectively was observed as compared to weed free till harvest (Table 2). By keeping the plots weedy upto first 15, 30, 45, 60 days and till harvest, reduction in gran yield was observed to the extent of 3.4, 20.1, 36.8, 41.0 and 48.6% respectively. In 1976 season also similar trends were observed. However, the reduction in grain yield was of greater magnitude as compared to 1975 season.

These results indicated that by allowing the weeds to compete for first 15 days

Table 2: Grain yield of sorghum (kg/ha) as influenced by weedy and weed free periods

Treatments		1975	1976
Weed free for			
First 15 days	(W_1)	3493	3026
First 30 days	(W_2)	4121	3466
First 45 days	(W_3)	4775	4310
First 60 days	(W_4)	4862	4260
Till harvest	(W_5)	5016	4538
No weeding for			
15 days	(W_6)	4855	4372
30 days	(W_7)	4015	2949
45 days	(W_8)	3175	2749
60 days	(W_9)	2967	2311
Till harvest	(W_{10})	2588	2123
Cultivars			
CSH-5	(V_1)	4845	3679
CSH-3	(V_2)	3127	3141
C.D. (P=0.05)			
Weeding intervals		397	373
Cultivars		168	130

Interaction was significant at 5% level in 1976

Table 3 : Dry matter production of weeds in g/m^2 as affected by different treatments

Treatments	1975 season 30	60 (days)	90	Mean	1976 season 30	60 (days)	90	Mean
Weeding intervals								
Weed free for 30 days (W_1)	–	10.25	53.25	31.75	–	8.75	51.38	30.07
Weed free for 60 days (W_2)	–	–	8.50	8.50	–	–	8.00	8.00
Weed free till harvest (W_3)	–	–	–	–	–	–	–	–
No weeding for 30 days (W_4)	19.38	–	–	19.38	17.75	–	–	17.75
No weeding for 60 days (W_5)	18.75	103.00	–	60.88	17.13	77.50	–	47.67
No weeding till harvest (W_6)	17.88	94.38	187.25	99.84	18.13	109.50	157.88	95.17
Mean	18.67	69.21	83.00	56.96	17.67	65.25	72.42	39.72
Fertility levels								
N P K								
25 12.5 12.5 (F_1)	13.67	38.17	43.00	31.61	9.84	30.67	38.00	26.17
50 25.0 25.0 (F_2)	17.00	48.50	74.00	46.50	13.17	34.17	60.67	36.00
75 37.5 37.5 (F_3)	14.49	83.49	79.50	59.16	19.00	91.50	88.67	66.39
100 50.0 50.0 (F_4)	29.50	106.67	135.50	90.56	28.67	104.67	102.34	78.56
Mean	18.67	69.21	83.00	–	17.67	65.25	72.42	–
Moisture regimes								
Irrigated	18.17	79.59	85.25	61.00	17.50	64.25	71.75	51.17
Rainfed	19.17	58.84	80.74	52.92	17.83	66.25	73.09	52.39

the losss was 3.6%, but when weeds were allowed to grow further for another 15 days (i.e. upto 30th day), the reduction was 24.4%. This drastic reduction was due to severe competition offered by weeds. Hence, this period of 30 days after sowing appeared to be critical for weed competition in both the varieties of sorghum, as observed by Sankaran and Damodaran (1974).

The CSH-5 was superior to CSV-3 and did not differ much for various weed-free or weedy periods.

Subsidiary experiment

The dry matter production of weeds increased with increase in fertility levels and the maximum dry matter was recorded at a fertilizer dose of 100 N, 50 P and 50 K kg/ha (F_4). The rate of dry matter production was maximum between 30th and 60th day and fertility levels between F_3 and F_4, and F_2 and F_3 in 1975 and 1976 and 1976 season, respectively (Table 3).

The dry matter production of weeds under irrigated condition was more as compared to rainfed condition in 1975 season, but was similar in 1976. This indicates that weeds absorb good amount of moisture even under limited moisture supply and can equal the dry matter production to the level of the irrigated condition.

The perusal of data on weed dry matter at various fertility levels showed that weeds gave higher dry matter even at higher fertility levels both under irrgated and rainfed conditions. Thus, weeds utilise nutrients and offer better competition to the crop, as opined by Staniforth and Weber (1956).

Table 4: Grain yield of sorghum (kg/ha) as affected by different treatments.

Fertility levels (kg/ha) (F)				Weeding intervals (W)						Mean
				W_1	W_2	W_3	W_4	W_5	W_6	
		1975								
N	P	K								
25	12.5	12.5	(F_1)	3121	3232	3409	2151	2404	1945	2710
50	25	25	(F_2)	5385	3845	5042	3739	2830	2500	3800
75	37.5	37.5	(F_3)	5385	5848	5752	4212	3252	2933	4564
100	50	50	(F_4)	5344	5970	5773	4949	3440	2994	4742
Mean				4833	4698	4994	3763	2981	2592	
C.D. (P=0.05)					F	W	F x W			
					655	477	950			
		1976								
F_1				2442	2703	3156	1928	1801	1670	2283
F_2				2717	3331	4191	2442	2144	1897	2784
F_3				3320	4140	4644	2524	2662	2288	3263
F_4				3468	4655	5082	3018	2342	2425	3532
Mean				2987	3707	4268	2478	2287	2070	
C.D. (P=0.05)					F	W	F x W			
					108	200	402			

Moisture regimes differed significantly in 1976 only. Other interactions were not significant.

Results of sorghum grain yield in 1975 and 1976 are presented in Table 4. As the trend was same, the results are discussed averaged over two years. Grain yield increased significantly with increase in fertility levels, except being non-significant between F_3 and F_4 in 1975. The grain yield of irrigated sorghum was significantly more than (3162 kg/ha) non-irrigated sorghum (2768 kg/ha) only in 1976 season. The plots kept weed free for first 30, 60 and till harvest gave 67.7, 80.3 and 98.7% increase in rain yield as compared to no weeding till harvest. On the other hand, 37.6%, 43.1% and 49.6% reduction in sorghum grain yield was observed due to no weeding upto 30, 60 and upto harvest respectively in comparison to weed free till harvest. This indicated that severe competition existed for first 30 days of sowing, confirming the earlier findings in the first experiment.

The interaction between fertility levels and weeding intervals was significant. The increase in fertility levels coupled with increase in weed free period recorded higher yields, whereas at the higher fertility levels accompanied by lesser weed free period gave lower yield. This result indicated that even at higher fertilisation, weeds compete strongly for essential nutrients and suppress the growth of sorghum crop resulting in lower yield.

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CRITICAL STAGE FOR WEED COMPETITION IN SOYBEAN, GROUNDNUT AND MAIZE

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ABSTRACT

Experiments were conducted during *kharif* 1978 and 1979 on red sandy loam soils to know the critical period of weed competition in soybean [*Glycine max* (L.) Merrill.], groundnut (*Arachis hypogæa* L.) and maize (*Zea mays* L.). Weed free periods were compared with the normal practice and unweeded control. Soybean and maize need a weed free period of first 30 to 40 days of sowing to obtain higher grain, while groundnut needs 40 to 50 days of sowing. Further, this critical period of crop weed competition varied depending on the plant type. In groundnut, BH-8-18 being semi-spreading in nature reduced weed growth than erect type TMV-2. Similarly lower weed dry weight was observed in Deccan 101 in maize and KHS 36-4 in soybean. Thus, plants with better coverage of canopy appeared to lessen weed growth. Weed competition reduced dry matter production/plant, dry matter distribution to economic part (in soybean and maize), pods/plant (in soybean), grains/cob (in maize) and individual grain weight (in soybean and maize). Besides, weed competition reduced the nitrogen yield in these crops.

Normal practice of hœing followed by hand weeding on 30 to 35 days after sowing in soybean and groundnut needs a supplemental weeding during early phase of crop growth. In maize such effects was not observed.

INTRODUCTION

Weeds cause severe competition to crops which lower the yield. Losses caused by weeds to the crops vary with intensity, nature of weeds and stage of the crop growth. Based upon these factors, weed crop competition has been estimated to reduce the yield of corn by 33 to 72% (Nizamuddin and Rehman, 1960), 18 to 52% in groudnnut (Kulkarni *et al.*, 1963) and 11 to 50% in soybean (Bhan, 1976). Further, weed crop competition in early stages of crop growth is harmful to crops. Therefore field studies were planned to know the critical period of weed competition in soybean, groundnut, maize and the relationship of plant types on weed competition.

MATERIAL AND METHODS

The experiments were conducted during *kharif* 1978 and 1979 on red sandy loam soil of average fertility. The treatments consisted of two varieties in each crop compared at different weed free periods (treatment details in Table 1). These treatments were compared with the normal practice (hœing followed by hand weeding on 30 to 35 DAS) and unweeded control. A common dose of fertilizer of 25 kg/ha each of N, P_2O_5 and K_2O in soybean, 25N, 50 P_2O_5 and 25 K_2O kg/ha in groundnut and 100N, 50 P_2O_5 and 25 K_2O kg/ha in maize were applied. A common row spacings of 30 cm with 10 cm between plants in soybean, groundnut and 30 cm between plants in rows kept apart at 60 cm

Table 1 : Effect of different weed free periods on yield (kg/ha) of soybean, groundnut and maize genotypes during *kharif* 1978 and 1979

Treatments	Seed yield of soybean		Pod yield of groundnut		Grain yield of maize	
	1978	1979	1978	1979	1978	1979
Weed free periods for first						
20 days	855	750	378	687	3726	1593
30 "	1108	913	1178	978	4288	1955
40 "	1089	1056	1480	1362	4068	2066
50 "	1112	1054	1575	1359	3998	2041
60 "	1117	1035	1685	1495	4687	2391
* 70 "	—	—	—	—	4059	2386
Normal practice	1012	654	516	521	4415	2255
Weed free throughout	1173	944	1594	1458	5108	2505
Unweeded check	519	500	172	378	3356	1436
C. D. (P=0.05)	345	168	419	300	N. S.	665
Varieties						
V_1	915[a]	788[a]	1067[a]	1007[a]	4226[a]	1959[a]
V_2	928[a]	938[b]	1077[a]	1068[a]	4154[a]	2169[a]

V_1 and V_2 denote – Hardee and KHS-36-4 in soybean; TMV-2 and BH-8-18 in groundnut; and Deccan hybrid and Deccan 101 in maize, respectively.
* 70 days weed free in maize only.
Treatment averages followed by the same letter indicate non-significance at 5% level.

in maize were followed. The plot sizes were 3.0 m x 3.0 m in soybean, groundnut and 6.0 m x 3.0 m in maize. For convenience, the data on yield components and weed dry weight for *kharif* 1979 are presented.

RESULTS AND DISCUSSION

Soybean

Between varieties, KHS 36-4 was superior to Hardee with regard to seed yield (Table 1) mainly because of better yield components (Table 2). KHS-36-4 besides possessing higher dry matter (4.3 g/plant) also had significantly higher dry matter distribution to seeds (72.4%) indicating higher efficiency in converting dry matter to economic seeds than Hardee (3.8 g/plant and 69.4%). However, lower 100 seed weight than Hardee may be due to limitation of sink size. Further, weed dry weight was lower in KHS-36-4 on 53rd DAS than Hardee indicating varietal difference in smothering weed growth (Table 3).

Increasing the weed free period upto 30 to 40 days increased grain yield significantly due to improvement in the yield/plant owing to increased number of pods/plant. Besides, it improved the dry matter production/plant and percent dry matter distribution into seeds which enhanced 100 seed weight. Weed free period beyond 40 days did not improve yield. This indicates eliminating weed competition during initial 40 days improved the potentiatlity of the plant to produce more dry matter and improve the efficiency of the plant by way of increasing the sink size. This is evident from the higher negative relationship between dry matter on 53rd day with seed yield/plant (-0.56**) than at harvest (-0.51**).

Table 2 : Effect of different weed free periods on yield components of soybean, groundnut and maize genotypes during *kharif* 1979

Treatments	Soybean			Groudnut			Maize	
	Seed yield g/plant	No. of pods/ plant	100 seed wt (g)	Pod yield/ plant (g)	Pods/ plant	100 kernal wt (g)	Grain yield/ plant (g)	1000 grain weight (g)
Weed free periods for first								
20 days	6.74	26.56	12.00	6.45	6.40	23.04	94.2	220
30 "	8.43	30.33	12.00	10.35	7.78	25.29	104.7	225
40 "	8.58	30.00	12.41	12.51	9.53	25.29	103.0	268
50 "	9.78	32.23	13.25	11.41	11.50	25.33	115.7	247
60 "	8.75	30.66	13.41	12.33	9.55	27.41	115.3	238
70 "	—	—	—	—	—	—	118.0	246
Normal practice	6.90	25.89	12.74	5.82	7.23	25.33	125.3	252
Weed free throughout	9.05	28.41	13.79	11.35	10.15	27.10	114.3	231
Unweeded check	5.39	20.36	11.37	3.68	5.07	20.40	52.8	196
C. D. (P=0.05)	1.80	4.20	1.49	2.38	4.14	1.12	14.5	18
Varieties								
V_1	6.80[a]	24.56[a]	13.81[b]	8.53[a]	7.08[a]	20.69[a]	105.3[a]	232[a]
V_2	19.10[b]	31.54[b]	11.43[a]	9.95[b]	9.72[b]	29.11[b]	108.6[a]	240[a]

Table 3 : Effect of different periods in weed competition on weed dry weight of soybean, groundnut and maize genotypes (g/0.5 m^2) during *kharif* 1979

Treatments	Soybean		Groundnut		Maize	
	53 DAS	At harvest	65 DAS	At harvest	60 DAS	At harvest
Weed free periods for first						
20 days	6.35 (39.6)	7.95 (62.7)	8.44 (70.33)	7.74 (59.4)	6.21 (38.0)	8.27 (67.7)
30 "	4.79 (12.2)	5.50 (29.6)	4.66 (20.85)	6.47 (41.9)	4.00 (15.3)	6.97 (48.2)
40 "	3.18 (9.3)	4.70 (21.7)	5.58 (12.15)	5.18 (26.2)	2.87 (7.4)	5.51 (29.8)
50 "	1.00 (00.0)	4.30 (18.0)	2.53 (5.50)	4.74 (21.9)	1.79 (2.3)	4.56 (20.0)
60 "	1.00 (00.0)	3.22 (9.5)	1.50 (1.35)	4.61 (20.6)	1.00 (00.0)	4.10 (16.4)
70 "	—	—	—	—	1.00 (00.0)	3.54 (12.8)
Normal practice	4.45 (19.2)	5.78 (32.8)	4.62 (20.55)	6.21 (38.5)	2.67 (6.2)	5.97 (34.5)
Weed free throughout	1.00 (00.0)	1.00 (00.0)	1.00 (00.0)	1.00 (00.0)	1.00 (00.0)	1.00 (00.0)
Weedy check	9.27 (85.4)	9.48 (90.1)	11.53 (273.25)	8.87 (78.2)	8.27 (68.1)	10.11 (101.1)
C. D. (P=0.05)	0.49	0.77	0.57	0.53	0.31	N.S.
Varieties						
V_1	3.99[a] (23.3)	5.23[a] (26.3)	4.87[a] (69.78)	5.74[a] (37.7)	3.35[a] (17.2)	5.60[a] (37.6)
V_2	3.76[a] (20.7)	5.24[a] (26.4)	4.59[a] (31.23)	5.47[a] (33.9)	3.28[a] (13.3)	5.51[a] (35.4)

Data analysed using $\sqrt{x+1}$ transformation, values within the parentheses are original figures.

Groundnut

Between varieties, BH-8-18 produced slightly more pod yield than TMV-2 due to more pods/plant and higher 100 seed weight. Added to this, total dry matter production was also higher in BH-8-18 (21.5 g/plant) than TMV-2 (13.8 g/plant). The better expression of BH-8-18 in yield components was due to lower weed dry weight as a result of lower weed number particularly monocots right from early period of crop growth. BH-8-18 being semi-erect might have suppressed the weed growth and eventually had better expression of growth and yield. While TMV-2 being erect did not appear to have suppress the weed growth.

Among weed free periods, plot kept weed free for first 40 days gave higher pod yield which was comparable to pod yield in weed free period beyond this period. This indicates that groundnut needs a weed free period of first 40 days of sowing for realising higher pod yield. Increasing weed free period increased pods/plant due to more branches/plant and 100 seed weight due to more dry matter production. All this improvement was due to elimination of weed competition as evident from significantly lower weed population particularly monocots. Weed competition curtailed plant growth by reducing plant dry matter which reduced the pods/plant and 100 seed weight. This indicates that weed competition curtails both sink number and sink size in groundnut.

Maize

Deccan 101 performed better than Deccan hybrid mainly due to superior yield components which was a reflection of lower weed population as well as weed dry weight indicating the differences in plant stature and leaf alignment. Deccan 101 is reported to have wider leaf area above the cob and more leaf angle than Deccan hybrid. Perhaps due to better coverage of land by the foliage, the weed dry weight as well as weed population was lower in Deccan 101 than Deccan hybrid. Reducing the weed dry weight increased the plant performance in terms of both biological yield (total dry matter production) and economic yield (seed yield) as evident from significant relationship observed between grain yield/plant with weed dry matter on 53rd day (-0.61**) and at harvest (-0.33*), total plant dry matter with weed dry matter at harvest (-0.70**).

Increased grain yield due to weed free period was due to higher grain yield/plant owing to more cobs/plant with higher seeds of larger size. This higher grain seed weight was perhaps due to higher dry matter production/plant as a result of reduced weed competition as evident from lower weed dry matter.

The total amount of N removed by maize grain was 105.8 kg/ha when the crop was weed free throughout. On the other hand when the plot was kept weedy throughout, the N content in the grains/ha was 53.4 kg. Similarly, the total N content in the pods of groundnut in weedy and weed free plots were 4.5 and 68.6 kg/ha respectively. In soybean, the total N content in the grains in the weedy and weed free treatments were 5.5 and 50.6 kg/ha respectively. This indicates weed competition reduced the nitrogen yield in these crops.

For getting higher yield, soybean and maize need a weed free for first 30 to 40 days of sowing and groundnut 40 to 50 days of sowing. Crop weed competition varied depending on the plant type besides it reduced the protein yield of soybean, groundnut and maize.

ACKNOWLEDGEMENTS

This study forms part of the research work conducted in the ICAR Project on

All India Coordinated Research Programme on Weed Control (In-ARS-47) funded by PL-480 (FG.In.562). Authors are thankful to the funding agency and the University of Agricultural Sciences, Bangalore, for the necessary facilities.

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STUDIES ON NITROGEN ECONOMY IN WHEAT THROUGH EFFICIENT USE OF WEED CONTROL MEASURES

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ABSTRACT

In a field investigation in 1978 and 1979 at Kanpur, India, it was revealed that the application of methabenzthiazuron 1.4 kg/ha after two days of sowing provided an excellent weed control including *Phalaris minor* Retz. and *Chenopodium album* L. without any phytotoxic effect on wheat crop. Metoxuron 1.0 kg/ha at 30-day stage of crop showed cent per cent mortality of *Phalaris minor* and other broad-leaved weeds with a slight injury to wheat crop which recovered within a week. Both the herbicides, gave 13% and 11% more yield than weedy check and hand weeded crop, respectively. Grain production at 80 kg N/ha, in the absence of weed (manual or chemical weeding) was as high as obtained with the application of 120 kg N/ha in the weedy check. The economic optimum levels of N for methabenzthiazuron, metoxuron and hand weeded were computed to be 106.8, 96.4 and 106.4 kg/ha respectively.

INTRODUCTION

Weeds growing in association with the crop surpingly utilize considerable amount of nutrients and deprives the opportunity of the crop to elicit their yield potential. The National Coordination Committee on efficient use of inputs stated in Delhi during April, 1974 that weeds take about 30-40% plant nutrients applied to the crops (Dryden and Krishnamurthy, 1977). This indicated the possibility of saving substantial amount of nutrients through efficient weed management. The present investigation was attempted in this direction in wheat.

MATERIAL AND METHODS

A field investigation was carried out at Student's Instructional Farm of C. S. Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India during winter 1978 and 1979. The treatments were compared in split-plot design replicated thrice, keeping four weed management practices viz., weedy check, manual weeding (once) by *Khurpi*, methabenzthiazuron [1-(benzothiazol-2-y1)-1, 3-dimethylurea] 1.4 kg/ha and metoxuron [N-(3-Chlro-4-methoxyphenyl)-N,N-dimethylurea) 1 kg/ha in main plots and five levels of N through urea namely 0, 40, 80, 120 and 160 kg N/ha in subplots. An early maturing wheat cultivar K-816 was sown on Dec. 20 in 1978 and Dec.25 in 1979 after giving pre-sowing irrigation. The seeds were drilled behind country plough at 20 cm inter-spaces. Entire dose of 80 kg P_2O_5/ha through single superphosphate and 40 kg K_2O/ha through muriate of potash along with 50% of N was placed in furrows through seeding spout fitted with country plough. The remaining N was top-dressed after first irrigation.

The soil of the experimental site was sandy loam in texture, low in N, medium in P and fairly rich in K. Methabenzthiazuron was sprayed as pre-emergence two days after sowing (DAS) whereas metoxu-

Table 1 : Weed dry matter yield (kg/ha) at 70 DAS as influenced by weed management and N-levels

Treatments	Dry matter 1978	kg/ha 1979
Weed management (w)		
Weedy check	879	1181
Methabenzthiazuron	256	168
Metoxuron	65	75
Hand Weeding (once)	60	65
C. D. (P=0.05)	73	78
N-levles, kg/ha (N)		
0	177	186
40	218	267
80	309	374
120	430	460
160	440	573
C. D. (P=0.05)	65	132

Interaction was significant in both the years

ron was applied at post-emergence 30 DAS. BAKPAK sprayer fitted with WFN-78 nozzle was used with a solution of 1000 l/ha to pre-emergence and 600 l/ha to post-emergence spray. Observations on weed number and dry matter were made from the randomly located quadrates each m^2 in all plots.

RESULTS AND DISCUSSION

Weed studies

Among weed species, *Phalaris minor* Retz., was predominent constituting 65% of weed intensity. Other species observed were *Anagallis arvensis* L. (13.05%), *Chenopodium album* L. (7.52%), *Sinberia pinatifoda* (6.19%), *Spergula fallax* Krause (3.98%), *Melilotus abla* Desr. (2.43%) and *Asphodelus tenuifolius* Cavan (1.99%). *Cynodan dactylon* (L.) Pers., was also found in patches in some of the treatments during 1979.

The dry matter accumulation of weeds was remarkably extenuated due to the herbicidal application (Table 2). Application of methabenzthiazuron and metoxuron proved quite effective against *P. minor* along with broadleaved weeds and regis-

Table 2 : Grain yield of wheat (kg/ha) as influenced by weed management and N-levels

Weed management practices (W)	Nitrogen (kg/ha) (N) 0	40	80	120	160	Mean
			1978			
Weedy check	916	1066	1583	2250	2816	1785
Methabenzthiazuron (1.4 kg/ha)	1366	2133	3050	3133	3080	2552
Metoxuron (1 kg/ha)	1533	2216	2950	2866	2816	2476
Manual weeding (once)	1166	1600	2383	2910	2533	2118
Mean	1245	1754	2491	2864	2811	
	W		N	W x N	N x W	
C.D. (P=0.5)	219		224	248	468	
			1979			
Weedy check	560	1385	2321	2695	1710	1734
Methabenzthiazuron (1.4/kg/ha)	978	1830	2830	2715	2545	2179
Metoxuron (1 kg/ha)	1080	2063	2755	2525	2421	2169
Manual weeding (once)	855	1580	2685	2434	2283	1967
Mean	868	1714	2647	2592	2239	
	W	N	W x N	N x W		
C.D. (P=0.05)	195	143	287	325		

tered herbicidal efficiency > 90%. *Phalaris* plants at 2-3 leaf stage became flaccid which finally dried up followed the application of metoxuron. Death of dicot weeds as well as *Phalaris* was accomplished in about 10 days. The crop foliage expressed early phytotoxicity to metoxuron which was detoxified rapidly and recovered within a week. Manual weeding (once) could not be proved successful like chemical due to the morphological similarity between crop and *Phalaris* plants particularly in intraspaces of crop rows. Application of varying levels of N led to a linear increase in dry matter content during both years of investigation.

The interaction between weed management and levels of nitrogen was found significant during both years. It was observed that dry matter content of weeds was spectacularly high at all levels of N in weedy check as compared to treated plots during entire span of investigation.

Effect on grain yield

The application of methabenzthiazuron 1.4 kg/ha and metoxuron 1.0 kg/ha registered 13% more yield than weedy check and 11% more than manual weeding plots (Table 3). The higher yield in herbicide treated plot was due to better control of weeds including *Phalaris minor*. The yield obtained under manual weeded plots was significantly lower as compared to treated plot owing to lack of elimination of morphologically similar *Phalaris* plants completely particularly from intraspaces. Appliction of N registered a corresponding increase in grain yield upto 120 kg N/ha during 1978 and 80 kg N/ha during 1979. Beyond these levels the response ceased.

The interaction between weed control measures and level of N was found significant during both the years. Grain production at 80 kg N/ha in the absence of weeds (chemical and manual) was as high as that received under high level of N (120 kg/ha) in the presence of weeds (weedy check).

Response function

The regression between doses of N and grain yield of wheat was worked out separately for each weed management practices on the basis of mean data of two years (Table 3). The response was quadratic in nature. The equations computed suggested a better response to N under treated plot due to the effective weed control.

Metoxuron (1.0 kg/ha) showed the maximum response to N application fol-

Table 3 : Regression equations, N optima and response per kg of nitrogen in different weed management practices

Weed management	Regression equation	N optima (kg N/ha)	Response (kg grain) per kg of N
Weedy check	$y = 8.79 + 9.44x - 1.25x^2$	126.8	20.98
Methabenzthiazuron (1.4 kg/ha)	$y = 11.20 + 12.26x - 2.01x^2$	106.8	27.99
Metoxuron (1 kg/ha)	$y = 13.02 + 10.86x - 1.92x^2$	96.4	29.43
Manual weeding (once)	$y = 12.25 + 10.99x - 1.78x^2$	106.4	27.45

Note: Purchase price of N and sale price of wheat grain have been considered at Rs. 4.50/kg and Rs. 120/100 kg respectively.

lowed by methabenzthiazuron (1.4 kg/ha) and manual weeding (once). Economic optimum doses of N were computed to be 106.8 kg, 96.4 kg, 106.4, and 126.8 kg/ha respectively for methabenzthiazuron, metoxuron, manual weeding and weedy check. Thus, a saving of about 20 to 30 kg N/ha could be made through herbicides in comparison to weedy check in wheat.

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NUTRIENT REQUIREMENTS FOR RAINFED AND IRRIGATED GROUNDNUT UNDER DIFFERENT LEVELS OF WEED MANAGEMENT

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ABSTRACT

Nutrient requirements to produce a quintal of groundnut pods under rainfed and irrigated conditions varied widely due to different levels of weed management. NPK requirement under rainfed conditions to produce a quintal of pods was 18.5, 2.34 and 6.40 kg under unweeded conditions and 7.01, 0.56 and 1.26 kg under weed free conditions. In an irrigated crop the NPK requirement per quintal of pods was 5.04, 1.06 and 2.71 kg without weeding and 4.49, 0.91 and 1.59 kg with weeding. Manual or chemical weeding were equally effective. Nutrients' productive efficiency was higher due to weeding under dryland conditions than under irrigated conditions emphasising the need for effective weed control under drvland conditions.

INTRODUCTION

Efficient weed control is an essential prerequisite for increasing crop productivity. Groundnut (*Arachis hypogea* L.) crop removes 63.0 N, 4.8 P and 38.2 K kg for every one tonne of unshelled nuts and two tons of haulm (Collins and Morris, 1941). Weeds are major competitors for nutrients and efficient weed control increases crop yields (Mani, 1973). The nutrient requirements for rainfed and irrigated groundnut under different levels of weed management was studied from the data of two experiments conducted at the Tirupati Campus of Andhra Pradesh Agricultural University, India.

MATERIAL AND METHODS

The experiments were conducted on TMV 2 spanish groundnut one in rainfed in monsoon 1975 and the other in irrigated in summer 1977. The first experiment was primarily designed to study the crop-weed competition effects on rainfed groundnut (Naidu, 1977) and the second on the effect of presowing, pre-emergence and post-emergence weed control methods in irrigated groundnut (Seshaiah, 1978). The NPK uptake by the crop and weeds was calculated and for the purpose of this paper only the data relevant to NPK uptake by the crop and weeds in unweeded and weed free environment are presented.

RESULTS AND DISCUSSION

The data relating to pod, haulm yield and NPK uptake by the crop and weeds and nutrient requirements to produce one quintal of pods in unweeded and weed free crop under rainfed and irrigated conditions are presented in Table 1.

Nitrogen requirements to produce a quintal of pod was highest followed by K and least for P irrespective of weed management both under rainfed and irrigated conditions. Nitrogen requirement to produce a quintal of pods under rainfed con-

Table 1: Nutrient removal by groundnut and weed (kg/ha), and nutrients required to produce a quintal of pods.

Levels of Weed management	Rainfed									Irrigated								
	Crop			Weeds			Total			Crop			Weeds			Total		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
UNWEEDED																		
Nutrient removal	48.3	1.9	6.7	39.0	9.1	23.5	87.3	11.0	30.2	60.1	11.0	19.6	14.7	4.6	20.7	74.8	13.6	40.3
Yield (kg/ha)	(P) 470	(H) 826			(W) 3050					(P) 1483	(H) 2010			(W) 1123				
Nutrients required (kg) to produce a quintal of pods	–	–	–	–	–	–	18.50	2.34	6.40	–	–	–	–	–	–	5.04	1.06	2.71
WEED FREE																		
(Hand weeding) Nutrient removal	81.0	6.0	11.1	11.0	1.3	5.5	92.0	7.3	16.6	115.0	23.0	39.8	1.2	0.5	1.6	116.62	23.5	41.4
Yield (kg/ha)	(P) 313	(H) 1298			(W) 512					(P) 2596	(H) 3671			(W) 101				
Nutrient required (kg) to produce a quintal of pods	–	–	–	–	–	–	7.01	0.56	1.26	–	–	–	–	–	–	4.49	0.91	1.59
(Chemical weeding) Nutrient removal	–	–	–	–	–	–	–	–	–	128.3	24.6	37.6	3.9	1.4	5.1	132.2	26.0	42.7
Yield (kg/ha)										(P) 2760	(H) 3051			(W) 138				
Nutrients required (kg) to produce a quintal of pods	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4.79	0.94	1.55

P: Pods, H: Haulm, W: Weed

dition in a weedy crop (where weed dry matter was 3,050 kg/ha) was 18.5 kg and the same quantity of pods could be produced with only 7.01 kg of N in weed free crop (where the weed dry matter was 512 kg/ha) which amounts to an increase in efficiency by 263%. In irrigated crop the nitrogen requirement was 5.04 kg under weedy condition (where weed dry matter was 1,123 kg/ha) and 4.49 kg under weed free condition (where weed dry matter was 101 kg/ha) giving an efficiency of 112%. The requirement of phosphorus under unirrigated condition in weedy crop was 2.34 kg as against 0.56 kg in weed free crop giving an efficiency of 421% whereas under irrigated condition it was 1.06 kg under weedy condition and 0.91 kg under weed free condition resulting in an efficiency of 116%. The potassium requirement under rainfed condition was 6.40 kg for a quintal of pod under weedy condition and 1.26 kg under weed free condition giving an efficiency of 507%. This was 2.71 kg and 1.59 kg respectively for weedy and weed free irrigated crop giving an efficiency of 170%. Manual weeding or chemical weeding gave almost the same efficiency (Table 1), provided the weed control by herbicides was satisfactory.

The study indicated that productive efficiency of nutrients is enhanced considerably by the removal of weeds. The productive efficiency in weed free environment was very high under rainfed conditions for K followed by P and N. The same trend was seen though to a lesser magnitude under irrigated condition. A great emphasis is therefore necessary on thorough weeding in groundnut crop under rainfed condition when costly fertilisers are used. Incidentally this study indicated a possible reason for the conflicting responses of groundnut for NPK fertilization under rainfed condition. Thorough weeding or otherwise seem to have greater influence on the efficiency of the crop to utilise nutrients.

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EFFECT OF FERTILIZER AND HERBICIDAL INTERACTIONS ON SOIL MICROBIAL POPULATION AND NUTRIENT UPTAKE BY SOYBEANS

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ABSTRACT

A field investigation was carried out to study the fertilizer and herbicidal interactions on soil microbial population and nutrient uptake by soybean crop and weeds under recommended and 75% recommended fertilizers in combination with four weed control treatments.

The bacterial, fungal and actinomycetes population were affected considerably upto 45th day after spraying, alachlor and metribuzin. The two herbicides did not appear to have any adverse effect on the microbial populations in subsequent period. There were no significant differences in microbial population when treated with recommended and 75% of the recommended dose of fertilizer upto 30th day. At 45th day, 75% of recommended dose had higher population of bacteria and actinomycetes. In general, fungal population was inhibited upto 45th day of the crop in both the levels and recovered at harvest.

Uptake of N, P_2O_5 and K_2O was higher in the recommended dose of fertilizer compared to 75% of fertilizer dose in all the treatments. Herbicidal treatments greatly increased the uptake of nutrients by the crop even upto 50% more than the control. This trend was inferred to be because of the fact that the herbicidal treatments reduced the weed flora effectively and thus reduced the uptake of nutrients by the weeds proportionately.

INTRODUCTION

Weed infestation resulting in competition with the crop for nutrients, water and light is one of the important factors bringing down the soybean yields. Effective control of weeds can also minimise the use of costly input of fertilizers on the one hand and enhance the uptake of nutrients by the crop on the other. However, pre-emergence application of herbicides to control weeds may have secondary influence on the microbial population as well as on the nodulation of the pulses. Milika *et al.* (1972) reported that alachlor applied before sowing tended to inhibit nodulation and root growth. While Baltazar (1976) noticed that soybean plants sown directly after trifluralin incorporation at 1 to 2 kg/ha had few nodules and only negligible amount of N fixed. However, Velev and Rankov (1977) observed no substantial or lasting changes in soil biological activity with metribuzin at 0.75 kg/ha. The present investigation was carried out to study the uptake of nutrients by crop and weeds and to evaluate the fertilizer and herbicidal interactions at the recommended and 75% of the recommended dose of fertilizers on soil microbial population and nodulation characteristics in soybean.

MATERIAL AND METHODS

The field experiment was conducted at the Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore

Table 1: Uptake of nutrients by weeds (kg/ha) and soybean (kg/ha) as affected by different weed control methods at two levels of fertilizers

Treatments	Weeds			Crop		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Weed control methods						
Unweeded control	31.56	15.27	70.93	106.56	18.88	46.14
Hand weeding twice (20 & 40 DAS)	19.14	12.76	49.45	145.99	29.13	71.20
Alachlor 2.5 kg a.i./ha	13.47	9.05	43.67	145.85	28.71	70.18
Metribuzin 1.0 kg a.i./ha	15.87	9.00	50.85	139.30	28.24	69.02
C. D. (P = 0.05)	3.32	3.37	4.14	3.16	0.34	0.84
Fertilizer levels						
Recommended dose	21.58	12.22	55.45	137.71	26.51	64.63
75% Recommended	18.44	10.82	52.00	131.13	26.03	63.63
C. D. (P = 0.05)	2.35	–	2.93	2.23	0.24	0.60

Interaction differed significantly at 5% level in all the above cases.
Recommended dosage is 37.5 kg each of N, P_2O_5 and K_2O/ha.

during summer 1979 on a red sandy loam having a pH of 5.7 and with low status of organic carbon (0.23%), available N (0.0109%) and P_2O_5 (0.001%). The eight treatments (Table 1) were repeated four times in a Randomized Block Design. The pre-emergence application of alachlor and metribuzin was done a day after sowing. Hardee variety of soybean treated with *Rhizobium* was planted in rows 30 cm apart with a 10 cm spacing between plants. Fertilizers as per the treatment schedule were applied at the time of sowing.

Data on nodule count and dry weight of nodules of soybeans, grain yield and other attributes of the crop were collected. Soil microbial populations were estimated by dilution plate method (Allen, 1953). Crop and weed samples collected for dry matter estimation were used for nutrient uptake studies.

RESULTS AND DISCUSSION

The predominant monocot weeds in the experimental site were *Cynodon dactylon* Pers. *Cyperus rotundus* L., *Echinochloa colonum* L., *Setaria glauca* Beauv., and *Dactyloctenium ægyptium* P. The dicot weeds were *Acanthospermum hispidium* DC., *Amaranthus viridis* L., *Achyranthes aspera* L., *Bidens pilosa* L., *Euphorbia hirta* L., *Leucas aspera* Spreng., *Phyllanthus niruri* L., *Portulaca oleracea* L. and *Tridax procumbens* L.

Effect of weeds on the uptake of nutrients

Weed flora with the recommended dose of fertilizers being more, absorbed significantly higher N and K_2O than those under 75% of the recommended dose of fertilizers (Table 1). The loss of nutrients due to weeds was as high as 32 N, 15 P_2O_5 and 71 K_2O kg/ha. It could be inferred that without proper weed control enormous loss of nutrients to the extent of more than 100% N, 66% P_2O_5 and 40% K_2O was observed compared to those obtainable in weed control treatments by herbicides.

Uptake of nutrients by the crop was significantly higher under the recommended doses of fertilizers than with constraint level of 75% of the recommended dose

Table 2 : Nodule number and dry weight (g/plant) of soybean in relation to weed control treatments at two levels of fertilizers

Treatments	Days after sowing: Nodules		Dry weight	
	20	40	20	40
Weed control methods				
Unweeded control	19.38	25.38	17.69	118.33
Hand weeding twice	19.13	26.50	19.07	129.34
Alachlor 2.5 kg/ha	15.63	19.00	10.26	92.66
Metribuzin 1.0 kg/ha	8.63	15.75	8.05	95.46
C. D. (P = 0.05)	2.81	4.50	2.53	13.14
Fertilizer levels				
Recommended dose	15.13	20.50	13.73	107.45
75% of recommended	16.25	22.81	13.80	110.44
C. D. (P = 0.05)	–	–	–	–

Interaction differed significantly at 5% in all the cases

(Table 1). This was due to availability of more nutrients at higher fertility levels. Uptake of the nutrients by the crop was also higher with weed control treatments than found with weedy checks. The two herbicides effected an overall efficiency by increasing the N uptake by about 40% and P_2O_5 and K_2O uptake by about 55%. Hamed (1977) reported that proper weed control increased the N uptake from 29 to 65 kg N/ha. While Mathan *et al.*(1976) observed increase in exchangeable K in the soil with the use of higher doses of alachlor. In the present investigation too, increased uptake of nutrients by the crop was a direct consequence of less weed competition and better root growth. Correlation studies indicated a negative relationship between N, P_2O_5 and K_2O uptake by the crop and weeds (–0.637*, –0.383* and –0.840**). Thus, increase in nutrient uptake by the soybean crop was due to decrease in nutrient uptake by the weeds indicating improved fertilizer use efficiency by efficient weed control.

Effect of herbicides on nodulation

Nodule counts and dry matter weight of nodules were unaffected by fertilizer levels. There were also no differences between unweeded control and hand weeding in nodule numbers but the dry weight of nodules was higher in hand weeded plots (Table 2). Herbicides, particularly metribuzin drastically reduced both the number and dry weight of nodules. On the 20th day after sowing the dry weight of nodules in hand weeded treatment was nearly two fold that of the herbicidal treatments. On the 40th day, this difference was narrowed down and there was just an improvement in dry weight of nodules with about 30% increase in hand weeded plots over the herbicidal treatments. Milika *et al.* (1972) also reported that alachlor applied before sowing tended to inhibit nodulation and root growth. These data indicate that an important process of symbiotic nitrogen fixation is initially affected through pre-emergence application of herbicides but with time there appears to be a good recovery in the dry weight of nodules.

Effect of herbicides on microbial populations

Herbicides alachlor and metribuzin

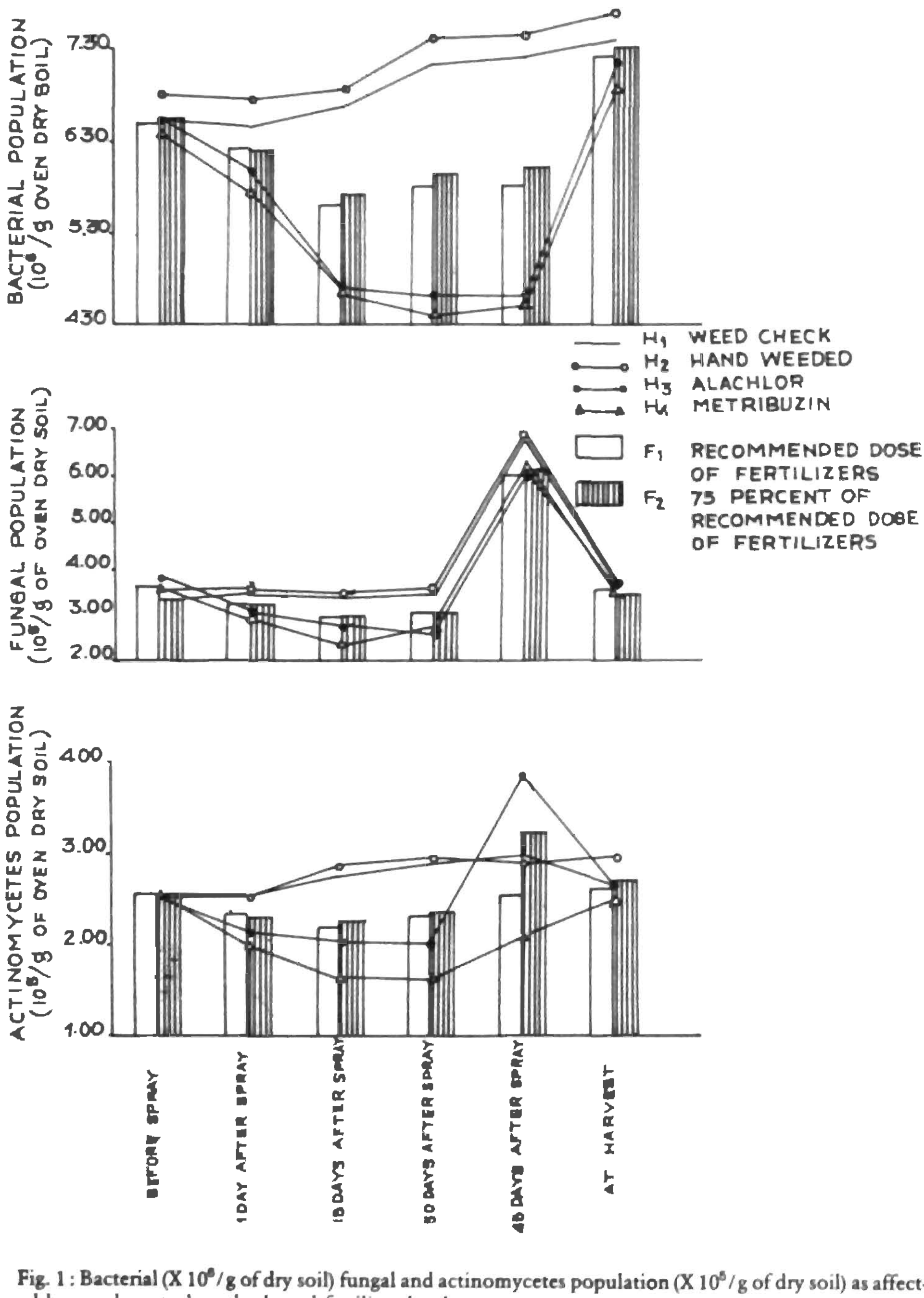

Fig. 1 : Bacterial (X 10^6/g of dry soil) fungal and actinomycetes population (X 10^5/g of dry soil) as affected by weed control methods and fertilizer levels.

Table 3 : Grain yield of soybean (kg/ha) in relation to weed control treatments at two levels of fertilizers

Weed control methods (W)	Fertilizer dose (F)		Mean
	Recommended dose	75% Recommended dose	
Unweeded control	1293	1290	1292
Hand weeding at 20 and 40 days after sowing	1978	1937	1958
Pre-emergence application of alachlor at 2.5 kg a.i./ha	1974	1941	1958
Pre-emergence application of metribuzin at 1.0 kg a.i./ha	1932	1919	1926
Mean	1794	1772	
C. D. (P = 0.05) W	F	W x F	
33	NS	46	

drastically reduced the bacterial populations between the 15th and 45th day after spray and the fungal and actinomycetes populations between the 15th and 30th day after the spray (Fig. 1). This indicated that immediately after herbicide application, microbial populations in the soil received a set back because of the disturbed soil chemical environment. This set back was however overcome by soil micro-organisms later and they started growing normally. Metribuzin affected the soil microflora more than alachlor. Rankov and Velev (1976) observed similar results with metribuzin with concentration of more than 3.5 mg a.i. per 100 g of alluvial meadow soil inhibiting the propagation of soil micro-organisms for a short while. Enkina and Vasilev (1974) on the other hand found that alachlor did not adversely affect bacterial, actinomycetes and fungal populations but tended to increase the bacterial population. The present studies thus indicated that herbicides affected the propagation of soil micro-organisms adversely in the initial stages but the effect was overcome soon.

The effect of herbicides on nodulation in soybeans, soil microbial populations and the uptake of nutrients could be further judged from the yield data summarised in Table 3. Weed control treatments provided significantly higher yields over those with no control measures. There was a drastic reduction in yield by over 50% if weeds were not checked by either hand weeding or through herbicides. Severe competition for nutrients with the crop leading to loss of nutrients could be considered as the main reason for such a drastic reduction in yield in the treatments without weed control. Though nodulation and soil microbial populations were affected by herbicides in the initial stage of the crop, these were not reflected in the yield of soybeans. However, further investigations are needed to evaluate the extent to which nitrogenase activity of the nodules was affected by herbicidal application. Herbicides were however, largely helpful in eliminating competition for nutrients by the weeds and in improving the fertilizer use efficiency.

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CHEMICAL CONTROL OF WEEDS IN SUGARCANE

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ABSTRACT

Sugarcane production is largely influenced by early tillering and growth which is affected by competition through weeds. With increasing cost of labour and paucity of time, chemical weed control is becoming popular. However, the herbicides are to be used cautiously especially at the proper time and dosage depending on the variety based on tolerance study conducted elsewhere. There was significant negative association between weed dry matter and cane attributes. For highest cane production a weed free environment for at least 66 days is a must. It has been observed that many varieties are sensitive to even a slight higher dose. For sugarcane, in general, use of alachlor at 2.5 kg. a.i./ha or atrazine at 2.0 a.i./ha seems to be most effective and economical. Many varieties did not germinate when applied with diuron even at lower dose.

INTRODUCTION

The agronomic aspects of sugarcane production are directly influenced by weed competition. It has been estimated that weed competition causes 15% loss in the production of sugarcane. During early stage, weeds take advantage of soil fertility, space and moisture available in the soil and in severe weed competition ultimate loss in yield might touch 50%. With the intensive cultivation of crops, and labour becoming scarce, the use of herbicides has become more important in the commercial agriculture. Sugarcane, has been reported to be tolerant to many of the herbicides. However, the tolerance and response to a chemical used as a herbicide depend upon several characters such as crop, variety, soil condition, stage of application etc. A brief report of the work done on weed control in sugarcane is presented in this paper.

MATERIAL AND METHODS

Various experiments conducted at the Sugarcane Breeding Institute, Coimbatore from 1972-73 are grouped below:

(a) *Studies on crop weed competition and assessment of loss due to weeds*

The experiment was carried out with the variety Co 6304 in a sandy loam soil during 1977-78. The treatments consisted of unweeded check, weed free environment for the first 21, 36, 51, 66, 81 and 96 days. All the plots were given uniform weeding at 100th day and the crop was earthed up after the fertiliser application. The effect of weed competition on tillering, cane yield and sucrose percent were assessed.

(b) *Varietal tolerance to herbicides*

The experiment was laid out in split plot design with three replications. The main plot treatments were unweeded check, atrazine (Gosaprim 80 WP) at 2.4 and 9.6 kg a.i./ha., and diuron (Karmax 80 WP) at 2.4 and 9.6 kg a.i./ha. Ten varieties viz., Co 281, Co 449, Co 527, Co 658,

Table 1 : Effect of intensity of weed competition on tiller production and cane yield

Treatment	Weed dry matter kg/ha	Tillers /ha '00	Cane yield t/ha	Sucrose per cent juice
Unweeded control	8608	668	76.8	14.3
Weed free for				
first 21 days	7686	670	80.3	14.4
" 36 days	6386	848	84.6	15.1
" 51 days	4368	936	85.1	15.4
" 66 days	2686	1368	86.8	16.1
" 81 days	2365	1468	90.3	16.9
" 96 days	1668	1568	94.3	16.6
C.D. (P=0.05)	194	178	6.3	NS

Co 997, Co 1158, Co 1163, Co 1340, Co 62174 and BO 17 were tried as sub plot treatments. The herbicides were applied as pre emergence on third day after planting of sugarcane crop. The tolerance of the varieties to the herbicides at two levels was assessed by recording the final cane yield and quality.

(c) *Screening herbicides for weed management*

During 1977-79, newer herbicides viz., alachlor (2.5 kg a.i./ha), dosamine (5.0 kg a.i./ha), TBA with 2,4-D, fluchloralin (2.5 kg a.i./ha) were studied along with atrazine 2.0 kg/ha at Coimbatore and Amaravathi Co-op. Sugar Factory area. At Coimbatore the soil type was loamy with adequate irrigation facilities. The crop was raised during the main seasons 1977-78 and 78-79 with variety Co 6304 in RBD with three replications.

The trial was repeated at Amaravathi Sugar Factory area during 1977-78 main season and special seasons of 1977 and 78 with variety Co 6304. Simultaneously, granular formulations of dinitramine was compared with emulsified form in a separate trial. It was also compared with TBA application and hand weeding.

RESULTS AND DIŞCUSSION

(a) *Crop weed competition*

The major weeds observed in sugarcane field were *Achyranthes aspera* L., *Trianthema portulacastrum* L., *Alternanthera echinata* (Smith), *Gynandropsis gyonandra* L., and *Acalypha indica* L. (in dicots); *Cyperus rotundus* L. and *Cynodon dactylon* Pers. (among monocots).

Weed competition caused considerable yield losses (Table 1). The loss is mainly due to restriction on the tiller production. Tillering in sugarcane although a genetic factor is also largely influenced by environmental factors, such as light and temperature. Due to smothering effect of the weed *Trianthema portulacastrum* L., the light penetration on the germinated shoots as well as micro climatic temperature is lowered which resulted in poor tillering. Although sucrose per cent juice was not affected significantly, there is indication of better juice quality by keeping field weed free, during the early part of the crop growth. Thus, sugarcane needs a weed free period of 66 days after planting for better yield.

(b) *Relationship between population and weed dry matter with yield and quality of cane*

The data on the weed dry matter, weed population and yield from the trial

Table 2: Relationship of weed number and weed dry matter with cane attributes

Weed attribute	Cane attribute		Correlation coefficient	Regression equation
Weed number/m^2	Millable canes/ha	(x_1)	-0.6490*	101.78 - 0.2130 x_1
	Cane yield t/ha	(x_2)	-0.6965**	144.23 - 0.3712 x_2
	Sucrose per cent juice	(x_3)	-0.3953*	48.35 - 0.3953 x_3
	Sugar yield t/ha	(x_4)	-0.0900	-
Weed dry matter kg/ha		x_1	-0.6060**	90.93 - 0.0300 x_1
		x_2	-0.6590**	149.05 - 0.1785 x_2
		x_3	-0.7017**	16.74 - 0.0079 x_3
		x_4	-0.5078**	13.67 - 0.0036 x_4

on the suitability of various herbicides were used to work out correlation coefficients and regression equation (Table 2).

Both weed number and weed dry matter showed negative relationship with millable canes, cane yield, sucrose per cent juice and sugar yield. Further better relationship was observed with weed dry matter than weed number. The results have shown clearly that the suppression of sprouting and subsequent growth of weeds using pre emergence herbicides were more efficient than allowing the weeds to grow and their removal by hand weeding.

(c) *Differential tolerance of sugarcane varieties to herbicides*

Data on cane yield and sucrose per cent juice as influenced by the herbicide treatments of the ten varieties studied are presented in Table 3. Significant difference in cane yield was observed among the sugarcane varieties under different treatments. Both low and high doses of diuron reduced the cane yield significantly in Co 281, Co 449, Co 658, Co 1158, Co 62174, Co 1340, and high dose only in Co 997 and BO 17. Atrazine reduced the cane yield significantly in Co 1340, Co 62174 and Co 997 at both the doses. The yield of Co 1158 was reduced only at higher dose. Varieties Co 527 and Co 1163 were found to be tolerant to both atrazine and diuron while variety Co 281 was tolerant to atrazine. Thus varieties showed differential response to herbicides as in other crops.

(d) *Screening herbicides for weed management*

The results of the evaluation of newer herbicides made during 1977-81 are presented in Tables 4 and 5. None of the herbicides had any adverse effect on the initial germination of sugarcane (Table 4). However, tiller production was reduced in dosamine, TBA with 2,4-D and fluchloralin. This was mainly due to lesser activity of the chemicals on the weed growth as could be seen from the increased dry matter of weeds in these treatments. However, the number of millable canes was not affected much by the use of herbicides. Highest cane yield of 103.6 t/ha was obtained in the case of weed control treatments with alachlor followed by hand weeding and atrazine which were on par. In the present study, alachlor and atrazine proved better and the farmer is neither available in India nor manufactured. The next choice of using pre-emergent herbicide is only atrazine. At the reduced dosages of 2.0 kg a.i./ha, compared to previous year's study, there was no adverse effect on the crop and at the same time, there was equally better control of weeds. Simazine and atrazine have proved to be highly selective and long lasting in the

Table 3: Effect of herbicides on cane yield and quality of different varieties.

		Co 281	Co 449	Co 527	Co 658	Co 997	Co 1158	Co 1163	Co 1340	Co 62174	Bo 17	L.S.D. (P=0.05)
	Weed free check	124.0	96.0	76.4	152.7	112.8	110.2	85.2	205.7	134.7	56.7	15.1
	Atrazine 9.6 kg/ha	116.6	99.4	120.1	187.4	53.3	87.3	114.1	159.4	90.5	50.2	
Cane Yield t/ha	" 2.4	141.7	137.4	89.1	115.3	59.7	136.8	97.4	153.1	83.3	56.7	
	Diuron 9.6	0	0	83.3	0	4.8	0	99.7	0	14.7	37.4	
	" 2.4	94.0	82.7	89.3	112.9	59.3	120.0	83.3	121.7	42.5	45.1	
	Weed free check	17.34	19.20	17.16	17.97	19.58	18.46	16.08	18.15	17.75	16.21	0.13
	Atrazine 9.6 kg/ha	16.51	20.14	17.04	19.23	20.15	18.63	18.62	17.97	17.39	14.92	
Sucrose % juice	" 2.4	17.63	18.66	19.00	18.96	17.80	18.49	18.47	17.65	19.44	16.25	
	Diuron 9.6	-	-	14.92	-	16.46	-	17.40	-	18.92	16.44	
	" 2.4	15.58	16.92	16.44	18.40	18.59	15.92	17.63	14.33	19.20	15.83	

Table 4: Effect of different herbicides on weed control and cane yield

Treatments	Germination %	Tillers 00/ha	Weed dry matter kg/ha	Millable canes 00/ha	Cane yield t/ha	Sucrose %
Alachlor 2.5 kg/ha	66.0	1666	686	1126	103.6	18.86
Atrazine 2.0 "	58.0	1566	756	1031	96.8	17.96
Dosamine 5.0 "	51.0	1326	1438	938	90.8	17.13
TBA + 2, 4-D "	50.0	1368	1600	968	90.3	17.86
2,4-D + TBA "	48.0	1306	1368	1036	91.3	17.91
Fluchloralin 2.5 kg/ha	48.0	1368	2036	987	86.8	16.60
Hand weeding	65.0	1613	2368	1146	101.3	17.90
CD (P=0.05)	NS	372	212	NS	6.8	NS

Table 5: Effect of certain herbicides on cane yield and quality

Treatment	Cane girth (cm)	Millable canes '00/ha	Sucrose % juice	Cane Yield t/ha
1. Dinitramine (EC) at 0.96 kg/ha	2.9	1104	15.76	78.1
2. " 0.72 "	2.8	995	14.39	80.6
3. " 0.48 "	2.8	984	16.96	80.3
4. Dinitramine (G) 0.48 "	2.7	1032	15.74	81.3
5. " 0.96 "	3.0	1028	16.87	83.6
6. T.B.A. 8.00 "	3.0	838	16.73	78.3
7. " 10.00 "	2.8	1028	15.41	78.6
8. " 12.00 "	2.6	1013	16.49	69.3
9. Hand weeding (two at 35 and 70 days	2.8	1312	18.67	88.1
C.D. (P=0.05)	NS	144	1.40	11.9

control of weeds (Talbert and Fletchal, 1964). This is one of the advantages when used in sugarcane crop. Based on the experience at the Institute farm, this was commercially used in private farm with heavy soil and variety CoC 671. There was effective control of all the weeds including *Parthenium* which was a menace in the area for the past five years. The total cost of the chemical at the dosage adopted worked out to Rs. 300/- per ha excluding application cost. Still it seems to be a better one compared to hand weeding, which costs Rs. 360/- per ha.

It has been reported by Lyons and Whitting (1965) that surface applied pre-emergence herbicides are erratic under furrow irrigation with only occasional rainfall and mechanical incorporation has enhanced their efficiency under these conditions. Recent trials comparing granular and spray applications under different methods of incorporation have indicated that granular formulations are as effective or in most cases more effective with rotqtiller type incorporation than similar applications of sprays. A similar study was also conducted at this Institute during 1977-78 with dinitramine as granular application and compared with spray application of the same chemical as well as TBA and hand weeding. With the variety Co 6806 it was observed that there was reduction in yield by application of these herbicides compared to hand weeding. There was reduction in the sucrose per cent juice also. Hence it can be concluded that these two chemicals are not practically suitable for this variety of sugarcane.

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STUDIES ON THE WEED PROBLEMS OF CASSAVA-LEGUME INTER-CROPPING SYSTEMS

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ABSTRACT

A trial on the Cassava-legume intercropping was conducted in the lateritic soils in the high rainfall (2800 mm/year) tract of Kerala. The effect of five leguminous intercrops of cassava viz., cowpea, groundnut, blackgram, greengram and soybean on the nature, intensity and population of weeds were studied, comparing with a sole crop of cassava. The main crop and intercrops were planted simultaneously and the nature of weed flora and weed intensity in different plots were recorded two months after planting. The weeds collected were identified, grouped and oven dried.

The results showed that intercropping with legumes, reduced the intensity of weeds in cassava in general. Cowpea and blackgram were most effective in smothering the weeds, while groundnut and greengram were moderate. Another interesting observation was that in all the intercropped fields monocot weeds predominated whereas in the control, dicot weeds predominated. About 77% cost of weeding can be saved by intercropping, besides obtaining additional gross income of Rs. 403/- to Rs. 1758/- per ha in cassava with cowpea, groundnut, blackgram and greengram.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a cheap source of carbohydrates in most of the tropical countries. The slow growing nature of the crop and its sparse canopy during the initial growth phase leaves plenty of light encouraging several types of weeds to flourish in the interspaces. Uncontrolled weed growth was found to reduce root yield in cassava by 40 to 68% (Akobondu, 1980). Recent report from the International Institute of Tropical Agriculture (IITA, 1979) indicates the possibility of checking the weed growth in cassava gardens by intercropping. The present study examines the nature and magnitude of crop-weed competition in five cassava-legume intercropping systems.

MATERIAL AND METHODS

The trial was conducted at the College of Horticulture, Vellanikkara, Trichur on laterite soil with the annual rainfall of 2800 mm. Five cassava-legume intercropping systems were compared with sole crop of cassava. The intercrops were cowpea, cv. Kanakamani [*Vigna unguiculata* (L) Walp], groundnut, cv. TMV-2 (*Arachis hypogea* L.), blackgram cv. T-9 [*Vigna mungo* (L.) Hepper], greengram cv. Madhira [*Vigna radiata* (L.) Wilezek], soybean cv. EC. 39821 [*Glycine max* (L.) Merrill]. M_4, a tall, comparatively non-branching variety of cassava was used for the study. The experiment was laid out in randomized block design with four replications. The plot size was 5.4 m x 5.4 m. Cassava was planted on mounds at a spacing of 90 cm x 90 cm. Cowpea was planted in single row in between cassava rows, at a distance of 15 cm. The other four intercrops were raised in double rows between cassava providing a spacing of 20 cm x 15 cm. The main crop and the intercrops were planted on the same day in May. Cassava received N,

Table 1: Effect of intercrops on weed dry matter (kg ha^{-1}) and cost of weeding ha^{-1} in cassava plots.

Treatments	First weeding				Second weeding		
	Dicot	Monocot	Total	Women days	Total wt	Women days	Total cost of weeding, Rs
Cassava + cowpea	30.3	39.1	69.4	3½	6.3	1	32.00
Cassava + groundnut	60.5	130.4	190.9	11	22.3	2	93.00
Cassava + blackgram	24.0	61.9	85.9	6	19.5	2	56.00
Cassava + greengram	96.8	97.7	194.5	10	33.5	2	84.00
Cassava + soybean	168.3	100.3	268.6	15	108.5	8	161.00
Cassava sole crop	212.3	133.5	345.8	17	107.5	9	182.00
C. D. (P=0.05)	56.3	N.S.	111.6	–	47.3	–	–

Cost of 1 women day is Rs. 7/-

P_2O_5 and K_2O, 75 kg each ha^{-1}, while the intercrops received 10 kg N ha^{-1} and 20 kg each ha^{-1} of P_2O_5 and K_2O. In addition, a uniform dose of farm yard manure was applied at 12.5 t ha^{-1}.

Weed samples were collected from one sq m randomly before first and second weedings, at two months and three and a half months after planting respectively. The dry weight of monocot and dicot weeds were recorded separately. At second weeding, since the weed population was too low, the dry matter of dicot and monocot weeds were studied together.

The time taken by a labourer to weed each plot was recorded and the cost of weeding in each intercropping systems was worked out. The main crop was harvested ten months after planting and fresh weight of tubers from each plot was recorded separately. The economics of the cropping systems were worked out.

RESULTS AND DISCUSSION

The following weeds were collected from the experimental area and identified.

Brachiaria ramosa (Linn.) Stapf, *Cynodon dactylon* Pers, *Dactyloctenium ægyptium* L., *Eleusine indica* Gærtn, *Ischæmum aristatum* Linn., *Leptochloa filiformis* R & S, *Panicum repens* Linn. (Poaceæ), *Cyperus rotundus* L., *Cyperus iria* Linn. (Cyperaceæ), *Tridax procumbens* L., *Vernonia cineria* Less., *Vicoa indica* D.C., *Emilia sonchifolia* D.C.(Asteraceae), *Desmodium triflorum* D. C., *Mimosa pudica* L. (Leguminosæ), *Achyranthes aspera* L., *Alternanthera sessiles* Br., *Amaranthes viridis* L. (Amaranthaceæ), *Euphorbia hirta* Linn., *Phyllanthes niruri* Linn. (Euphorbiaceæ), *Sida rhombifolia* Linn., *S. acuta* Burm. (Malvaceæ), and *Scoparia dulcis* Linn. (Scrophulariaceæ).

None of the weed species was found to be specific to any of the cropping systems tested. There was marked reduction in the production of dry matter in weeds when cassava was inter-cropped with any one of the legumes except soybean (Table 1). Cassava-cowpea combination proved to be the most effective in inhibiting the weed growth. Weed growth in terms of dry matter production at second weeding was very much less than at first weeding. When dicots and monocots were considered separately, it was found that the growth of dicot weeds was suppressed by all the intercropping treatments except cassava-soybean and cassava-greengram combinations. While 61% of the total dry matter produced by weeds came from dicots in sole crop plots, it was only 28 and

Table 2: Economics of cassava-legume intercropping systems.

Treatments	Cassava (kg ha^{-1})	Yield of intercrops (kg ha^{-1})	Price Equivalent		Total (Rs)	Cost of cultivation (Rs)	Profit (Rs)
			Cassava (Rs)	Intercrops (Rs)			
Cassava + cowpea	19726	586	7890	1758	9648	4691	4957
Cassava + groundnut	19726	879	7890	1758	9648	5029	4619
Cassava + blackgram	19726	538	7890	1614	9504	4715	4789
Cassava + greengram	19726	115	7890	403	8293	4560	3733
Cassava + soybean	19726	–	7890	–	7890	4453	3437
Cassava sole crop	19726	–	7890	–	7890	4256	3634

Cassava at Rs. 0.40/kg. Blackgram and cowpea at Rs. 3.00/kg, Groundnut at Rs. 2.00/kg, Greengram at Rs. 3.50/kg.

50% in plots growing cowpea, groundnut and blackgram as intercrops.

The labour requirement for weeding plots under different intercropping systems varied considerably (Table 1). Among different intercropping systems, the labour requirement for weeding cassava-cowpea and cassava-blackgram cropping systems were very low, 3.5 and 6 women days respectively, as compared to 17 required for the sole crop of cassava. For the second weeding also, the intercropped plots except that of soybean required less labour as compared to sole crop plot of cassava. Of all the combinations, intercropping with cowpea brought the cost of weeding to the minimum.

Intercropping did not affect the yield of cassava tubers (Table 2). Besides, additional yields of 586, 879, 538 and 115 kg ha^{-1} were obtained from the intercrops of cowpea, groundnut, blackgram and greengram respectively.

Intercropping with legumes like cowpea, groundnut, blackgram and greengram controlled the weed growth in cassava plots to varying degrees. As compared to sole crop plots, dry matter accumulation in weeds in plots intercropped with cowpea, blackgram, groundnut and greengram was reduced by 80, 75, 45 and 22% respectively at two months after planting. Evidently, of all the legumes tested, cowpea proved to be the most effective intercrop in smothering weeds in cassava fields. Initial fast rate of growth and consequent coverage of the interspaces by this crop in a short time would have made it difficult for the weeds to come up. On the other hand, groundnut, a slow growing crop was not as effective as cowpea or blackgram in suppressing the weeds. The poor growth of greengram and poor establishment of soybean due to the heavy rains at germination, explain the comparatively high weed infestation in plots cropped to greengram and soybean.

The results also indicated that legume intercrops suppressed the dicot weeds more than the monocots (Table 2). This may perhaps be due to the increased competition between legumes and dicot weeds resulting from their morphological similarities. The fresh tuber yield of cassava was not adversely affected by intercropping, indicating thereby these intercrops exploit only the interspaces left unutilized by the main crop.

A comparison of the labour cost involved in weeding operation of different cassava-legume intercropping systems showed that considerable saving can be made by intercropping. The second weeding in cassava fields may even be dispensed with by intercropping with cowpea or blackgram.

ACKNOWLEDGEMENTS

Acknowledgements are due to Mr. Luckins C. Babu, Assistant Professor of Agricultural Botany for the identification of weeds, Mr. V. K. G. Unnithan, Assistant Professor of Statistics for analysing the data and Dr. P. A. Wahid, Associate Professor (Radio tracer) for reading the manuscript.

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EFFECT OF GLYPHOSATE ON AMMONIFICATION, NITRIFICATION AND DEHYDROGENASE ACTIVITY OF A PLANTATION CROP SOIL AMENDED WITH DIFFERENT ORGANIC CHEMICALS AND GROUNDNUT CAKE

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ABSTRACT

Glyphosate [N-(phosphonomethyl) glycine] at 0, 10, 100 and 1000 ppm incorporated to a plantation crop soil with and without urea, N-serve coated urea, urea with 5% groundnut cake or benomyl (100 ppm) was incubated for observing the changes in the rate of ammonification, nitrosofication, nitrification and dehydrogenase activity in the soil for a period of 56 days.

Glyphosate at all the concentrations either alone or in combinations had no significant effect on ammonification and nitrification. There was no significant difference in the dehydrogenase activity in all concentrations of glyphosate irrespective of various amendments. However, several folds increased activity of dehydrogenase with groundnut cake than the treatments with N-serve plus glyphosate or with different concentrations of glyphosate alone was observed. A fungus, *Penicillium* sp has been found to utilize glyphosate as a sole source of carbon and phosphorus.

INTRODUCTION

Glyphosate is a post emergence, non-selective herbicide which appears exceptionally promising for perennial weed control. It is becoming most popular in tea plantations and also in control of perennial weeds in field crops. It undergoes rapid inactivation in soil by sorption to clay, organic matter and subsequent degradation to CO_2 (Rueppel *et al.*, 1977). As it is a non-volatile and highly soluble in water it is known to readily bound to kaolinite, illite and bentonite clay, charcoal and muck. Fe^{+++} and Al^{+++} saturated clays, and organic matter adsorb more glyphosate. Glyphosate mobility in the soil is limited by pH, phosphate level and soil type, and found to have co-metabolism in soil (Spranckle *et al.*, 1975). The degradation rate was found to vary in different soil and it was primarily due to microbial. Carbon substrate amendments failed to substantially increase the degradation rates in different soils having low degradation rates (Moshier and Penner, 1978).

However, no reported information is available on its behaviour in Indian situations. It is important to know its effect on soil beneficial microorganisms. This paper presents the effect of glyphosate on ammonification, nitrification, and soil biological activities in terms of dehydrogenase activity in a coffee plantation soil with various organic amendments under tropical Indian situations.

MATERIAL AND METHODS

Top 15 cm soil of a coffee plantation (Chickmagalur, Karnataka State, pH 8.2) was collected and used for this study under laboratory conditions. At room temperature, 250 g of 2 mm seived soil was incubated in plastic pots (22.5 cm x 18 cm) with lids containing four pin holes for gas exchange. All the treatments were replicated twice. The treatments included were

1) soil alone,
2) soil + 1.25 g urea,
3) 2 + 10 ppm glyphosate (V/M),
4) 2 + 100 ppm glyphosate,
5) 2 + 1000 ppm glyphosate,
6) soil + 1.25 g urea coated with N-serve 100 ppm (W/W),
7) 6 + 10 ppm glyphosate,
8) 6 + 100 ppm glyphosate,
9) 6 + 1000 ppm glyphosate,
10) soil + 1.25 g urea + 5% groundnut cake,
11) 10 + 10 ppm glyphosate,
12) 10 + 100 ppm glyphosate,
13) 10 + 1000 ppm glyphosate and
14) soil + 1.25 g urea + benomyl 100 ppm + 10 ppm glyphosate.

Commercial formulation of glyphosate (36 EC) and benomyl (50 wp) was used on active ingredient basis. After thorough mixing of each soil with above treatment the soil was moistened and incubated at 60% water holding capacity. The soil samples were drawn at periodical intervals and analysed. Dehydrogenase activity (DHA) in the samples was estimated as described by Casida *et al.* (1964). NH_4-N, NO_2-N, NO_3-N were determined colorimetrically.

RESULTS AND DISCUSSION

Significant change in the dehydrogenase activity (DHA) of the soil at all concentrations of glyphosate studied with or without N-serve was not observed (Fig. 1). A combination of glyphosate at 10 ppm and benomyl at 100 ppm showed inhibitory effect on DHA till 28 days only. Thereafter there was no significant change from that of treatment receiving glyphosate alone (10 ppm).

Ten fold increase in DHA in all the concentrations of glyphosate with groundnut cake was observed. Further, maximum DHA was recorded at 7th day (30 fold increase) in all the above treatments, thereafter, it steeply decreased till 28 days. Interestingly, glyphosate at 1000 ppm with groundnut cake showed a second peak of increased DHA which consistently increased even upto 56 days.

Glyphosate at different concentrations tried individually or in combination with N-serve, GN cake or with benomyl had no significant change in the rate of ammonification (Fig. 2). Similarly at no stage of incubation period NO_2-N was detected in any case of the treatments.

There was no significant change in the NO_3-N content in all the treatment combinations tried with glyphosate except with 1000 ppm. The latter, with and without N-serve showed decrease in NO_3- N throughout the period of incubation (Fig. 3).

The overall respiratory activity of the soil, as determined by the DHA, which represents the net effect of various metabolic processes taking place in the microbial cells, showed no marked change with the glyphosate individually at different concentrations or in combination with N-serve, or groundnut cake or with fungicide benomyl. This indicates the compatibility of the herbicide with the above agricultural chemicals and organic substances. However, 10 to 30 folds increase in dehydrogenase activity at different incubation periods with groundnut cake irrespective of glyphosate is due to increased availability of organic nutrients which has increased the heterotrophic microbial activity in the soil. But, increased dehydrogenase activity after 28 days, only with

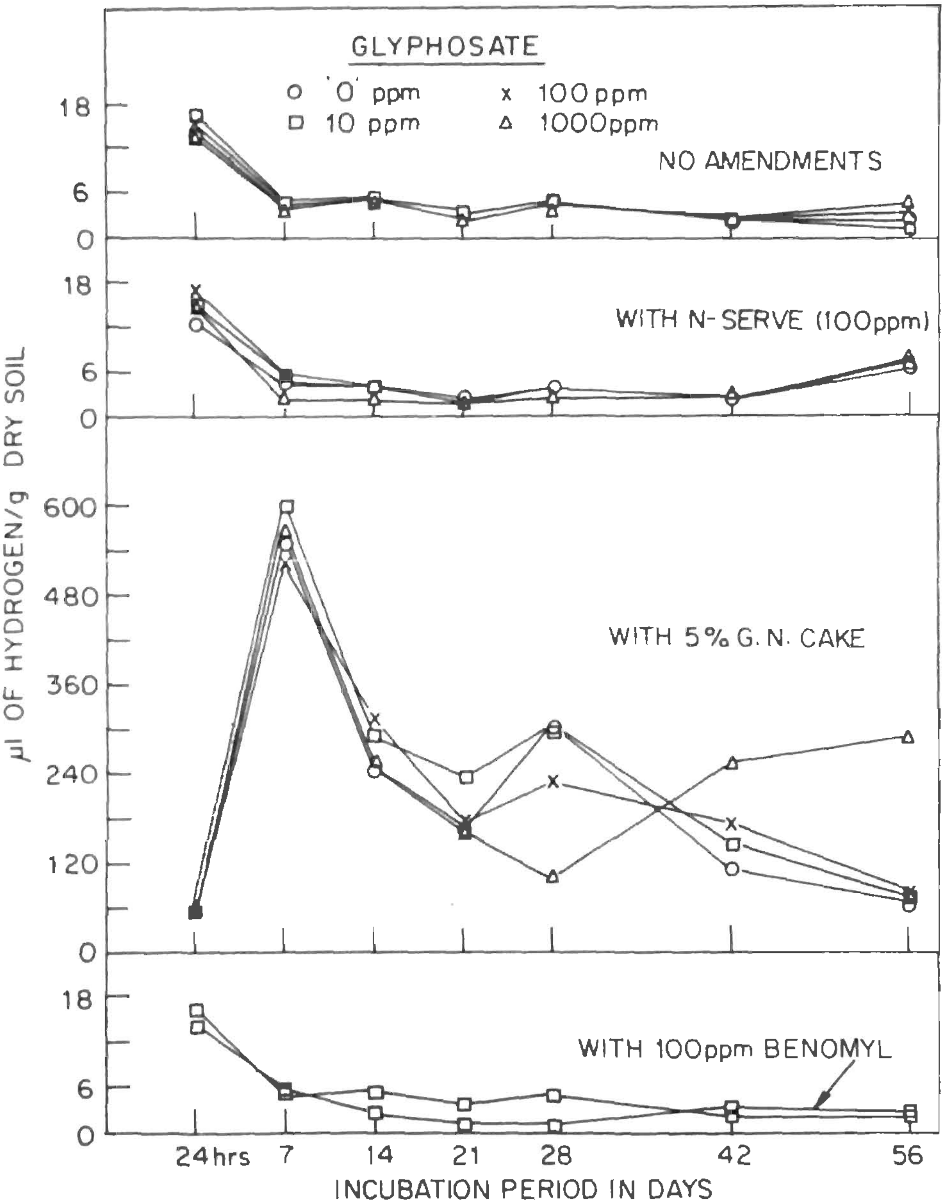

FIG. 1. EFFECT OF GLYPHOSATE ON DEHYDROGENASE ACTIVITY OF A COFFEE PLANTATION SOIL.

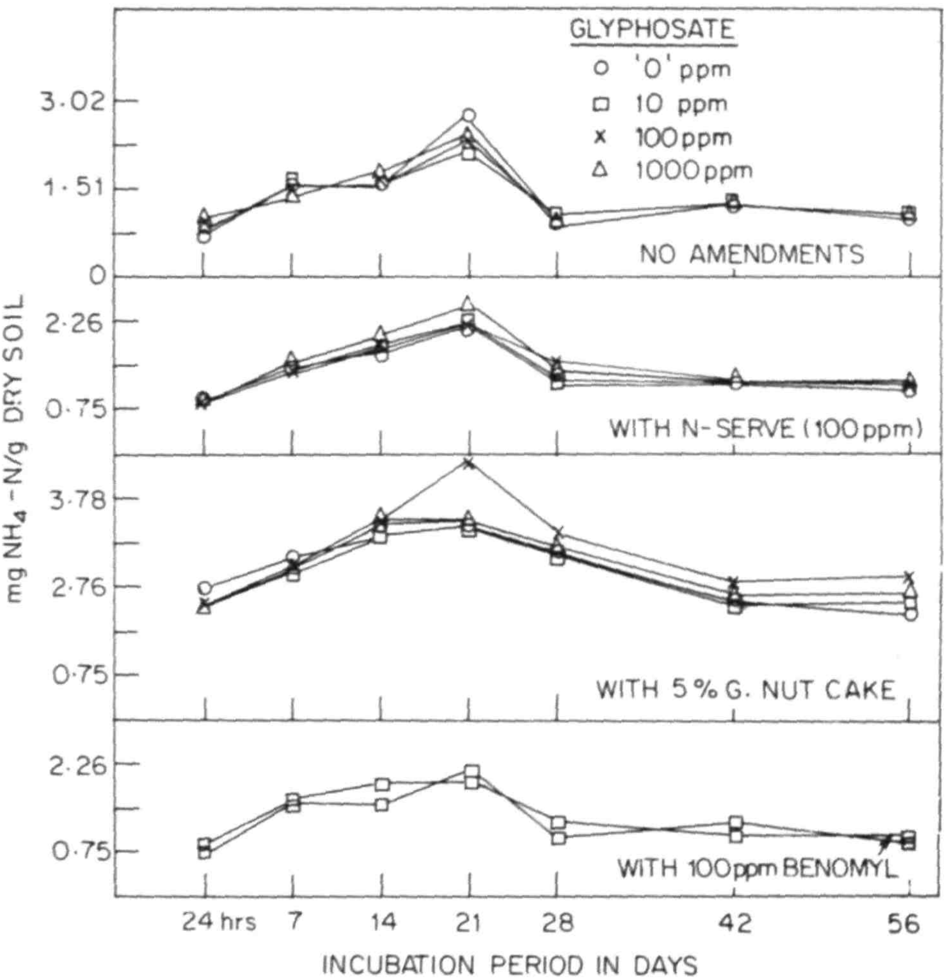

FIG. 2. EFFECT OF GLYPHOSATE ON AMMONIFICATION IN A COFFEE PLANTATION SOIL.

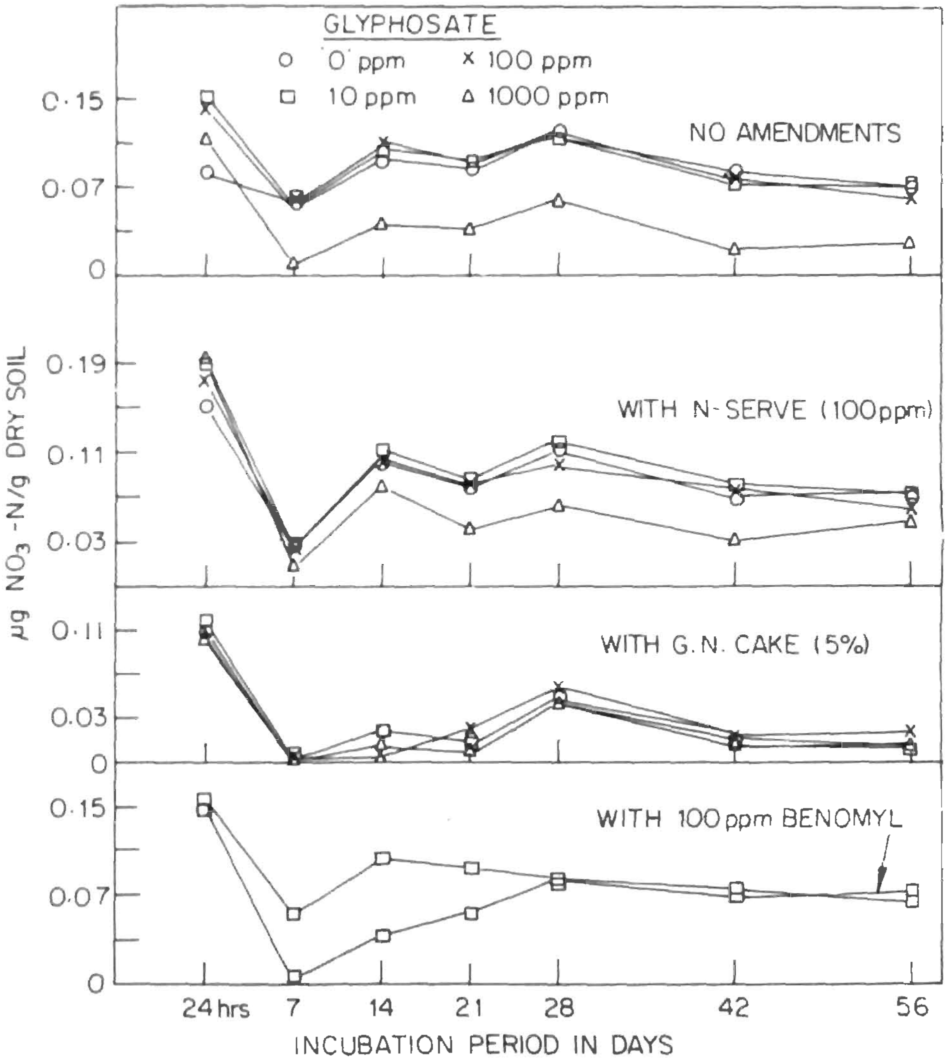

FIG. 3 EFFECT OF GLYPHOSATE ON NITRIFICATION IN A COFFEE PLANTATION SOIL.

1000 ppm glyphosate plus groundnut cake is perhaps due to the dominance of a glyphosate utilizing fungus *Penicillium* sp. associated with other microorganisms. The fungus was found to utilize glyphosate as a sole carbon or phosphorus source when grown in pure culture on Czapecks-Dox fungal broth. Microbial degradation of glyphosate to CO_2 is known to take place in soil within 20 days (Moshier and Penner, 1978). Therefore, the increased DHA may be due to the increased availability of nutrients from glyphosate also. In general the soil used was poor in nitrification although ammonification was quite rapid. The reduction in NO_3-N content in all the treatments irrespective of glyphosate is attributed to immobilization due to heterotrophic microbial activity. But the marked decrease in NO_3-N with 1000 ppm glyphosate with and without N-serve or groundnut cake must be due to increased heterotrophic microbial activity.

In conclusion glyphosate is quite safe with regard to total biological activity of the soil in terms of dehydrogenase activity and ammonification even at very high concentrations recommended as herbicide. Glyphosate is degraded easily by microorganisms.

ACKNOWLEDGEMENTS

Sincere thanks are due to Dr. P. V. Rai, Professor of Agricultural Microbiology, G.K.V.K., Bangalore, for the help and encouragement received in carrying out this study.

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INCREASING CORN AND CASSAVA PRODUCTION IN ALANG-ALANG AREA

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ABSTRACT

Two experiments were conducted in Sukadana Sub-Station, Lampung during wet season 1980-1981. Several methods of tillage and weed control were studied on corn. It was found that strip tillage (using glyphosate 4 *l* prod/ ha and plowed along the rows) gave good result. A 24% increase in yield was obtained compared with conventional tillage. Atrazine at a dosage of 2.4 kg/ha active applied at 1 day after sowing was most effective than other treatments. In another experiment several weed control methods were tested on cassava. Direct application of glyphosate at the rate of 3 *l* prod/ha in between rows of cassava at 1 and 3 months after planting (MAP), respectively, yielded the highest fresh weight of tubers among weed control methods tested. High yield was also harvested from the plots which were hand weeded once at 1 MAP Fb. glyphosate 3 *l* prod/ha at 3 MAP. These treatment increased cassava yield over handweeded plots. It was also found that cassava cultivar Adira 2 (with branches) and cultivar Adira 1 (with no branches) had yield losses about 71% and 82%, respectively, which were caused by weed competition.

INTRODUCTION

Alang-alang (cogon) area is mostly located in red yellow podsolik soil. This soil has low pH, poor plant nutrient content, low organic matter and susceptible to erosion. The whole area in the country covers about 15 million ha. Glyphosate and dalapon have been used to kill alang-alang which will produce a mulch of dead trash. And crops seeds are sown through the mulch (Ismail *et al.*, 1981; Mock and Erbach, 1977; Terry, 1981).

The reduction in yield of corn was 40% due to weed competition (Nieto, 1970). At present, triazine herbicides are widely used for control of most prevalent broadleaf weeds and grasses in this crop.

In Indonesia cassava is mainly consumed as the major part of the diet and rest as cattle feed. Cassava is normally grown in less fertile soil with minimum input, using non improved varieties and traditional cultivation which give very low yield. Manual weeding usually absorbs for about one third of the total labour used in raising this crop. Chemical weed control with paraquat and glyphosate have also been developed as an interrow weeding besides other pre-emergence herbicides (Centre for Overseas Pest Research, 1978).

These trials were conducted to study the possibility of increasing corn and cassava production especially in alang-alang area to support the government program to fulfill national food need.

MATERIAL AND METHODS

The experiments were conducted at Sukadana Sub Station, Lampung during the wet season 1980-1981. Soil type of this location was red yellow podzolic and mostly covered with alang-alang (*Imperata cylindrica*).

Table 1 : Dry weed weight (g/m^2) as affected by weed control, plant spacing and tillage method in corn.

Method of weed control	Grasses				Broadleaf weeds			
	Normal tillage		Strip tillage		Normal tillage		Strip tillage	
	75 x 40	75 x 20	75 x 40	75 x 20	75 x 40	75 x 20	75 x 40	75 x 20
Unweeded	204 b	287 c	53 a	98 ab	30 a	79 b	37 a	17 a
Weeded twice 21 and 42 DAS	5 a	14 a	13 a	7 a	1 a	1 a	1 a	1 a
Atrazine, 2.4 kg a.i./ha, 1 DAS	29 a	101 ab	19 a	6 a	0 a	37 ab	1 a	2 a
Thiobencarb/Pre-metryne 4.4 kg b.a./ha, 1 DAS	180 b	169 bc	13 a	121 b	13 a	51 ab	5 a	8 a
Mungbean inter-cropping	190 b	41 a	26 a	41 ab	29 a	7 a	11 a	13 a
Mean	122	122	23	55	15	35	11	8

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. DMRT based on transformed data.
Sprayed with glyphosate 3 l prod/ha 3 weeks before planting and plowed along the rows.

Table 2 : Plant height at 60 DAS (cm) and yield of corn as affected by methods of weed control, plant spacing and tillage methods.

Method of weed control	Plant height				Yield t/ha			
	Normal tillage		Strip tillage		Normal tillage		Strip tillage	
	75 x 40	75 x 20	75 x 40	75 x 20	75 x 40	75 x 20	75 x 40	75 x 20
Unweeded	175 a	186 a	193 a	203 a	1.6 a	3.3 ab	2.5 a	4.1 a
Weeded twice 21 and 42 DAS	176 a	199 a	204 a	215 a	2.0 a	4.3 a	2.8 a	4.6 a
Atrazine, 2.4 kg a.i./ha, 1 DAS	191 a	199 a	197 a	218 a	2.5 a	4.2 ab	3.4 a	4.7 a
Thiobencarb/Pre-metryne 4.4 kg b.a./ha, 1 DAS	187 a	189 a	190 a	209 a	1.7 a	3.0 ab	2.5 a	4.0 a
Mungbean inter-cropping	163 a	188 a	187 a	199 a	1.1 a	2.1 b	2.4 a	3.3 a
Mean	178 c	192 b	194 b	209 a	1.8 d	3.4 b	2.7 c	4.1 a

1. *Effect of weed control, plant spacing and tillage methods on corn yield.*

This trial was laid out in a split-split plot design with three replications. Main plot was tillage methods, plant spacings as sub plots and weed control methods as sub-sub plots (Table 1).

Plot size was 4 m x 6 m. The plant spacing was 75 cm x 40 cm with two plants per-hill and corn variety H-6 was used. Fertilizers of 45 N + 45 P_2O_5 + 50 K_2O kg/ha were applied as basal and 90 kg N/ha was given at one month after sowing.

Assessments of dry weight, plant height and yield were observed during the trial.

2. *Effect of weed control on the growth and yield of cassava cultivar Adira 1 and Adira 2*

An experiment was arranged in a split plot design with three replications. Culti-

Table 3: Dry weed weight (g/m^2) as affected by weed control in cassava cultivar Adira 1 and Adira 2 at 6 MAP.

Method of weed control	Grasses		Broadleaf weeds	
	Adira 1	Adira 2	Adira 1	Adira 2
Unweeded	663 e	481 cd	98 a	91 a
Weeded twice, 1 and 3 MAP	266 bcd	152 bc	87 a	63 a
Paraquat 0.5 kg a.i./ha, 1 and 3 MAP	526 de	266 cd	59 a	11 a
Glyphosate 3 *l* prod/ha, 1 and 3 MAP	41 a	21 a	65 a	9 a
Weeded 1 MAP fb. paraquat 0.5 kg a.i./ha, 3 MAP	149 abc	193 bc	42 a	22 a
Weeded 1 MAP fb. glyphosate 3 *l* prod/ha, 3 MAP	132 ab	65 ab	20 a	31 a
Alachlor 4 l prod/ha, 1 HST fb. paraquat 0.5 kg a.i./ha at 3 MAP	353 cd	621 e	27 a	55 a
Mean	304 a	257 a	57 a	40 a

vars were put in the main plot and several methods of weed control in the sub splots (Table 3). It was replicated three times, plot size was 5 m x 6 m and plant spacing was 100 cm x 100 cm.

Fertilizers given were 30 N + 30 P_2O_5 + 15 K_2O kg/ha as basal application. 60 N + 35 K_2O kg/ha were applied at 60 days after planting. Pest and disease control were done to protect plants damage. Dry weed weight, plant height and yield data were recorded.

RESULTS AND DISCUSSION

1. *Effect of weed controls, plant spacing and tillage methods on corn yield*

It had been observed that few sedges were found in the experimental plots after killing alang-alang. Dominant grasses and broadleaf weeds in the plots were *Imperata cylindrica* L., *Digitaria sanguinalis* L., *Polytreas amauna, Synedrella nodiflora, Croton hirtus* L., *Phillanthus niruri* L., *Spygelia anthelmia,* and *Borreria latifolia.* The population of grasses was higher than that of broadleaf weeds.

The methods of tillage affected the weed infestation and the strip tillage had less weed population than that on the normal tillage. It seems that the mulch of dead trash suppressed the growth of weeds at the same time. It can also be used as a soil conservation especially to protect the soil erosion.

Plant spacing was not able to control the weeds growth and the dry weight of weeds was almost similar.

In terms of weed control, using atrazine 2.4 kg a.i./ha at 1 day after sowing gave good result. Both grasses and broadleaf weeds did not differ significantly compared to weeded twice.

The dry weight of weeds in the plot of mungbean intercropping was lower than in the unweeded plot. Mungbean which had rapid growth was able to reduce weed infestation in the plots, while Saturn (Thiobencarb/prometryne) was not effective to control weeds (Table 1).

Visual observations to evaluate the growth of corn in the field showed no difference between normal and strip tillage. Plant height was also unaffected by tillage, but there was a tendency that plants growing better when the soil was tilled by strip

Table 4 : Plant height at 60 DAP and yield of cassava cultivar Adira 1 and Adira 2 as affected by methods of weed control.

Method of weed control	Plant height (cm)		Yield t/ha	
	Adira 1	Adira 2	Adira 1	Adira 2
Unweeded	141 c	98 b	2.9 c	4.6 b
Weeded twice, 1 and 3 MAP	195 ab	127 ab	15.8 ab	15.7 a
Paraquat 0.5 kg a.i./ha, 1 and 3 MAP	188 ab	126 ab	12.4 abc	12.2 ab
Glyphosate 3 *l* prod/ha, 1 and 3 MAP	202 a	146 a	20.7 a	19.8 a
Weeded 1 MAP fb. paraquat 0.5 kg a.i./ha, 3 MAP	182 ab	133 a	16.3 a	13.7 a
Weeded 1 MAP fb. glyphosate 3 *l* prod/ha, 3 MAP	178 ab	136 a	18.2 a	17.9 a
Alachlor 4 l prod/ha, 1 HST fb. paraquat 0.5 kg a.i./ha at 3 MAP	168 bc	99 b	5.9 bc	10.8 ab
Mean	179 bc	124 b	13.2 a	13.5 a

tillage than those in normal tillage. Plant height on 75 cm x 20 cm spacing was higher than those in the 75 cm x 40 cm plants. This is due to inter competition between the corn plants. The plant height was also unaffected by the methods of weed control. However, in the plot which was treated with atrazine the plant height was relatively higher than that of other plots (Table 2).

The highest yield was obtained in the plots with strip tillage while in the plots of normal tillage was 24% lower in yield than in the strip tillage.

The same plant population but different in plant spacing resulted significant difference in yield. It was observed that the yield of 75 cm x 20 cm was about 40% higher than the yield obtained for 75 cm x 40 cm. Wider plant spacing had also affected the yield. It appears that there was greater inter competition among the corn plants when planted two plants/hill at 75 cm x 40 cm spacing than one plant/hill at 75 cm x 20 cm spacing.

2. Effect of weed control on the growth and the yield of cassava cultivar Adira 1 and Adira 2

The major weeds were *Imperata cylindrica* L., *Ischæmun timorense* L., *Borreria latifolia* L., *Spygelia anthelmia*, *Synedrella nodiflora* Gærtn., *Eupatorium odorata*, *Croton hirtus* and *Phyllanthus niruri*. Sedges were found very few.

Cassava cultivar Adira 1 has no branch while cultivar Adira 2 has branches. It was observed that the plots with cultivar Adira 2 had lesser weed infestation. The branches of cultivar Adira 2 had shaded the soil surface and suppressed the growth of weeds, especially alang-alang which is sensitive to shading.

In methods of weed control, glyphosate 3 *l* prod/ha at 1 and 3 months after planting (MAP) controlled weeds significantly. Similar result was found in the plots that handweeded once at 1 MAP followed by (fb.) spraying of glyphosate 3 *l* prod/ha at 3 MAP. And using either paraquat 2.5 1 prod/ha or alachlor 4 *l* prod/ha were not able to suppress the growth of weeds (Table 3).

The methods of weed control affected the growth of plants. In the plots with alachlor 4 *l* prod/ha, 1 day after planting fb. paraquat 2.5 *l* prod/ha at 3 MAP was similar to unweeded plots where the plants grew stunted. In other plots plant was not significantly affected by weed control methods. However, in the plots treated with glyphosate 3 *l* prod/ha at 1 and 3 MAP, cassava grew vigorously for the cultivars Adira 1 or Adira 2 (Table 4).

The highest weight of fresh tubers was harvested in the plots which was treated with glyphosate 3 *l* prod/ha at 1 and 3 MAP. High yield was also obtained in the plots which were weeded once at 1 MAP fb. glyphosate 3 *l* prod/ha at 3 MAP. These treatments gave better yield than in the plots weeded twice at 1 and 3 MAP. The plots treated twice by paraquat or weeded once fb. paraquat and application of alachlor fb paraquat did not control the growth of existing weeds and consequently yields were low.

The two cultivars used had different competition ability. Cultivar Adira 2 had greater competitive ability than cultivar Adira 1. Cultivar Adira 2 and cultivar Adira 1 had reduction in yield 71% and 82%, respectively, due to the competition of weeds.

CONCLUSIONS

Strip tillage (using glyphosate 4 *l* prod/ha and plowed along the rows) in alang-alang area gave better corn yield than that in the conventional tillage. Yield increase was about 24%. This method of tillage could be practised to minimize soil erosion, especially in red yellow podzolic soil. Atrazine 2.4 kg a.i./ha can be used as an alternate for handweeding in terms of weed control. Mungbean intercropping with corn was also able to reduce weed infestation.

Cassava cultivar Adira 2 has greater competitive ability than cultivar Adira 1. Direct spray of glyphosate 3 *l* prod/ha in between rows of cassava at 1 and 3 months after planting and handweeding once a month after planting fb. glyphosate 3 *l* prod/ha at 3 months after planting were better and gave higher yields than handweeded twice at 1 and 3 months after planting.

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INVESTIGATIONS OF VARIOUS HERBICIDES FOR AQUATIC WEED CONTROL

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ABSTRACT

Field trials carried out during the fall of 1980 indicated that water lilies *(Nymphæa odorata)* could be controlled by isopropylene glyphosate (N-(phosphonomethyl glycine) at 6 kg/ha, 2,4-D + Dicamba 4 kg/ha and MCPA (Methylchlorophenoxyacetic acid) 4 kg/ha. Water milfoil (*Myriophyllum spicatum*) and water pennywort (*Hydrocotyle umbellata*) were also controlled by glyphosate 3 kg/ha and Banvel 720 respectively. Water fern Azolla caroliniana was controlled by diquat [6,7-dihydrodipyrido (1,2- 2,1-c) pyrazinedium ion] 3 kg/ha. The control of submerged weed *Hydrilla verticillata Royle* by diquat and copper in combination, dipotassium endothal salt and copper are also briefly discussed.

INTRODUCTION

The control of aquatic weeds by the use of herbicides to reclaim or maintain cultivable freshwaters plays an important role in the economy of fisheries, irrigation, agriculture, recreation and public health. Although control of aquatic weeds is occasionally attempted by other means like manual, mechanical and biological, the chemicals still form the mainstay of large-scale control operations and economic benefits. During the recent years however concern for environmental impact and regulations imposed on wide-scale use of herbicides have limited the number of chemicals available for control. In order to increase their effectiveness the application techniques, formulation methods have to be improved and control recommendations are no longer general and broad-based. The specific control of some of the aquatic weeds by a few chemicals which have shown encouraging results are described in this paper. The trials were carried out while the junior author was working at the Centre for Aquatic Weeds, University of Florida, Gainesville on an one year Research Programme under the IDRC Research Associate Award.

SPRAYING OPERATIONS AND METHODS

Spraying operations were carried out by helicopter and air-boat for surface weeds and trailing hoses for submerged weeds. The treatments were made in marked plots of 105 m x 18 m in a large swamp infested with water lilies, milfoil, water shield (*Brassenia schreberi*) and a variety of other weeds also. A pond covered with *Azolla caroliniana* and a long channel with water-pennywort (*Hydrocotyle umbellata*) and spikerushes (*Eleocharis*) were also treated. Hydrilla was treated in a small lake divided into 4 to 5 ha areas for separate treatments.

The helicopter was provided with a micro-foil spray boom approximately 6 m long so that it could make 3 trips to cover each of the 18 m wide plots. Half to one gallon of herbicide was taken to spray at 3 to 6 kg/ha in 75 to 150 l of water for each plot. The requisite quantity of spray solution was carried each time to spray over two duplicate plots. A professional herbicide applicator carried out the spraying operation.

The air-boat had a water pump (3.5 hp) that could draw in water from the lake and a manifold fixture connected to the pump helped to draw in the chemical also from a separate tank and both water and chemical are mixed before delivery from the pump. A spray gun is attached to the pump by a polythene tubing. The pump delivered at the rate of 38 l/min. and the spray volume was varied from 1425 to 2375 l/ha.

The application of chemicals on submerged weeds was achieved by means of weighted trailing hoses (3.6 to 4.5 m) long from a horizontal boom connected to the water pump in the boat. The chemical and water were mixed in a separate tank in order to facilitate mixing a herbicide carrier substance also. The hoses could sink to the bottom by short G.I. pipe sections at the ends. Chemicals used were diquat 4.5 kg a.i./ha in combination with 3.6 kg Cu/ha. Similarly endothall (as Aquathol K) was tried in another plot at the rate of 35.5 kg a.i./ha in combination with 3.6 kg Cu/ha. Copper was supplied in the chelated form (Cutrine) for treatments. The herbicide carrier (Nalaquatic) was mixed at 6 l/380 l of spray mixture. It is visco-elastic polymeric compound heavier than water and has to be properly mixed by agitation in the spray tank before delivering the mixture.

A granular formulation of endothal (Mono-N, N-dimethylalkylamine salt) commercially sold as Hydout pellets was also used in an area of 0.4 ha on Hydrilla at the rate of about 25 kg a.i./ha by mounting a fertilizer granule applicator at the bow of the boat and scaterring the pellets uniformly over the water surface so that the pellets could sink to the bottom and slowly release the phyto-toxic material.

The effects and control of weeds by the herbicides were evaluated on a 0 to 10 scale in which 0 was considered as no control and 10 as 100% control. Plots without any treatments served as control for comparison.

CONTROL OF FLOATING WEEDS

The control of *Azolla caroliniana* was studied in a small pond about 0.21 ha in area covered with the weed over the surface and in moist soil near the margins. As the plants were easily disturbed by the airboat and escape the spray they were driven to the periphery of the pond by the propwash and spraying was carried out from the central cleared zone all around the pond. Diquat was used at 3 kg/ha and the spray was delivered in a tangential flatcone with neither too fine nor too coarse droplets. The plants were killed within a week after treatment and the pond was cleared of weeds. No fish mortality due to oxygen depletion was noted as decaying weeds were confined to the peripheral zone and open water areas was present in the center.

CONTROL OF EMERGENT WEEDS

The effects of spraying on water lilies, milfoil, spike-rushes and grasses (*Panicum* spp.,) in field plots evaluated four weeks after treatment showed extensive damage and evidence of control by some of the herbicides against specific weeds at certain rates while other chemicals and doses were not so effective on the same or other weeds. Water lilies could be controlled by isopropylene glyphosate (Round-up) at 6 kg/ha giving 80 to 100% control. 2,4-D + Dicamba (Banvel 720) also showed effective control on water lilies at 6 kg/ha giving about the same extent of control. Results obtained with MCPA at 6 kg/ha were not so satisfactory. Other herbicides viz., 2,4-DP (2,4-dichloropropionic acid), Emulsamine (E-3), low volatile ester of 2,4-D and Weedar 64 tried at 4 and 6 kg/ha also were not effective. Among the other weeds milfoil which was present in some of the plots could be controlled by glyphosate at 3 kg/ha and above Weedar 64 and Emulsamine 3 at 4 and 6 kg/ha respectively. The effect of other chemicals could not be assessed as the weed was not present to a large extent in the other plots. *Eleocharis* appeared to be susceptible to 2,4-DP at 6 kg/ha and Weedar 64 and Emulsamine 3 to which they were exposed in a few plots did not seem to have much effect. The effect of Weedar 64 against *Brasenia* was satisfactory as it gave 80% control at 6 kg/ha compared to less than 50% control with MCPA and 2,4-DP. Pickerel weed, *Pontederia* sp appeared to be well controlled by 2,4-DP at 6 kg/ha rather than by MCPA or Weedar 64 at the same rate.

In another field trial, water pennywort in a channel (0.24 ha) was controlled with Banvel 720 14.25 l/ha. Spikerushes also present in the channel could be controlled by diquat at 2.5 kg/ha.

CONTROL OF SUBMERGED WEEDS

Control of *Hydrilla verticillata* using diquat 4.5 kg a.i./ha and Copper 3.6 kg a.i./ha and Aquathol K (dipotassium salt of Endothal 40.3%) 35.5 kg a.i./ha and copper 3.6 kg a.i./ha was achieved in 4 to 5 ha plots of a large lake (Pearl lake 23 ha). The application was made by the deep water injection method using trailing hoses. Nalaquatic – a commercial polymer compound was also combined in the treatment mixture to place the toxic chemicals near the target weed, as the formulation was heavier than water and formed a mayonise like consistency. This was found to be advantageous also because the treatment could be made regardless of the depth instead of treating the entire volume of water.

Endothal Mono (N,N-dimethylalkaline salt of endothal 22.4%) pellets applied at the rate of 25.3 kg a.i./ha in a 0.4 ha plot of the lake also easily controlled *Hydrilla* as the herbicide was slowly released by the pellets and got absorbed by the plants.

HYDRILLA CONTROL BY DRAWDOWN OPERATIONS

The growth of *Hydrilla* was controlled to a considerable extent in a large water body, the Rodman reservoir which extended over thousands of acres, by a novel method of water level fluctuation based on an understanding of the reproductive biology of the weed. As the *Hydrilla* tubers which are the main source of infestation germinated only once in the life cycle of the plant and disappeared after producing a new plant, the first drawdown was carried out in late winter to induce the tubers to germinate and the top soil was allowed to dry up killing the newly sprouting plants. This was followed by a second drawdown also in the next year starting from October before new tubers were formed and any old tubers remaining in the soil were either prevented from germinating or the newly sprouted plants died immediately due to lack of water. This was an essential operation and the first one was more optional. The two operations together constituted a reliable method of controlling the growth of *Hydrilla* in a large waterbody.

DISCUSSION

The field trials described above indicated that specific weed problems could be tackled by some of the available registered chemiclas but the herbicides appeared to have some selectivity with regard to the dose and the weed. This was helpful in a way to avoid total elimination of plants some of which were beneficial to the ecosystem. When a single weed was causing the problem it was found to control that weed would be better rather than killing all the plant life present. Both diquat and endothal were known to have relatively short half-life and were used extensively for the control of floating and submerged weeds. The synergistic effects of using these chemicals in combination with copper have earlier reported to be successful (Sutton and Blackburn, 1971; Haller and Sutton, 1973; Gangstad, 1978). The new formulation of glyphosate appeared to be particularly suitable for the control of water lilies as reported by Riemer and Welker (1974) also.

The modern approach to treatment of submerged weeds is to place the chemical as closely as possible to the target weed rather than charging the whole water volume and diluting the chemical. This was achieved by means of the trailing hoses which could be kept well below the water surface by the weighted ends and moving the boat slowly. The bottom placement technique was first developed by McClintock *et al.* (1974) and has been more usefully adapted by the addition of polymer compounds in the treatment mixtures. This type of treatment not only increased the precision of application but also reduced the cost of application and ensured safety to fish. Similarly, the granular formulations improved the efficacy of releasing the herbicide material with a margin of safety and easiness of application.

ACKNOWLEDGEMENTS

The financial assistance of International Development Research Center, Canada is gratefully acknowledged.

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EFFICACY OF PARAQUAT FOR CONTROL OF SUBMERGED WEEDS

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ABSTRACT

The noxious submerged weeds *Hydrilla verticillata* Casp., *Vallisneria spiralis* L., *Najas indica* (Wield.) Cham. and *Ceratophyllum demersum* Linn., are widely distributed with fluctuating density in ponds causing interference with fish culture practice. In laboratory experiments paraquat (1,1'-dimethyl-4, 4'-bipyridinium salt) was found to be effective in killing the weeds at 4 mg/l in 8 to 12 days. In field trials the same weeds occurring in mixed infestation could be cleared (93-98%) with 3 to 4 mg/l in two weeks.

The problems of mass decomposition following treatment and subsequent rise of nutrient level in water are considered. Economics of clearance and effect of chemical on biotic community of the pond are discussed.

INTRODUCTION

Excessive growth of aquatic weeds are undesirable as they seriously limit the optimum use of the water resources. Of the various category of water plants the submerged ones are far more difficult to clear than others. Conventional methods of removing the weeds by manual or mechanical means have become quite costly. Hence, control by use of herbicides has drawn considerable attention in recent years. Paraquat have been advocated for control of submerged weeds (Blackburn and Weldon, 1964; Silvo, 1968). The present study was undertaken to assess the usefulness of paraquat for control of submerged weeds in fish ponds and study its effect on the biotic community of the water body.

MATERIAL AND METHODS

In laboratory trials submerged weeds like *H. verticillata, V. spiralis, N. indica* and *C. demersum* grown in earthern gamla, glass jars and plastic pools (1 m diameter) having soil base were treated with different doses of paraquat (*Gramoxone* 20%). The herbicide was tested for toxicity on fingerlings (85-122 mm) of fish *Cirrhinus mrigala* (hamilton) and zooplankton collected from Killa fish farm and kept in glass jars of 10 *l* capacity.

In field trials mixed association of 2 or 3 of the above weeds were treated with effective doses ascertained from yard trials. For proper distribution the chemical diluted in clear water (500 l/ha) was sprayed over the pond surface by a foot-pump sprayer. The soil water and plankton of the treated ponds were collected before and after the treatment to study the change. In all, four field trials were carried out in fish farm ponds of area 0.024 to 0.036 ha having mixed infestation of submerged weeds like *H. verticillata, C. demersum, N. indica* and *V. spiralis.*

RESULTS AND DISCUSSION

Laboratory trials

The dose of 4 mg/l and above fully killed *V. spiralis* in 10 days, whereas *H. verticillata, C. demersum* and *N. indica* required 3 mg/l for full clearance in 8 days (Table 1). In case of partial kill there was regeneration from left over viable plant remains in 3 to 4 weeks. The dissolved oxygen in the treated jars before treatment was 6.2 to 8.0 mg/l. The same dropped to 0.2 to 0.4 mg/l by the third day after treatment. In all trials plants kept as control were healthy.

In the first trial carried out with plants grown in plastic pools, a mixed infestation of *H. verticillata, V. spiralis* and *N. indica* was fully cleared with paraquat at 4 mg/l and above in 12 days (Table 1). In the second trial mixed infestation of *H. verticillata, N. indica* and *C. demersum* were fully cleared with 4 mg/l in 10 days. In both trials regeneration of plants from the left over viable remains were noticed in pools of partial kill. In experimental pools dissolved oxygen was 6.4 to 8.6 mg/l before treatment. The same decreased to 0.4 to 1.6 mg/l by third day after treatment and subsequently increased to 3.6 to 5.4 mg/l by 21 days. In control pools, there was no change in condition of plant or water during the same period.

In toxicity tests carried out with *C. mrigala* no mortality was recorded with tried doses of 2 to 6 mg/l during 72 hours when the room temperature was 30.8°C.

Glass jars containing 5 l of pond water, were stocked with zooplankton composed of *Keratella, Moina, Cyclops* and *Diaptomus* and treated with 1, 2, 3 and 4 mg/l of paraquat. In 36 hr all the organisms were killed and doses 3 and 4 mg/l in the order of *Moina, Keratella, Cyclops* and *Diaptomus*. In jars treated with 2 and 1 mg/l and control no mortality of any of the forms were recorded.

Field Trials

In second and third trials, 90% and 70% clearance were obtained with doses 3 and 2 mg/l respectively. In the third trial pond there was regeneration from left over viable plant remains. The soil pH, water pH and total alkalinity recorded little change in two weeks after treatment (Table 2). However the dissolved oxygen in the treated ponds dropped from the initial value of 7.2 – 9.6 mg to 1.4 – 3.0 mg/l by third day but increased to 6.4 – 8.0 mg/l in two weeks. The PO_4-P of water also recorded substantial increase by two weeks after treatment.

The existing fishes *Cyprinus carpio* Linnæus, *Clarias batrachus* (Linnæus), *Coilisa fasciata* (Bloch), *Channa functatus* (Bloch) and *C. striatus* (Bloch) present in the treated ponds were not affected by the treatment. The plankton organisms recorded before treatment were *Volvox, Pediastrum, Synedra, Cyclops, Cypris, Brachionus, Diaptomus* and *Moina* in considerable numbers (average 214/l) disappeared following treatment. However three weeks after, plankton forms *Euglena, Anabæna, Pediastrum, Spirogyra, Keratella, Cyclops, Diaptomus* and *Nauplii* in comparatively large numbers (average 364/l) were recorded in the ponds. Regeneration tests conducted by putting fresh plants of *Lemna* and *Spirodella* in treated ponds showed that paraquat activity in the water is lost by 12 days.

The cost of clearance ranged from Rs. 2316/- to Rs. 3076/- per ha metre water area (30 to 40 kg of herbicide at Rs. 76/- and 6 men days at Rs. 6/-). This looks higher compared to manual clearance cost of Rs. 960/- mentioned by Philipose (1968). In small areas where no other method is possible, clearance by paraquat can be tried.

Thus from laboratory and field trials, it was evident that paraquat at 3 to 4 g/l cleared these weeds in two weeks. It was also observed that *V. spiralis* required

Table 1 : Effect of different doses of paraquat submerged weeds in laboratory trials.

No. of expt. and container	Date / Air temp.	Weed species	Herbicide mg/1	% kill by wt.	Remarks
1 Gamla	18.1.78 27 °C	*H. verticillata*	1.0	65	Regeneration from left over parts
			2.0	85	"
			3.0	100	Kill in 10 days No regeneration
			4.0	100	"
2 Glass jar	12.4.78 30 °C	*V. spiralis*	2.0	60	Regeneration from root stock
			3.0	80	"
			4.0	100	Kill in 10 days No regeneration
			5.0	100	"
			0.0	–	No kill
3 Glass jar	16.7.78 29 °C	*C. demersum*	1.0	70	Left over parts viable. Regeneration.
			2.0	80	"
			3.0	100	Kill in 8 days. No regeneration
			4.0	100	"
			0.0	–	No kill.
4 Gamla	12.5.79 31 °C	*N. indica*	2.0	75	Left over parts viable
			3.0	100	Kill in 8 days. No regeneration.
			4.0	100	"
			0.0	–	No kill.
5	24.5.79	*H. verticillata*	3.0	75	Regeneration from
Plastic pool	31 °C	*V. spiralis*			left over parts
		N. indica	4.0	100	Kill in 10 days. No re-generation.
			5.0	100	"
			0.0	–	No kill.
6 Plastic pool	22.8.79	*H. verticillata*	2.0	80	Regeneration from left over parts.
	28 °C	*C. demersum*	3.0	90	Kill in 10 days. No regeneration.
		N. indica	4.0	100	"
			0.0	–	No kill.

Table 2: Effect of paraquat on submerged weeds in field trials and the change of soil and water qualities.

Trial No. Date	Weed species and % composition	Weed density kg/sqm	Pond area, ha	Average depth, m	Water temp. °C	Paraquat mg/l	% clearance (by wt)	Before treatment: soil pH	Water pH	Total alkalinity mg/l	D. O. mg/l	PO_4-P mg/l	Two weeks after treatment: Soil pH	Water pH	Total alkalinity mg/l	D. O. mg/l	PO_4-P mg/l
1 8.1.80	*H. verticillata* – 40% *V. spiralis* – 25% *N. indica* – 35%	26.6	0.032	1.06	23.8	4.0	96	7.2	7.8	85.0	8.4	0.01	7.0	7.6	92.0	6.4	0.03
2 18.4.80	*H. verticillata* – 70% *N. indica* – 30%	42.2	0.036	0.75	29.6	3.0	90	6.8	7.6	76.0	7.2	0.02	6.8	7.4	84.5	5.8	0.05
3 14.11.80	*H. verticillata* – 30% *C. demersum* – 45% *N. indica* – 25%	36.4	0.034	0.82	24.2	2.0	70	7.0	8.0	80.0	8.6	0.03	6.9	7.6	108.5	7.0	0.04
4 6.5.81	*H. verticillata* – 60% *C. demersum* – 40%	28.2	0.024	0.65	30.2	4.0	92	6.9	7.9	72.0	9.6	0.02	6.8	7.8	105.5	7.6	0.05
(Control)	*H. verticillata* – 30% *C. demersum* – 40% *N. indica* – 30%	30.6	0.034	0.71	30.4	0.0	–	7.0	7.8	70.0	9.2	0.03	7.0	7.8	72.0	9.0	0.02

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slightly higher dose than other weeds. Pahuja *et al.* (1973) observed *Gramoxone* (paraquat) 5 mg/ml to be effective against *H. verticillata*. In field trials clearance of 90% and above can be considered effective as the left over weeds can easily be removed by netting.

From the present trials it is clear that fishes present are not affected by the treatment. The toxicity test with fingerlings of *C. mrigala* also confirm the same (Lawrence *et al.*, 1963; Silvo, 1968). As observed from laboratory trials zooplankton can tolerate upto 2 mg/l of paraquat. In the field study, though the plankton organisms disappeared with 3-4 mg/l they reappeared after two weeks with greater density and differing composition, as observed by Silvo (1968).

It was observed that some vegetative buds (turions) and root stock of some aquatic plants which remain embedded in mud surface remain unaffected by the treatment. As paraquat is known to be rapidly absorbed by clay and organic particles, plant parts in bottom mud might not get the required concentration for its kill.

CONCLUSION

Paraquat being highly water soluble is easy to apply. However its greatest disadvantage is that it cannot be used in ponds having suspended silt or organic matter. But most of the weed ponds have clear water, hence the chemical can be safely applied. Though the recommended doses are safe for fish, assessment of the long range toxicity risk to humans, fish and other wild life need to be further investigated.

ACKNOWLEDGEMENTS

The authors are indebted to Dr A. V. Natarajan, Director, Central Inland Fisheries Research Institute for his keen interest and encouragement. Their thanks are also due to Mr. R. D. Chakrabarty and V. Ramachandran for valuable and helpful criticism.

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INVESTIGATIONS ON THE ECOLOGICAL EFFECTS OF *SALVINIA* WEED DEPOSITS IN THE INSHORE WATERS OFF COCHIN

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ABSTRACT

The problem of pollution from *Salvinia* weed has been attracting considerable attention in this region for the last two decades. The spontaneous growth of this weed choking the waterways, lakes and estuaries during the monsoon and post-monsoon seasons has become a menace. The immediate effect of the spreading weeds is the physical interference in the aquatic environment affecting the fishing operations as well as the inland navigation, which naturally attracts more attention. Although there were a few reports on the effect of *Salvinia* as a biological pollutant, there is no information as to its effect on the ecosystem and the living resources of the inshore waters.

The paper presents the results of investigations on the short-term as well as long-term effects of weed deposits in the inshore areas off Cochin during 1976–78. Data include hydrographic properties, distribution of benthic population, primary productivity and also microbiological aspects.

The period of weed deposition starts immediately after the onset of monsoon season and continues till January. Along with the flood waters enormous quantities of *Salvinia* reach the estuarine areas. As soon as the weeds come into contact with the saline water they start to decay. The tidal movement brings the major part of them to the inshore areas and the decayed weeds settle to the bottom in large quantities. This process continues till January–February. However, the peak period is between October–January. This phenomenon invariably results in a decrease in dissolved oxygen contents of the benthic area. The comparatively low rate of primary production observed in the waters of the benthic region during this period along with high dark fixation indicate abnormal conditions prevailing there. The long-term effects appear to be the interference on the benthic population, especially the filter feeding animals.

Nine genera of bacteria in the weed deposits were isolated and the morphological, biochemical and physiological characters of representative isolates and their seasonal abundance were studied. The variety and number of genera in the weed deposits were maximum in the post-monsoon season and scanty during the monsoon season. Three major micro-organisms – bacteria, fungi and actinomycetes absorbed in the *Salvinia* detritus rich sediments were recorded in all the three seasons. The association of the micro-organisms with the decaying weed indicates the role of microbenthos in the organic cycle in the shore waters off Cochin.

Although these effects appear to be seasonal in nature, the phenomena continues every year with cyclic regularity. The possible environment damage and its consequences to the ecosystem in general and to the fishery of this area in particular are also discussed.

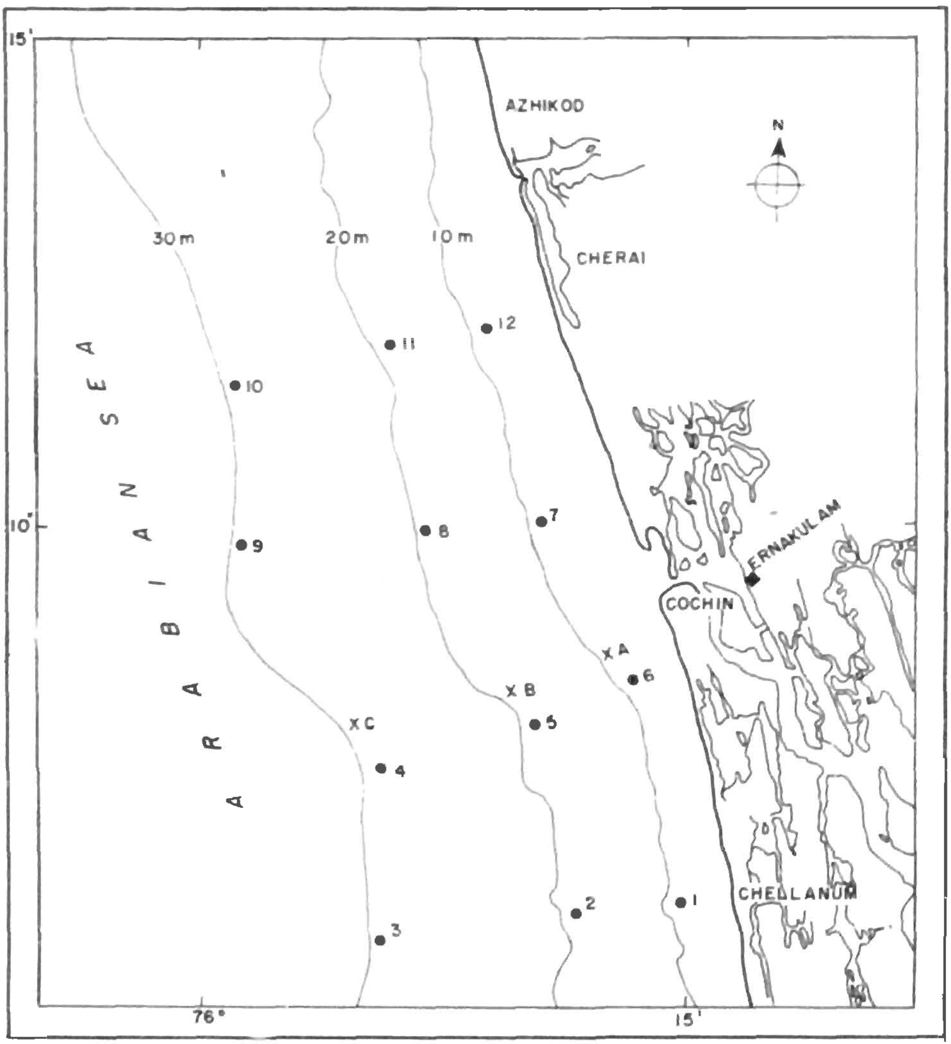

Fig. 1 Map showing the area investigated and the station positions.

INTRODUCTION

The massive growth and subsequent proliferation of the aquatic weed *Salvinia molesta* Mitchell has become a menace in the rivers, backwaters and inshore areas of Kerala (south west coast of India) for the last several years. Family Salviniaceæ (pterydophyta) consists of two main living genera : *Salvinia* and *Azolla*. The plants are inhabitants of tropical fresh waters. It is a free floating hydrophyte and the stem is a branched rhizome attaining a length of about 10 cm. The method of reproduction is both by vegetative and sexual methods. However, the chief method of propagation is by vegetative means. This paper deals with the results of investigations conducted to assess the adverse effects, if any of the large quantities of weed on the living resources of the inshore areas of Cochin.

MATERIAL AND METHODS

During 1976-77 samples were collected from three stations at depths 10, 20 and 30 m and in 1978 from 12 stations in a grid of four transects at the respective depths of 10, 20 and 30 m. The station positions are given in Fig. 1. Water samples were collected from surface and bottom and analysed for salinity, dissolved oxygen and nutrients by standard methods. Dredge samples were collected during a dredge of 45 cm x 12 cm size and grab samples by a Van-Veen type grab of 0.05 m^2 and analysed for the benthic fauna. Primary productivity of the water from the surface as well as just above the benthic region was estimated by C^{14} method. For the microbiological studies, surface water samples for bacterial assay were collected in a sterile 250 cc glass bottles in aseptic conditions. Sediment samples were collected by using a grab. Central portion was collected in sterile petridishes using a,sterile spatula and transported to the laboratory. Analyses were carried out within 30 hrs. The samples were kept at 4°C until the time of analysis. Autoclaved sea water was used for making serial dilutions. Water and sediment samples were suitably diluted and plated on ZoBells "medium 2216"; Kurters Agar and Martins Rose bengal agar for the enumeration of bacteria, actinomycetes and fungi respectively. All the zymogenous bacteria were isolated in their selective media in suitable dilutions. Colonies were counted after the respective incubation period at RT. The generic classification of bacterial isolates was done according to a modified scheme of USIO SIMIDU and Kayuyoshi Aiso in 1962.

RESULTS

Hydrography

In general, the hydrographic parameters like water temperature, salinity, dissolved oxygen and nutrients did not show much variations except for the very low dissolved oxygen values recorded at the benthic regions during the months of January, July and November 1976, which coincided with the presence of heavy weed deposits in the inshore area. However, this feature was not noticed during 1978. The extremely low values of dissolved oxygen were recorded during January 1976, July and November 1977 (Table 1) which coincided with the presence of decaying weeds at the benthic areas and is possibly due to the high rate of organic decomposition in the area at the respective stations. Since the rate of weed deposition and degree of decomposition are not consistent and also considering the effect of water currents, it is rather difficult to interpret such variations in hydrographic parameters. However, it is observed that in the monsoon and post-monsoon seasons the beaches extending to several kilometers to south of Cochin are seen densely covered with decayed weed masses indicating the effect of southward after currents.

Table 1 : Hydrographical parameters off Cochin at 10, 20 and 30 m during January, July and November (1976, 77 & 78)

Period	Parameters	Stns.	I 10 m	II 20 m	III 30 m
January '76	Temperature	S	29.0 °C	29.5 °C	28.5 °C
		B	28.5	28.4	28.0
	Salinity ‰	S	22.5	30.5	28.0
		B	28.7	30.0	28.5
	D. oxygen ml/l	S	2.35	1.94	2.28
		B	1.98	1.81	1.23
July '76	Temperature °C	S	28.5	28.20	–
		B	26.5	25.50	–
	Salinity ‰	S	34.67	35.34	–
		B	35.0	34.10	–
	D. oxygen ml/l	S	3.64	4.60	–
		B	3.42	4.0	–
November '76	Temperature °C	S	29.50	28.70	29.20
		B	28.50	28.20	28.80
	Salinity ‰	S	34.72	34.86	32.53
		B	34.86	34.23	34.16
	D. oxygen ml/l	S	4.14	3.94	3.70
		B	4.00	4.30	3.80
January '77	Temperature °C	S	29.0	29.2	29.5
		B	28.5	28.5	28.7
	Salinity ‰	S	32.18	32.10	32.5
		B	32.30	30.88	33.0
	D. oxygen ml/l	S	3.91	3.94	4.2
		B	4.11	3.90	3.0
July '77	Temperature °C	S	26.5	25.50	–
		B	26.0	25.00	–
	Salinity ‰	S	12.48	18.80	–
		B	32.80	31.60	–
	D. oxygen ml/l	S	4.94	4.96	–
		B	2.42	2.50	–
November '77	Temperature °C	S	30.0	30.0	30.50
		B	29.5	29.0	28.50
	Salinity ‰	S	32.7	32.0	31.10
		B	33.9	35.10	35.15
	D. oxygen ml/l	S	2.78	3.75	3.81
		B	2.40	2.73	1.51
January '78	Temperature °C	S	29.1	29.5	29.5
		B	28.0	27.8	27.8
	Salinity ‰	S	32.1	32.0	31.5
		B	34.0	34.0	34.0
	D. oxygen ml/l	S	4.30	5.0	4.7
		B	3.6	4.2	4.0

S = Surface, B = Bottom

Table 2 : Benthic production and dark assimilation ratio during the pre-monsoon period in the inshore area of Cochin

Months	St. No.	Benthic production	Dark assimilation	Dark assimilation ratio
1978 January	1	3.66	8.67	2.36
	3	4.23	5.95	1.40
February	1	3.38	13.61	4.02
March	3	3.38	6.03	1.78
	4	3.10	6.81	2.19
April	1	4.0	11.89	2.97
	2	4.54	6.42	1.41
	3	3.19	5.38	1.68
	4	3.32	6.21	1.87
	5	2.99	3.70	1.23

Primary productivity

Primary productivity data collected during 1976, 1977 and 1978 by C^{14} method showed that the rate of production at the surface layers in the area was uniformly high compared at the benthic region, (Surface: 55–125 mg $C/m^3/hr$; Benthic: 10 mg $C/m^3/hr$). One interesting feature observed was that at certain periods, especially during January–April 1978, high dark fixation rates were observed in coincidence with the presence of heavy weed deposits at the bottom (Table 2).

Benthic fauna

Qualitative distribution pattern of the benthic biomass for the period 1976–77 is given in Table 3. Although the data do not

Table 3 : Abundance of benthic biomass at 10 m off Cochin [Samples collected with a dredge (45 cm x 12 cm) towed for 15 minutes]

Station	Groups			1976			1977						
		Jan.	Mar.	Apr.	May	July	Aug.	Nov.	Dec.	Jan.	Feb.	Mar.	May	July
I	Squilla sp.	1		1				1	3		3	1		
	Cynoglossus sp.	1	1		1			1		2	7	2		
	Crabs			2						1	6			
	Sciænid sp.		2	1	2						5			
	Gastropods	103	45		8	10		1	14	2	85		15	7
	Dentalium sp.	5							1				300	
	Tureteua sp.	25			4	24	1			13	15	6	38	14
	Bivalves	2	4	15	116	3				1	120	5	14	2
	Murex sp.										45			
	Nudibranchs					2	1							
	Echroid sp.	12												
	Echinoderms			10	5	1				5		1	11	2
	Polychætes			5	1									1
	Acetes sp.										5			

provide a full representation of the benthos due to the inherent limitations of the dredge sampling, it gives a general picture about the distribution and abundance of major groups in the inshore areas. Conspicuous absence of filter feeding organisms like the bivalve molluscs during monsoon is probably due to the physical disturbance to them by the cellulose deposits accumulated during the disintegration of the decaying weeds. Besides, the dominance of polychæte worms and molluscs such as *Tellina* met which are indicative of abnormal conditions.

Microbiological studies

Microbiological studies were carried out during January to October 1978 only. The occurrence of zymogenous bacterial pattern is given in Fig. 2 along with total bacterial population. The monthly total bacterial count per ml of sea water varied within a very limited range indicating the existence of a fairly constant level of population in the surface waters and in the detritusrich sediments. The total bacterial population ranged from 99.36×10^6 to 265.32×10^6/g in the sea water and in the sediments from 137.2×10^6 to 232.6×10^6/ml; 9 genera of bacteria belonging to six families viz., Neisseriaceæ (25%); Pseudomonadaceæ (10%); Vibrionaceæ (25%); Nicrococcaceæ (5%); Bacillaceæ (5%) and Enterobacteriaceæ (25%) and Contaminants (5%) were found associated with the weed deposits. *Alcaligenes*, *Pseudomonas* and *Vibrio* occurred in abundance in all the three seasons. There was no marked pattern of distribution among the microflora, but all the zymogenous microflora exhibited the maxima in the post-monsoon period. The inter-relationship of different microbial flora is given in Table 4. From the present investigation, it

Table 4: Occurrence of microflora and their inter-relationship in the surface water and sediments in the inshore area of Cochin

Months		Bacteria 10^6/ml	Actinomycetes 10^6/ml	Fungi 10^6/ml	Inter-relationship between different microflora		
					B:F	B:A	F:A
January	SR	99.36	21.63	28.34	3.50	4.59	1.31
	SD	145.60	42.81	8.75	16.64	3.40	0.20
February	SR	166.60	28.46	44.63	3.73	5.85	1.56
	SD	197.00	56.46	16.40	12.01	3.48	0.29
March	SR	107.33	32.50	18.40	5.89	3.30	0.56
	SD	116.83	62.64	24.50	4.76	1.86	0.39
April	-	-	-	-	-	-	-
May	SR	137.40	40.40	19.48	7.05	3.40	0.48
	SD	152.66	80.10	22.46	6.79	1.90	0.28
June	SR	158.60	31.80	25.36	6.25	4.98	0.79
	SD	140.80	64.74	18.46	7.62	2.17	0.28
July	SR	186.60	44.32	60.42	3.08	4.21	1.36
	SD	166.40	72.16	37.20	4.47	2.30	0.51
August	SR	265.32	66.16	66.16	4.01	4.01	1.00
	SD	137.16	68.28	24.50	5.59	2.00	0.35
September	SR	252.60	64.20	63.21	3.99	3.93	0.98
	SD	212.86	66.16	22.62	9.91	3.21	0.34
October	SR	256.40	52.62	71.64	3.57	4.87	1.36
	SD	232.64	82.06	32.20	7.22	2.83	0.39

SR = Surface, SD = Sediments, B = Bacteria, A = Actinomycetes, F = Fungi

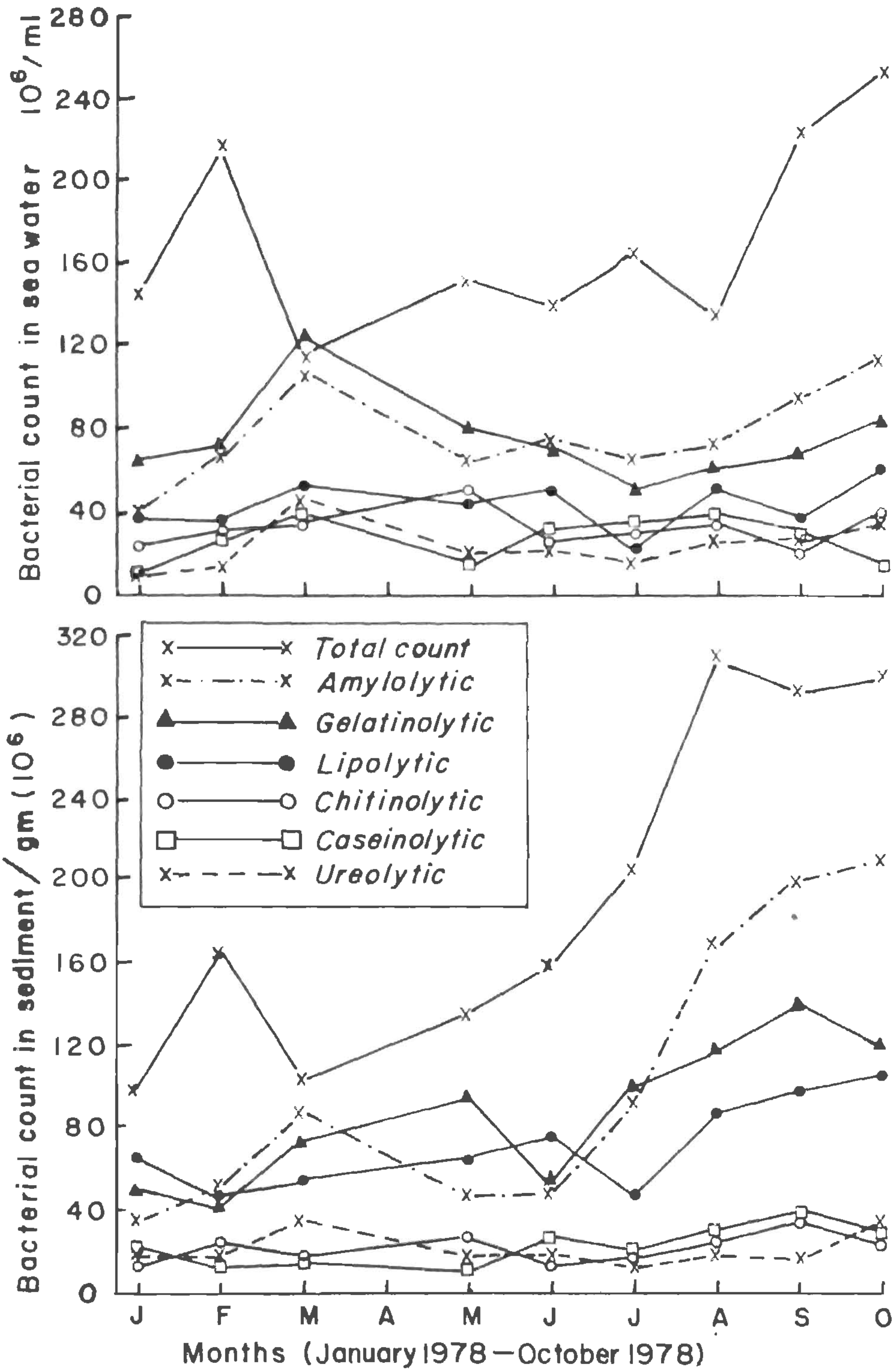

Fig. 2 The interrelationship of different microbial flora in waters and sediment off Cochin.

is evident that marine microbes play a significant role in biodegradation of water weeds like *Salvinia*. Bacteria isolated from sea water is equally virulent in the biochemical activity when compared to the bacteria isolated from the sediment. Fungi and actinomycetes were found to be only secondary disintegrators of organic matter in the marine environment.

DISCUSSION

The vast expanse of fresh and brackish water areas available in this region provides an ideal situation for the aquatic plants such as *Salvinia* to grow and flourish. The process is accelerated by the presence of excess nutrients, especially phosphate reaching the backwaters from the adjacent agricultural lands through rivers and streams. These nutrients promote the growth of water plants which are often limited by a natural shortage of nutrients. Considering the ecological peculiarities of this area, and the availability of plenty of water resources in the form of rivers, lakes and backwaters, the weed growth and subsequent problems caused by it are of great significance.

The effect of this phenomena on the aquatic resource in general and on the fisheries in particular is of considerable interest. The weeds utilize most of the available nutrients thus restricting the survival and growth of other useful plants and animals. Further, the free use of water ways is disturbed and also the flow of water is reduced. When they remain as a thick mat, the penetration of light is reduced to a considerable extent. The floating weeds interferes with the operation of fishing gears like stake nets and dip nets in the estuarine areas and also interferes with the trawl net operations in the inshore fishing areas. As soon as the weeds come into contact with saline water they start to decay and eventually settles at the bottom.

The present observations agree with the previous reports on the ecology of *Salvinia* in estuarine waters of Cochin in certain aspects by Gopalan and Nair (1975). They stated that the density of fauna of the level bottom under the weed mat is considerably poorer than the open area and the oxygen level of bottom waters in the weed covered areas was 2.82 ml/l whereas that of adjacent open waters was 4.31 ml/l in November. The present record of very low oxygen scale weed deposition at the bottom probably explains that the same conditions were prevailing in the inshore waters at that time.

There is practically no information on the effect of *Salvinia* and its decomposition products on the ecosystem. When the weed floats on the surface as a compact mass it prevents vertical mixing, shade out the phytoplankton and allow increase in free CO_2 and consequent decrease in pH. With the subsequent settling and decay of the weeds the pH in the sediment tend to rise. Present studies on primary productivity at the benthic area revealed that high dark fixation values (upto 100%) are present on several occasions. In normal sea water the dark fixation due to chæmosynthetic bacteria is usually found to vary between 1–2%, but as reported by Nielsen and Jensen (1957) it can be as high as 5% in certain specialised ecosystems. Nielsen (1960) has shown that dark fixation by bacteria tend to ascend rapidly instead of reaching a saturation plateau thereby the relative dark fixation exceeding 100% is attained for a six hour experiment. It is likely that the high bacterial population generated by the decaying weeds when enclosed in a bottle with C^{14} showed exhorbitantly high values as compared to phytoplankton production measured from the sea surface waters. The occurrence of ærobic chitin decomposing bacteria such as *Alcaligenes* and *Pseudomonas* in the sediments with a high rate of degradation potential as evidenced by their biochemical activities is a significant factor.

The fishery of this area is composed of both pelagic as well as benthic groups, of which shrimps dominate in the landings to a great extent. The period of weed deposition in the inshore area is in the period June-January which is repeated every year. The effect of weed deposition at the inshore area on the living resources is not yet fully understood. However, the phenomenon is of some significance since the monsoon season is the period of breeding of most of the commercially important species in these waters. Any disturbance in the ecosystem adversely affect the activities of the organisms. The effect of weed deposits on the benthic population appears to be transitional. Since the phenomena is repeated every year for a long time, it is quite possible that there will be a shift in the pattern of benthic population by the replacement of a resistant group in the benthic area of the inshore waters of this region which can, in the long run, even alter the food chain relationship.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute for suggesting the problem and encouragements during the course of this investigation. They wish to record their sincere thanks to Dr. P. Parameswaran Pillai for critically going through the manuscript.

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CONTROL OF *IMPERATA CYLINDRICA* WITH ASULAM/DALAPON COMBINATION: OBSERVATION ON THE EFFECT OF PLANT SIZE AND SHADING

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ABSTRACT

Three field experiments on asulam/dalapon combination for control of lalang [*Imperata cylindrica* (L.) Beauv.] were conducted in mid – 1980 in Chantaburi, Thailand. The formulated combinations as ARD 13/31 at 2.86 + 4.29, 4 + 6 and 4.57 + 6.68 kg a.i./ha of asulam and dalapon respectively were applied to the young plants naturally grown under approximately 70% rubber shade and to the mature plants naturally grown in the open. It was found that in the first 3 months all the combinations provided a quite complete control of lalang in both locations. At 240 days after treatment the mature plants in the open produced regrowth 50 to 60% of the overall area while less than 10% of regrowth was observed with the youngers under shade.

The tank mix combinations of asulam/dalapon respectively at the rates 2 + 7.5, 2 + 10 and 3 + 10 kg a.i./ha on the young plants under shade also resulted in the same degree of control and regrowth of lalang as these of the ARD 13/31 combinations. The regrowth percentage of the youngers under shade was slightly less than those of the youngers in the open. Overall regrowth of the young plants in the open experiment observed at 240 days after application slightly exceeded 10%.

INTRODUCTION

The package product, asulam (methyl sulfanilyl carbamate)/dalapon(2,2-dichloropropionic acid), applied as the tank mix, has been sold in the local market since 1979. The combination was also reported effective against lalang [*Imperata cylindrica* (L.) Beauv.] under field condition in Malaysia (Hill and Ingran, 1980) and Thailand (Suwannaketnikom, 1980).

In 1980 the combination, under the code name ARD 13/31, was formulated as the mixed compound and has been marketing for the control of lalang in Malaysia. From the economic point of view, in Thailand, the chemical is still rather expensive and the cost can be lowered according to the observation when applied as the tank mix. Objectives of the studies are to observe the efficacy of asulam/dalapon combination applied as ARD 13/31 and as the tank mix for control of the naturally grown lalang at the young and full grown growth stages and when the plants grown under shade and open conditions.

MATERIAL AND METHODS

Three experiments were conducted in Chantburi, a hot and humid region in the east coast, 330 km to the east from Bangkok during July 1980 and May 1981. Rainfall usually occurs quite heavily in mid-April to May and July to September. The areas of pure and quite uniform stands of lalang were selected for the experiments under different conditions. The experimental plots were arranged in randomized complete block design. Each plot accommodated 3 fixed quadrats, 50 by 50 cm, by using 25 cm long stakes pegged into the soil. Stands of lalang in each quadrat were counted before and periodically after the herbicide application. Herbicides were applied through a knapsack sprayer equipped with a single flood jet nozzle (tip TK 2) discharging 1,000 L ha^{-1} at a pressure of 2.12 kg cm^{-2}.

The herbicidal effectiveness was evaluated at 0, 60, 90, 120, 150 and 180 days after application (DAA) by counting plant regrowth in the 'quadrat.' At 240 days after application assessments were made by visual observation of the percentage of overall regrowth in the plots.

Details of each experiment were described below:

	Experiment I	Experiment II	Experiment III
	Young plants, Under 70% shade	Mature plants, In open	Young plants, In open
Plant height (cm)	80 - 120	140 - 180	80 - 120
Shading (%)	70	0	0
Plot size (m^2)	3 x 8	3 x 5	3 x 5
Quadrats (50 by 50 cm) per plot	3	3	3
Replications	4	3	3
Type of combination and rates (kg a.i./ha) of asulam + dalapon)	a) ARD 13/31	ARD 13/31	Tank mix
	2.86 + 4.29	2.86 + 4.29	2.5 + 7.5
	4 + 6	4 + 6	2.5 + 10
	4.57 + 6.68	4.57 + 6.68	3 + 10
	b) Tank mix		
	2 + 7.5		
	2 + 10		
	3 + 10		
Application date	July 28, 1980	July 30, 1980	Sept. 8, 1980

RESULTS AND DISCUSSION

The effects of asulam/dalapon combination as ARD 13/31 at 3 rates on lalang are shown in Table 1. At 90 days after application (DAA) of asulam/dalapon the effects on the younger plants in 70% shade were more or less similar to the mature plants in the open condition. In all treatment in both conditions, regrowth occurred mostly in 2 to 5% of the initial population (Table 1). On the youngers in shade the regrowth percentage was maintained at this level even at 180 days after application whereas the percentage went up to about 10 (at medium and high rates) to 20 (at low rate) on the mature plants in the open. The differences were even more clearly distinguished at 240 days after application. As the mature plants in the open produced about 50 to 60% regrowth the young plants in shade produced only less than 10% regrowth of overall.

Young plants were more affected by the ARD 13/31 compared to the mature plants, as observed by Ivens (1976) on *Imperata cylindrica* with dalapon and glyphosate. Asulam is more dependent on the stage of growth than dalapon or glyphosate, as the herbicide absorption depends on the nature of leaf surface which vary as the plant ages. Young leaves may have an incomplete wax deposit and may retain more spray than the mature foliage (Fryer and Evans, 1970). Shading is no doubt

Table 1: Effect of asulam/dalapon combination as ARD 13/31 on the young plants under the shade and on the matured plants in the open field.

Treatment, kg a.i./ha	Expt. I. Young plants, 70% shade				Expt. II, Mature plants, 0% shade			
	Initial stands/ quadrat	Regrowth, of initial 90 DAA	as % stands 180 DAA	Overall regrowth, % 240 DAA	Initial stands/ quadrat	Regrowth, of initial 90 DAA	as % stands 180 DAA	Overall regrówth, % 240 DAA
ARD 13/31								
Asulam/dalapon								
2.86 + 4.29	28.5	5.9	3.3	< 10	94.6	5.3	19.8	60.0
4.00 + 6.00	20.5	2.3	0.7	< 10	94.2	2.1	9.8	52.0
4.57 + 6.68	27.2	0.3	0.3	< 10	93.4	3.0	12.7	48.3
Glyphosate								
2.05	18.5	3.7	2.3	< 10	84.5	9.5	29.4	43.3
3.00	20.1	0.0	0.0	0	72.1	2.3	8.0	8.0
C. D. (P=0.05)	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	26.9

Quadrat = 50 cm x 50 cm; DAA = days after application

Table 2 : Effect of asulam/dalapon as tank mix combination on the young plants under shade and in the open condition.

Treatment kg a.i./ha	Initial stands/quadrat	Regrowth, as % of initial stands		Overall regrowth %
		90 DAA	180 DAA	240 DAA
Experiment I				
Plants under 70 % shade				
Asulam/dalapon tank mix				
2 + 7.5	19.6	0.3	0.8	< 10
2 + 10	20.6	0.9	1.0	< 10
3 + 10	20.6	0.0	0.0	< 10
Dalapon 10 + 8[1]	22.8	1.0	0.2	< 10
C. D. (P = 0.05)	N.S.	N.S.	N.S.	N.S.
Experiment III				
Plants in the open		90 DAA	150 DAA	240 DAA
Asulam/dalapon tank mix				
2.5 + 7.5	62.3	1.3	3.9	12.7
2.5 + 10	50.0	1.7	3.1	13.3
3 + 10	54.3	2.2	12.3	11.0
Dalapon 10 single appl.	63.7	6.3	12.1	31.7
C. D. (P = 0.05)	N.S.	N.S.	N.S.	N.S.

[1] Split application 2 weeks apart

another factor contributing to the different responses of the plants to the herbicide applied in both conditions. Treatments of asulam/dalapon as tank mix at 2.0 + 7.5, 2.0 + 10 and 3 + 10 kg a.i./ha^{-1} on younger plants under shade were found as effective on lalang as those of ARD 13/31 [probably even more (Table 2)]. It would probably be justified enough to compare the tank mix combination effects on lalang under shade and in the open even through some rates of asulam were slightly different.

At 90 DAA on the young plants under shade, regrowth occurred about 1 % compared with slightly more than 1 % on the young plants in the open (Table 2). The regrowth percentage of the plants in the open was increased up to 3 to 4 at 150 days while the plants under shade showed only very small increase at 180 DAA. At 240 days the plants in the open gave about 12% regrowth whereas the ones under shade produced less than 10% regrowth from the overall visual observation.

Anyway it can be noted the plants under shade were more sensitive to the tank mix of asulam/dalapon combination when compared with the plants in the open, even though the difference was not much. Lalang plants in full sunlight were found to produce three times as much total dry weight and leaf area as those in 56% full sunlight and twenty times as much as those in 11% full light after 89 days of growing (Petterson, 1980). Also relative humidity and light (Bukovac, 1976) might favour directly or indirectly the chemical absorption to the plants under shade.

From the three experiments it can be concluded that application of asulam/dalapon combination needs more specific timing to obtain a long run control of lalang, compared to glyphosate. The plants should be young and really in active stage. The plants under shade are more sensitive to the chemicals.

ACKNOWLEDGEMENTS

The authors wish to thank the May and Baker (Thailand) Co. Ltd., for providing facilities and chemicals for the research. The field assistance of Mr. S. Sawasdichai is also greatly appreciated.

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BIOLOGY OF *PARTHENIUM HYSTEROPHORUS* LINN. AND ITS ALLELOPATHIC EFFECT ON SUCCEEDING CROPS

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ABSTRACT

In a potculture study conducted during monsoon 1976-77 at Hebbal on the biology of *Parthenium hysterophorus* Linn., it was observed that the growth and spread of the weed was low upto 75th day from germination (rosette stage) and this stage appeared to be vulnerable for easy chemical control. From this stage onwards, dry weight increased consistently upto 165th day due to increase in plant spread in terms of secondary branches and leaf production. Added to this, flower production also increased from 75th day to 210th day. The weed growth in terms of leaf number and branches ceased at 165th day after emergence, but continued with flower production. Number of seeds/plant increased from 75th day (65) to 225th day (22,538). Dry matter distribution in different plant parts at different stages are discussed.

The allelopathic effect of *Parthenium* on succeeding field crops was studied through the pre-sowing incorporation of powdered *Parthenium* plant into the soil. Generally incorporation reduced the germination and growth of pulses more than cereals. Though the germination of paddy, oats and barley was not affected, further growth was reduced considerably. All the field crops showed a drastic reduction in plant dry weight. The reduction in dry weight was reflected through reduction in root length, number of leaves, tillers or branches and plant height. The study also brought out that the plant growth decreased with advance in growth, indicating continued inhibition.

INTRODUCTION

Parthenium hysterophorus Linn. belongs to the family Asteraceae. The weed in its introduction of 2½ decades, has spread to all parts of the country and is present in varying proportions causing alarm to the public and more so to the cultivators in selected patches. The weed is seen growing throughout the year and produces about 20,000 seeds/plant/year. However, systematic attempt has not been made to study the biology of weed. There is also an indication that the weed contains water soluble inhibitors like P-coumaric acid and caffeic acid which retards the growth of the crop. In this investigation, an attempt has been made to know the effect of incorporation of the weed on the succeeding crops.

MATERIAL AND METHODS

A potculture experiment on biology of *P. hysterophorus* was conducted for seven and half months from 1st May, 1976 at Hebbal. A pot size of 32 cm x 35 cm with 20 kg red sandy soil was used for raising four plants in each pot. The design followed was RBD with five replications. Fifteen fortnightly interval samples were taken from 15th upto 225 days after sowing to note the growth and multiplication of weed. The samples were taken upto 225 days only, as no further increase in dry matter was seen and there was some dessication of the plant.

In another potculture, study on pre-sowing incorporation of *Parthenium* dried powdered leaves, stem and flower was done during winter 1976. Thirteen crops like finger millet (*Eleusine coracana*

Table 1: Dry matter accumulation (g/plant) and distribution (% to total) in different plant parts in *Parthenium* at different growth stages.

Days after sowing	Dry weight/plant			
	Stem	Leaf	Flower	Total
15	0.07 (83.33)*	0.01 (16.67)	0.00 (0.00)	0.08
30	0.27 (53.30)	0.24 (46.70)	0.00 (0.00)	0.51
45	0.46 (32.40)	0.95 (66.90)	0.01 (0.70)	1.42
60	0.56 (22.39)	1.92 (76.41)	0.03 (1.20)	2.51
75	2.18 (36.60)	3.35 (56.20)	0.43 (7.20)	5.96
90	11.60 (51.55)	3.90 (17.33)	7.00 (31.12)	22.50
105	14.35 (54.13)	4.00 (15.08)	8.16 (30.79)	26.51
120	20.96 (56.98)	4.87 (13.25)	10.95 (29.77)	36.78
135	22.50 (57.84)	5.10 (13.11)	11.30 (29.05)	38.90
150	24.40 (49.59)	5.30 (10.77)	19.50 (39.64)	49.20
165	23.30 (42.03)	5.60 (10.10)	26.54 (47.87)	55.44
180	22.30 (41.68)	5.02 (9.38)	26.18 (48.94)	53.50
195	20.90 (44.05)	4.15 (8.75)	22.40 (47.20)	47.45
210	16.59 (47.05)	2.36 (6.69)	16.31 (46.26)	35.26
225	12.80 (49.23)	0.20 (0.77)	13.00 (50.00)	26.00
C.D. (P=0.05)	2.71	0.91	3.12	4.23

* Figures in the parantheses are per cent to total.

Gaertn.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), oats (*Avena sativa* L.), paddy (*Oryza sativa* L.), sorghum (*Sorghum bicolor* L.), maize (*Zea mays* L.) (cereals), soybean [*Glycine max* (L.) Merill], groundnut (*Arachis hypogea* L.), greengram *Vigna radiata* L.), blackgram (*Vigna mungo* L.), cowpea (*Vigna unguiculata* L.), and frenchbean (*Phaseolus vulgaris* L.) (pulses), were grown under normal conditions as well as in *Parthenium* incorporated pots. The design RBD with three replications was followed.

The pots of 42 cm x 42 cm with 28 kg red sandy soil were used for this study. Fifty grams of dried *Parthenium* powder (entire plant) was added to each pot 15 days prior to sowing of the crops. Water was added to these pots once in 4 days prior to sowing. Fifty seeds of each crop were sown in each pot well spread over. The recommended dosage of fertilizer as applicable to these crops were applied to both treated and untreated pots at sowing.

RESULTS AND DISCUSSION

Biology

The weed growth followed 'S' shaped growth as in other species (Table 1). The weed dry weight showed a gradual increase upto 75th day due to slow growth of the weed as evident from low increase in plant height and leaf production (Table 2). Then onwards dry matter increased consistently upto 165th day coinciding with rapid rate of senescence of leaves. The increase in dry matter/plant was nearly four-fold between 75 and 90 days mainly due to increase in secondary branches (nearly 6 times more), green leaves/plant (2½ times more), flowers/plant (18 times more) and seeds/plant (55 times more). At this period, increase in plant spread was almost

Table 2: Growth and multiplication of *Parthenium* at different growth stages.

Days after sowing	Plant height, cm	Branches/plant		Leaves/plant		Flowers/plant		Seeds/ plant
		Primary	Secondary	Green	Dried	Green	Dried	
15	0.8	–	–	4.1	–	–	–	–
30	2.0	–	–	7.7	–	–	–	–
45	9.3	2.6	–	11.2	–	10	–	–
60	13.2	3.2	1.8	15.4	–	18	–	–
75	44.4	10.1	6.0	52.2	–	70	16	65
90	77.1	11.1	35.8	123.0	14.7	1271	858	3579
105	78.2	11.4	42.7	136.3	40.6	1318	1554	6478
120	78.7	11.4	46.1	194.7	57.0	1999	1962	8183
135	87.8	11.5	49.5	518.8	65.0	1285	2400	10008
150	95.2	11.7	54.9	528.0	88.3	1172	2896	12077
165	110.4	13.0	54.2	211.5	262.4	1007	4313	17986
180	111.3	13.7	54.6	132.5	334.8	708	4677	19501
195	111.5	13.9	54.5	57.3	96.3	677	5106	21292
210	111.3	13.8	54.3	14.4	14.6	434	5389	22474
225	111.0	13.9	54.4	0.8	1.4	244	5405	22538
C.D.(P=0.05)	8.8	1.7	9.9	86.4	30.6	324	919	3831

two fold due to increase in secondary branches/plant.

Prior to 75th day, the relative increase in total dry weight although meagre, was approximately two fold. Similarly, faster weed growth after bolting with numerous branches and flower production has been reported by Kanchan (1977) under Bangalore conditions. The consistent increase in weed dry weight in stages after 90 days upto 165th day was due to accumulation of dry matter in stem, leaves (slightly) and flowers (considerably). This increase in dry matter accumulation of stem and leaf was due to increase in plant height and plant spread owing to increase in number of branches (largely secondary branches). During this period, increase in dry matter of flowers (18 times) was due to increased flower production and seeds/plant. The dry weight showed a decline from 165th day onwards mainly due to increase in rate of senescence of leaves and curtailed green flower production. Further, the dry weight of the floral parts exceeded the weight of other parts and this characteristic of the weed leads to abundant seed production.

Flowering was observed from 45th day onwards and the rate of flowering was slight initially upto 75th day. Then onwards, flower production increased considerably upto 225 days after sowing with less rate after 120th day. Similarly Hasler (1976) observed flowering from 4th week onwards until senescence in about 15 weeks (105 days) under Queensland conditions.

Stem constitute larger fraction of the dry matter both during early phase of the weed growth while distribution of dry-matter into leaves showed an increase upto 60th day coinciding with the initiation of flowers. After the flower production, dry matter distribution to leaves decreased considerably, while the dry matter distribution to stem did not alter much. The dry matter distribution to flower increased linearly upto 225th day (Table 1).

With regard to seed production, seeds/ plant increased from 65 on 75th day to

Table 3: Effect of Pre-sowing incorporation of *Parthenium* on germination and growth of various crops.

Treatments	Germination % 11th day	42nd day after sowing: Plant height (cm)	Root length (cm)	Leaves/plant	Tillers or branches/plant	Total dry weight (g/plant)
Crops						
Finger millet	96.41 (99.33)* (98.7)**	27.20 (67.9)**	25.85 (79.9)**	15.70 (44.0)**	1.25 (43.7)**	3.03 (61.8)**
Barley	85.64 (97.33) (100.0)	29.07 (89.8)	19.40 (86.2)	16.27 (54.9)	3.07 (43.8)	2.98 (51.7)
Wheat	84.78 (96.33) (95.3)	26.57 (91.6)	20.72 (81.5)	19.18 (64.4)	5.37 (56.3)	2.08 (58.2)
Oats	85.77 (97.33) (100.0)	35.82 (95.7)	16.35 (96.2)	9.27 (49.5)	1.58 (19.8)	2.62 (51.7)
Paddy	58.48 (71.33) (68.4)	11.55 (69.4)	15.30 (89.3)	19.37 (61.4)	6.17 (58.1)	1.06 (41.3)
Sorghum	75.85 (91.00) (96.4)	14.83 (56.0)	18.85 (79.8)	4.35 (77.6)	–	1.93 (41.6)
Maize	60.05 (75.00) (95.7)	33.65 (64.3)	27.63 (51.55)	5.67 (61.9)	–	6.94 (50.1)
Soybean	59.76 (74.33) (92.2)	32.35 (67.0)	20.00 (91.7)	7.87 (69.8)	3.17 (72.7)	2.47 (64.9)
Groundnut	41.53 (44.33) (35.7)	10.80 (73.7)	10.37 (89.6)	3.72 (85.5)	3.02 (49.6)	1.08 (51.4)
Greengram	63.19 (79.00) (97.5)	11.83 (62.1)	9.03 (72.0)	3.93 (84.4)	1.75 (40.0)	0.82 (18.6)
Blackgram	49.44 (57.33) (67.0)	12.95 (69.7)	11.60 (74.9)	4.37 (61.7)	2.42 (45.0)	1.10 (24.3)
Cowpea	74.25 (91.66) (90.9)	16.23 (66.8)	15.50 (85.6)	4.20 (64.7)	3.17 (72.7)	1.78 (42.4)
French bean	63.41 (80.33) (97.5)	21.13 (54.6)	15.57 (76.9)	4.03 (77.9)	2.75 (83.3)	1.87 (47.4)
C.D. (P=0.05)	10.35	4.01	3.24	2.15	–	1.00
Parthenium						
Incorporation	65.50 (76.46) (89.1)	18.40 (72.7)	15.37 (79.1)	6.83 (60.43)	–	1.53 (50.3)
Control	72.74 (85.79) –	25.29 –	19.42 –	11.31 –	–	3.05 –
F-test	**	*	**	**	–	**
F-test for interaction	N.S.	**	**	**	–	**

* Values within the parentheses are original figures, ** Figures represent per cent of the control, Data analysed using angular transformation.

22,538 on 225th day coinciding with complete maturity (Table 2). This gregarious nature of the weed helps in the production of numerous seeds and colonise the area by periodical germination. The earlier studies though not systematic in knowing the seed production potential, however, indicated varying seed production of 2000 to 20,000/plant/year (Hosmani and Prabhakara Setty, 1973; Mani *et al.*, 1976).

The study indicated slow rate of growth of the weed upto 75th day (coinciding bolting stage) which makes any attempt to kill this weed easier.

Allelopathic effect

Pre-sowing incorporation of *Parthenium* powder relatively lessened the germination of pulses than cereals, besides reducing the dry weight/plant (Table 3). This might be attributed to increased inhibition due to presence of water-soluble growth inhibitors in the *Parthenium*, as pointed out by Kanchan (1977).

Barley, oats, wheat and finger millet though had fairly higher germination in *Parthenium* incorporated pot, failed in dry weight. This reduction in dry weight was reflected more through reduction in number of leaves/plant and number of tillers/plant rather than reduction in plant height and root length. Paddy had moderate germination with considerable reduction in dry weight as reflected through reduction in number of leaves/plant, number of tillers/plant, plant height and root length. Cowpea had the least germination but the growth was better than others, though lower than control. Sorghum had relatively more adverse effect on dry weight than maize, even though both were similar in germination. This emphasizes the differential allelopathic effect of *Parthenium* on field crops.

With advance in crop growth, the inhibition effect on plant height, root length, number of leaves/plant and plant dry weight continued indicating continued presence of growth inhibitors and/or release of inhibitors. Similar indication of continued stunted growth of crops has also been observed due to the presence of inhibitors from the *Parthenium* (Kanchan, 1977).

CONCLUSION

Parthenium hysterophorus showed slow growth upto 75th day after sowing coinciding with the flowering stage and any effort directed to kill the weed will be easier at this stage. Plant produced flowers profusely and seeds to the extent of 22,538/plant in 225 days of living under potculture condition. The plant possess allelopathic effect on the field crops being the same more in pulses than in cereals, if field previously infested is used for sowing these crops. Both germination and growth were affected differentially depending on the field crop.

ACKNOWLEDGEMENTS

Authors are thankful to Mr. T. V. Ramachandra Prasad, Junior Agronomist, AICRP on Weed Control, UAS, GKVK for his valuable suggestions and help during the research work. Thanks are also due to the University of Agricultural Sciences, Bangalore for the necessary facilities.

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ALLELOPATHIC POTENTIAL OF *ECHINOPS ECHINATUS* ROXB.

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ABSTRACT

Echinops echinatus Roxb. is a winter season weed of north India, but it appears in the wet season in Indian arid zone, where it also perennates by rootstocks. The weed produces the allelopathic effects in the field, which reduce the growth and yield of pearl millet (*Pennisetum typhoideum* Rich.) and sesamum (*Sesamum indicum* L.) crops. The effect of aqueous extracts of leaf, stem and root of the weed has been studied on the germination of seed and seedling growth of pearl millet and sesamum. The order of inhibition was stem > root > leaf. Polarity of the allelochemics was determined by extracting parts of weed in different solvents (petroleum ether, benzene, chloroform, acetone, ethanol, methanol and water). In field, maximum inhibition was recorded in pearl millet where the weed biomass was earlier buried, while burnt biomass of the weed increased the yield of these crops.

INTRODUCTION

Echinops echinatus Roxb. (Family: Asteraceæ) is one of the most common weeds of winter season, but it appears in the wet season in Indian arid zone where it also perennates by rootstocks (Jha and Sen, 1981). It is a herb and a well placed plant is 1-2 m in height. It is spreading very fast from fallow, uncared and waste places to cultivated fields (Bhandari and Sen, 1979). Sarmà (1974) has reported its allelopathic effect and Jha and Sen (1981) have stated that the dry plant parts of this weed create toxic effects on plants of the next crop.

The present study was conducted to investigate the allelopathic interference of *E. echinatus* with two main crops of arid zone viz., pearl millet and sesamum under laboratory and field conditions.

MATERIAL AND METHODS

Ten grams of air-dried materials of leaf, stem and root of *E. echinatus* Roxb. were ground separately with 100 ml of distilled water and stored for 24 hr at 5°C. The filtrates obtained from these were taken as stock aqueous extracts and various dilutions of 1, 3, 5 and 10% were prepared. The seeds of pearl millet and sesamum were kept for germination in sterilized petri dishes in triplicate, lined with filter paper which was moistened with different concentrations of aqueous extracts or with distilled water for control. The number of seeds kept for germination in each petri dish was 10, under room temperature of 28 ±2°C and light intensity of 1000 lx. The observations were recorded after 48 hr for pearl millet and 72 hr for sesamum for percentage seed germination, and linear growth of the radicle and hypocotyl.

Different organic solvents (petroleum ether, benzene, chloroform, acetone, ethanol, methanol and water) were used for determining the polarity of allelochemics. Ten grams of dry matter of different parts of each weed was extracted in these organic solvents separately and successively for 24 hr and seed of sesamum were used for bioassay.

Table 1 : Effect of aqueous extracts from root, stem and leaf of *E. echinatus* on the seed germination and linear growth of seedlings (cm) after 48 hr in pearl millet and 78 hr in sesamum.

Plant parts	Concentration (%)	Pearl millet			Sesamum		
		% germination	Radicle length	Hypocotyl length	% Germination	Radicle length	Hypocotyl length
Control		80.0 ± 5.66	2.33 ± 0.20	2.13 ± 0.35	96.6 ± 5.77	3.73 ± 0.23	1.50 ± 0.26
	1	76.6 ± 5.77	2.33 ± 0.20	2.33 ± 0.20	100.0 ± 0.00	0.93 ± 0.11	1.26 ± 0.05
Root	3	76.6 ± 5.77	2.16 ± 0.32	2.26 ± 0.20	100.0 ± 0.00	0.93 ± 0.11	1.26 ± 0.05
	5	70.0 ± 3.33	2.00 ± 0.20	1.60 ± 0.20	90.0 ± 10.00	0.63 ± 0.23	1.03 ± 0.05
	10	70.0 ± 3.30	1.73 ± 0.20	1.70 ± 0.20	90.0 ± 10.00	0.36 ± 0.28	0.66 ± 0.15
	1	76.6 ± 3.33	2.00 ± 0.23	1.66 ± 0.51	93.3 ± 5.77	0.73 ± 0.50	1.53 ± 0.05
Stem	3	76.6 ± 5.77	2.20 ± 0.10	1.73 ± 0.32	90.0 ± 3.35	0.53 ± 0.11	1.00 ± 0.11
	5	76.6 ± 3.33	2.16 ± 0.32	1.56 ± 0.05	90.0 ± 3.35	0.50 ± 0.10	1.03 ± 0.11
	10	73.3 ± 5.77	2.00 ± 0.20	1.73 ± 0.30	86.6 ± 3.31	0.23 ± 0.05	0.60 ± 0.00
	1	66.6 ± 3.35	2.00 ± 0.20	2.36 ± 0.32	90.0 ± 3.35	2.03 ± 0.15	1.66 ± 0.40
Leaf	3	60.0 ± 3.33	2.03 ± 0.41	1.90 ± 0.10	86.6 ± 3.31	1.23 ± 0.25	1.10 ± 0.10
	5	66.6 ± 5.77	2.96 ± 0.96	2.20 ± 0.26	86.6 ± 3.31	0.96 ± 0.25	0.86 ± 0.15
	10	70.0 ± 6.66	2.66 ± 0.66	2.23 ± 0.32	76.6 ± 5.77	0.43 ± 0.05	0.70 ± 0.10

The allelopathic effect of *E. echinatus* at field level was also tested in plots of 4 m by 4 m. Three sets of plots were prepared: (i) with buried biomass, (ii) with burnt biomass, and (iii) without biomass of *E. echinatus*, as control. The crops in Indian arid zone are totally dependent on rainfall which is extremely erratic. Present experiment in field was carried out under natural semi arid climatic conditions. Immediately after first rain in July, the crop seeds were sown in the plots. Different growth parameters and crop yield were measured at the time of harvesting when the crops were about 3 months old.

RESULTS

Extracts of different concentrations of *E. echinatus* exhibited inhibition of radicle and hypocotyl growth. The percentage of seed germination also decreased in both the crops, except in sesamum where 1 and 3% root extracts promoted it. Maximum inhibition in sesamum was recorded in stem extract followed by leaf and root extracts. Radicle length in sesamum was highly reduced as compared with hypocotyl length, but in pearl millet the degree of inhibition in seedlings was lesser than sesamum. Leaf extract of weed was found to be promoting for pearl millet seedlings except at 10% concentration (Table 1).

Extracts of different parts of *E. echinatus* in different organic solvents exhibited variation in allelopathic effects on seedlings of *S. indicum*. In separate extracts, maximum inhibition of seedlings was caused in water extract followed by petroleum ether, ethanol, methanol, acetone, benzene and chloroform. In successive extracts, maximum inhibition was recorded in methanol followed by water, ethanol, petroleum ether, acetone, chloroform and benzene (Table 2).

Crop husbandry practice revealed that buried biomass of this weed inhibited in both the crops and yield was also reduced by 50% pearl millet and 32% in seasmum

Table 2: Effect of *E. echinatus* extracted separately and successively in different organic solvents on the seedling growth (cm) of sesamum after 72 hr.

Organic solvents	Separate extraction						Successive extraction					
	Leaf		Stem		Root		Leaf		Stem		Root	
	Rad.	Hypo.	Rad.	Hypo.	Rad.	Hypo.	Rad.	Hypo.	Rad.	Hypo.	Rad.	Hypo.
Petroleum ether	0.36 ±0.05	0.53 ±0.11	2.10 ±0.75	1.30 ±0.17	2.30 ±0.20	1.20 ±0.10	0.67 ±0.05	0.86 ±0.11	2.16 ±0.75	1.83 ±0.40	2.50 ±0.20	1.63 ±0.25
Benzene	2.90 ±0.10	1.80 ±0.20	4.13 ±0.32	2.00 ±0.40	3.16 ±0.35	1.50 ±0.26	2.80 ±0.34	1.93 ±0.20	3.56 ±0.32	2.26 ±0.25	3.27 ±0.20	2.13 ±0.35
Chloroform	3.16 ±0.40	1.46 ±0.40	3.36 ±1.26	1.76 ±0.15	2.73 ±0.23	1.50 ±0.20	3.03 ±0.05	1.87 ±0.20	2.16 ±0.72	2.00 ±0.45	3.13 ±0.70	2.20 ±0.26
Acetone	2.86 ±0.98	1.60 ±0.17	2.46 ±0.55	1.83 ±0.46	3.40 ±0.36	1.80 ±0.17	2.10 ±0.30	1.73 ±0.11	2.73 ±0.68	1.80 ±0.50	2.23 ±0.50	2.03 ±0.15
Ethanol	0.76 ±0.05	0.80 ±0.17	0.13 ±0.05	0.56 ±0.05	1.33 ±0.66	1.53 ±0.15	1.23 ±0.45	1.70 ±0.26	0.26 ±0.05	0.76 ±0.15	1.83 ±0.37	1.93 ±0.51
Methanol	0.93 ±0.11	0.86 ±0.05	1.36 ±0.23	1.46 ±0.20	0.90 ±0.45	1.33 ±0.28	0.40 ±0.02	1.10 ±0.26	0.36 ±0.25	0.80 ±0.20	0.33 ±0.05	1.43 ±0.15
Water	0.26 ±0.05	0.70 ±0.10	1.43 ±0.51	1.36 ±0.30	0.80 ±0.36	1.03 ±0.25	0.50 ±0.17	1.40 ±0.10	0.76 ±0.45	0.93 ±0.20	1.60 ±0.34	2.37 ±0.05
Control	2.80 ±0.32	1.66 ±0.35					2.80 ±0.32	1.66 ±0.35				

Table 3: Allelopathic influences of *E. echinatus* on different yield parameters of pearl millet and sesamum.

Allelopathic treatments	Plant height (cm)	Ear length (cm)	No. of ears/ plant	No. of tillers/ plant	Yield kg/ha	% increase or decrease in yield
Pearl millet only	104.4 ± 12.5	20.3 ± 3.9	3.3 ± 1.1	5.20 ± 1.1	303 ± 30	–
Pearl millet + weed buried	60.0 ± 27.4	17.5 ± 2.7	1.8 ± 0.8	4.0 ± 1.0	152 ± 17	−49.8
Pearl millet + weed burnt	105.2 ± 20.0	19.5 ± 3.4	3.0 ± 0.7	4.0 ± 1.0	354 ± 34	+ 16.8
	Plant height (cm)	Pod length (cm)	No. of pods/ plant	No. of branches/ plant	Yield kg/ha	% increase or decrease in yield
Sesamum only	74.0 ± 13.8	2.48 ± 0.38	20.4 ± 10.4	3.57 ± 1.8	247 ± 35	–
Sesamum + weed buried	62.5 ± 9.9	2.23 ± 0.24	19.5 ± 3.7	4.4 ± 1.1	166 ± 31	−32.4
Sesamum + weed burnt	85.7 ± 9.3	2.50 ± 0.3	19.5 ± 6.5	3.0 ± 1.0	239 ± 18	− 3.2

(Table 3). Burnt biomass of the same weed in field either increased the growth parameters or were at par with control. An increase in yield of pearl millet by 17% was recorded, while in case of sesamum + burnt biomass it was nearly equal to control.

DISCUSSION

E. echinatus also possesses high allelopathic potentiality and its different parts exhibit varying influence on different crops. Even the degree of inhibition is different to different organ of the same plant. During the present study, it was found that the radicle growth was inhibited more than hypocotyl in both the crops. Similarly, Ashraf and Sen (1978) have also obtained differential behaviour of *Celosia argentea* L., in fields with pearl millet and sesamum and they extended the explanation that plants interact differently with each other. Further, extracts of *E. echinatus* reduced the seed germination maximum upto 25 in pearl millet and 21% in sesamum, as observed by Sarma (1974) in *Argemone mexicana* L.

For the chemical nature of inhibitors, different extracts from organic solvents produced some facts which need further experimentation. Datta and Chatterjee (1980) ruled out the presence of large molecules like pectins, polysaccharides or proteins in inhibitors soluble in alcohol. Sen *et al.* (1968) have reported presence of hentriacontane ($C_{31}H_{64}$), hentriacantanol ($C_{31}H_{64}O$), B-amyrian ($C_{30}H_{50}O$) and lupeol ($C_{30}H_{50}O$) soluble in alcohol. In the present case, inhibitors are soluble in ethanol and methanol. Inhibition from petroleum ether extract indicates presence of some fatty substances. Less effect of chloroform extract on bioassay attributes non-solubility of inhibitors specially alkaloids. In successive extracts the inhibitors get dissolved more in a particular solvent and so the degree of inhibition reduces towards high polarity solvents. This seems one of the reasons for less inhibition in water extract of successive than separate extraction. Beneficial effects of allelochemics are also envisaged which get dissolved in chloroform and benzene.

Minimization of losses due to allelopathic action is possible if crop husbandry practices be employed. Sen (1979) has attributed that the effect of burnt biomass of *Indigofera cordifolia* Heyne, *Digera muricata* Mart. and *Cucumis callosus* was far better than buried biomass on the growth of pearl millet. Present results favour the use of burnt biomass of *E. echinatus*, which could not only reduce the allelopathism, but also increases the yield of pearl millet and sesamum.

In conclusion, the bioassays used to test the allelopathic potentiality of *E. echinatus* confirm the presence of growth inhibitors produced by the extracts as well as by the decomposition of organic residues. Extracts of stem material is found to be more toxic than other parts to both the crops which may be considered as the repository of inhibitors. The allelopathic mechanism allows this weed to compete advantageously with other weeds and pollutes the soil system. Therefore, it is recommended here to use burnt biomass of this weed in field to overcome allelopathic effect and for better yield.

ACKNOWLEDGEMENTS

The authors wish to thank Prof. H. C. Arya for encouragement. Opportunity provided to the senior author to work at Jodhpur University by the Tribhuvan University, Nepal is gratefully acknowledged.

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EEFECT OF PARTHENIN AND 2,4-D ON THE GROWTH OF RYE

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ABSTRACT

Parthenium hysterophorus L., is notorious for its health and agricultural hazards in India now and is being investigated from various angles for its control. Parthenin is the major constituent responsible for its allergy and allelopathic effects and shows promise as a growth inhibitor and interacts with auxins and growth regulators. Present study is one more step towards the confirmation of such properties. Twenty five seeds each of Rye (*Secale cereale*) were soaked for 24 hr in different concentrations of 2,4-D (2,4-dichlorophenoxyacetic acid), parthenin and their combination along with a blank water control. All the three treatments progressively decreased percentage germination. Parthenin under the combination treatment neutralised slightly the toxic effect of 2,4-D. Parthenin alone did not affect the morphology of the seedlings but 2,4-D and 2,4-D plus parthenin treatments affected adversely. 2,4-D caused certain morphogenic abnormalities. Both tiller formation and root/shoot dry weight were affected by 2,4-D and 2,4-D plus parthenin. Although the inhibitory effect of combination treatment was exerted at the same concentration, as in that of 2,4-D alone, but at higher concentrations parthenin is able to neutralise it.

INTRODUCTION

The biological activity of the aqueous lechates from leaves and flowers of *Parthenium hysterophorus* L., was reported by Lakshmi Rajan (1973), and Sukhada (1975) attributed their growth inhibitory effect to parthenin, caffeic acid and P – coumaric acid. Comparative studies with other growth regulators and inhibitors were taken up with parthenin later to assess its relative strength as a growth inhibitor and it was found to behave as an antiauxin (Khosla *et al.*, 1980). Besides, to get a still broader view of its biological activity as a growth inhibitor, present study was undertaken which describes the comparative effects of 2,4-D and parthenin on the growth of rye (*S. cereale*).

MATERIAL AND METHODS

Twentyfive seeds of rye were soaked for 24 hr in different concentrations (0.025, . 0.05, 0.1, 0.5, 1.0 2.5 and 5.0 mg/ml) of 2,4-D, parthenin and 2,4-D plus parthenin. A blank-water control was also set, along with each replication. Experiment was run in three replicates. These seeds were subsequently washed and sown in 30 cm plots with soil and manure in 2 : 1 ratio. The plots were irrigated periodically when required. Observations were made after 50 days with regard to germination (%), number of tillers, dry weights of shoots and roots, and morphological abnormalities induced in the seedlings.

RESULTS AND DISCUSSION

Parthenin at 0.025 mg/ml concentration did not affect the germination but at higher concentrations there was a progressive decrease in germination rate which became significant at 0.5–5.0 mg/ml concentrations. Lakshmi Rajan (1973) had found a decrease of 80–90% after 20–40 hr of treatment with parthenin in wheat. According to Khosla and Sobti (1981), parthenin at 2–3 mg/ml became lethal for most of the dicotyledons studied and 0.8 mg/ml for barley.

2,4-D alone and in combination with parthenin caused a gradual decrease in germination with increase in the concentrations, and was significant at 0.05 mg in combination and 0.5 mg/ml in 2,4-D alone. Germination did not occur in 2,4-D alone at 2.5 mg and 2,4-D plus parthenin at 5.0 mg/ml. Dnyansagar and Khosla (1968) have observed inhibition of germination of *Cassia tora* L., *Achyranthes aspera* L. and *Ruellia tuberosa* L. seeds with 2,4-D and ascribed it due to failure of cell division and extension of the embryo cells within the seed.

Parthenin alone was less effective in checking germination comparatively than 2,4-D and 2,4-D plus parthenin. Further, 2,4-D at 1.0 mg/ml strongly inhibited the germination and at 2.5 – 5.0 mg/ml it became lethal. Whereas, only 5.0 mg/ml of combination treatment became lethal to germination. This indicates the presence of parthenin in combination treatment at 2.5 mg/ml is responsible for neutralizing the lethal effect of 2,4-D.

Morphology of the seedlings was also not affected by parthenin but with 2,4-D and combination treatments leaves were variously abnormal. These abnormalities include fusion, onion-like leaf formation besides narrow leaves. This was perhaps due to continued growth of the apical meristem and failure of lateral meristem development. In various cases only tip of the leaf was open resembling a spear thereby, indicating a partial fusion. Such fused leaves have been referred to as a result of connations (Dnyanasagar and Khosla, 1969). Leaves formed subsequent to these leaves were contorted which may be due to differential growth and some-times pierced through these leaves. They were usually not expanded and formed looped structures. The percentage of such abnormal seedlings increased with increase in their concentrations. It was 10.0, 16.6, 70.0 and 100% at 0.05, 0.1, 0.5 and 1.0 mg/ml respectively of 2,4-D treatment. But in the combination treatment these values were comparatively less because of the presence of parthenin. The percentage of abnormal plants here was 4.5, 21.0, 35.0 50.0 and 60% at 0.05, 0.1, 0.5, 1.0 and 2.5 mg/ml respectively.

Tiller formation in the plants was not affected by parthenin. But with 2,4-D at 0.025 mg/ml an increase in the number of tillers, root and shoot dry weight was observed and this increase was significant in the latter two characters. At higher concentrations, progressive decrease was observed, being significant in tillers and root dry weight at 0.1 mg, and shoot dry weight at 0.5 mg/ml. In the combination treatment also a progressive decrease was found and the trend was similar to 2,4-D alone treatment. Root and shoot dry weight, though decreased with increase in concentrations of 0.1 to 0.5 mg, the decrease was significant at 1.0 mg in root dry weight and 2.5 mg/ml in shoot dry weight.

CONCLUSION

Parthenin affected the germination and root/shoot dry weight comparatively at higher concentrations to that of 2,4-D and combination treatments, whereas, parthenin did not affect tillers and their morphology. Only 2,4-D at 0.025 mg/ml concentration increased root/shoot dry weight but in combination treatment such effects were not found because of the presence of parthenin in the treatment. Significant reduction of all growth processes was induced at the samel level of

Table 1: Effect of parthenin (P), 2,4-D and in combination on the germination, shoot/root dry weights and number of tillers/plant of rye.

Concen-trations (mg/ml)	Germination (%)			Root weight (g)			Shoot weight (g)			No. of tillers		
	P	2,4-D	P + 2,4-D	P	2,4-D	P + 2,4-D	P	2,4-D	P + 2,4-D	P	2,4-D	P + 2,4-D
0(Control)	79.70			0.62			1.51			1.38		
0.025	79.90	73.20	68.20	0.72	0.97*	0.58	1.50	2.30*	1.42	1.34	1.58	1.31
0.05	77.20	64.40*	55.50*	0.65	0.58	0.57	1.63	1.35	1.21	1.42	1.13	1.39
0.1	67.70	64.40*	53.30*	0.66	0.50*	0.46*	1.50	1.47	1.15	1.26	0.82*	1.08*
0.5	53.30*	55.50*	55.50*	0.52	0.26*	0.37*	1.23	0.86*	1.05*	1.26	0.45*	1.03*
1.0	42.40*	8.90*	51.00*	0.41*	0.03*	0.35*	1.31	0.08*	0.89*	1.12	0.33*	0.76*
2.5	49.00*	–	8.80*	0.46*	–	0.05*	1.01*	–	0.10	1.16	–	0.33*
5.0	19.90*	–	–	0.20*	–	–	0.53*	–	–	1.18	–	–

* indicates significant difference at 5% level from the control value

combination treatment. 2,4-D at 2.5-5.0 mg/ml became lethal but in combination treatment this effect was observed only at 5.0 mg/ml. At 2.5 mg/ml of combination, the lethal effects were counteracted due to the presence of parthenin. These observations show parthenin has an antiauxin activity.

ACKNOWLEDGEMENTS

The authors are highly grateful to the Director, Dr. C. K. Atal for providing the facilities and a keen interest in the subject.

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REPORT OF THE EIGHTH CONFERENCE OF THE ASIAN-PACIFIC WEED SCIENCE SOCIETY

The eighth conference of the Asian-Pacific Weed Science Society (APWSS) was held from November 22 to 29, 1981 at West-End Hotel, Bangalore, India. The conference was organised by the Indian Society of Weed Science (ISWS) and the University of Agricultural Sciences (UAS), Bangalore with the co-operation of the Karnataka State Department of Agriculture, Indian Council of Agricultural Research, Indian Institution of Agricultural Technologists and the Government of India, on behalf of the APWSS. The theme of the conference was 'Perennial weeds in crop-land and unwanted vegetation in cropped lands'.

To conduct the 8th conference at Bangalore, members of the Organising Committee established in 1980 were drawn from Indian Society of Weed Science, U.A.S., Karnataka State Department of Agriculture, Government of India, Indian Council of Agricultural Research and Indian Institution of Agricultural Technologists. Dr. R. Dwarakinath, was the Chairman of the Committee till 5-9-1981 when Dr. N. G. Perur suceeded him. Dr. K. Krishnamurthy was nominated as Conference Secretary, Mr. K. Shankar, as Treasurer and the Director of Agriculture as Deputy Chairman. Dr. T. V. Sampath, joined at the later stage as Deputy Chairman. The two years of programming and planning work for the conference was assisted by the other organising committee members such as Dr. U. C. Upadhyay, Dr. K. C. Nag, Prof. B. V. Venkata Rao, Mr. B. J. Nanjundappa, Dr. S. R. Chandrasekharaiah, Mr. T. V. Ramachandra Prasad, Mr Salil Singhal, Dr. S.V.R. Shetty, Dr. H. S. Gill, Dr. K. A. Jalihal, Dr. S. K. Mukhopadhyay, Dr. H. K. Pande, Mr. B. Venkataswamy and Dr. K. D. Paharia. In addition, members of sub-committees like programme, publication, reception and transportation, and tours and hospitality, have also helped in various ways in conducting of the conference. The help rendered by the office secretaries Mr. Mohamed Ayaz Ahmed and Mr. B. V. Rama Iyengar, needs appreciation. Dr. H. R. Arakeri, President (APWSS – 1979-81) was the main architect in guiding the Organising Committee members in various ways.

Registration of delegates to the conference commenced on Sunday, 22nd November at 1330 hr and was continued upto 1730 hr on Tuesday, 24th November 1981. Of the 311 delegates registered, 290 from 18 countries, participated in the deliberations of the conference. The participants, countrywise were Japan-41, Australia-3, UK-6, USA-8, Malaysia-7, Indonesia-10, Thailand-7, Pakistan-1, Bangla Desh-1, Sri Lanka-2, Nepal-1, Philippines-8, West Germany-4, New Zealand-4, Canada-1, Italy-2, Singapore-5, and India-178. From India, farmers and students also participated in the conference, besides spouses from foreign countries.

The conference was inaugurated by His Excellency Governor of Karnataka, Mr. Govind Narain on Monday, 23rd November, 1981 at 1000 hr at the Chowdaiah Memorial Hall, Bangalore. Inaugural session was attended by delegates, dignitaries of Govt. Departments and Organisations, Office bearers of the APWSS, ISWS, Faculty of UAS, and other distinguished guests. Dr. N. G. Perur, Chairman, Organising Committee welcomed the gathering followed by the Inaugural address by Mr. Govind Narain. Dr. O. P. Gautam, Director General, ICAR, New Delhi in his keynote address stressed the need for establishment of National Institute on Weed Research in order to foster the development of Weed Science in India. Dr. S. Matsunaka, President, International Weed Science Society introduced the activities of the society and requested the weed scientists to venture upon new technology to combat weed menace. Dr. H. R. Arakeri, President, APWSS, dealing with the genesis of the society, complimented the members on the achievement of the society in a short span of 14 years. He also requested the members to help in strengthening the society. The inaugural session came to a close with a vote of thanks by Dr. K. Krishnamurthy, Conference Secretary.

During the conference deliberations of four days from 23rd to 27th November 1981, 120 research papers were presented under 14 technical sessions namely – (a) invited papers; (b) papers of general interest; (c) new herbicides and appliances; (d) weed control in rice; (e) wheat; (f) plantation crops; (g) sorghum, maize, pulses and intercrops; (h) banana, cotton, potato, sugarbeet and sugarcane; (i) biology of weeds; (j) physiology of weeds and herbicides; (k) allelopathy of weeds; (l) herbicides residues and interactions; (m) aquatic weeds and their control; and (n) obnoxious weeds and their control. Each technical session was ably conducted by a Chairman with the assistance of a Co-Chairman. There was sufficient time for active and useful interactions among the participating delegates. Finally, in a session on 27th November 1981, 'General discussion on experiences useful to India', various problems relating to Indian situation were discussed at length. Based on the discussions, several recommendations were made for the overall development of weed science activities in Asian-Pacific region in general and India in particular.

A mid-conference tour was arranged on 25th November 1981, which included visits to the UAS Botanical Gardens, GKVK, Bangalore; Indian Institute of Horticultural Research, Hesarghatta; Screening trials on herbicides of the Alkali & Chemical Corporation of India Ltd., Begur, Indo-American Hybrid Seeds Centre, Bangalore and Banana demonstration plot in Talaghattapura. Again on 28th November 1981, as post-conference tour, delegates who could not attend on 25th November, were shown round the above places. In addition, interested delegates were taken to places of tourist interest like – Mysore, Brindavan Gardens, Sravanabelagola, Belur and Halebid on both the days by the official travel agents.

Two entertainment programmes were arranged in the evenings for the benefits of the delegates. On 22nd November 1981 at 1900 hr during conference dinner at the West-End Hotel, Bangalore, Mr. Seshadri of MICO, Bangalore presented an excellent slide show about Karnataka with the background of Indian classical music. The All India Radio artistes exhibited percussion instruments display. Again on 24th November, 1981 between 1900 to 2030 hr dance-ballet by Prabhat Kalavidaru was exhibited at Chowdaiah Memorial Hall, Bangalore, for the benefit of the conference delegates. This included presentation of the well known items of Indian classical dance like Mohini Bhasmasura, Shila Balikeyaru, Manipuri, Rasa Leela and Bhagavad Gita. The delegates appreciated the excellent performance of the artistes.

The Executive Committee meeting of APWSS was held at 1800 hr on 23rd November 1981 in the West-End Hotel and the General Body meeting of APWSS was held on 27th 1981 at 1645 hr with the induction of new office bearers.

On 25th November 1981, the day of mid-conference tour, annual conference of the Indian Society of Weed Science and General Body meeting to elect new office bearers and the workshop of All India Coordinated Research Programme on Weed Control to chalk out future research programmes, were held concurrently.

Ladies programme was also arranged for the spouses of the delegates to keep them engaged for the period of the conference. The help rendered by all those concerned in this programme is acknowledged.

A press conference was held on 28th November 1981 at 915 hr in the Board Room of the West End Hotel to brief on the conference outcome.

The conference concluded with a vote of thanks by the Conference Secretary Dr. K. Krishnamurthy, who expressed sincere thanks on behalf of the Organising Committee to all those (individuals, organisations, institutes and Industries) who helped in various capacities in conducting this conference.

Assistance provided by the following organisations in arranging lunchs to the delegates contributed in a big way in making the conference a great success. (1) M/s. Monsanto Chemicals of India Ltd., New Delhi, on 23rd November 1981; (2) M/s. Coromandel Indag Products (P) Ltd., Madras on 24th November; (3) M/s. Agromore Ltd., Bangalore and Alkali & Chemical Corporation of India Ltd., Bangalore, on 26th November; and (4) M/s. Pesticides India Ltd., Udaipur and Kumiai Chemical Industry Co. Ltd., Japan, on 27th November 1981. In addition, M/s. Bayers India Ltd., Bombay hosted lunch to the delegates of the Indian Society of Weed Science on 25th November 1981. The Committee expresses its gratitude to all of them.

In honour of the participating delegates to this International Conference for the first time in India, Government of Karnataka honoured the delegates by hosting them a prestigious 'STATE DINNER' on 26th November 1981, at Kumara Krupa, Bangalore. Dr. M. Soerjani (Indonesia) thanked the State Government on behalf of the delegates.

The Organising Committee expresses its sincere thanks to the Japanese Association for Photo-Regulators for providing $ 1000 to defray the initial expenditure of the conference. Thanks are due to financial assistance of Rs. 30,000 extended by the Indian Council of Agricultural Research, New Delhi, M/s. Kumiai Chemical Industry Co. Ltd., Japan for Rs. 25,000/- and the University of Agricultural Sciences, Bangalore, for Rs. 10,000/-. Thanks are also due to M/s. Hoechst Pharmaceuticals Limited, Bombay, Cyanamid India Limited, Bombay, Bharat Pulverising Mills Pvt. Ltd., Bombay, Coromandel Indag Products (P) Ltd., Madras and Spencer International Hotels Ltd., Madras, for providing advertisements.

The Organising Committee thanks the Government of India for permitting to hold the Eighth Conference at Bangalore and to grant VISA to the participating delegates from abroad. Special thanks should go to Organising Committee members and Volunteers who toiled day in and day out towards success of the Conference.

Also special recognition should go to Prof. B. V. Venkata Rao, and the members of Publication and Programme Committee for their excellent job in handling the editing and printing of the proceedings. The committee also thank Dr. R. Dwarakinath, for guidance during the initial stages, as the Chairman of the Organising Committee.

All the conference work was held in the West-End Hotel, Bangalore. The co-operation and the help rendered in various ways by the authorities of the Hotel are placed on record and the Organising Committee express their deep sense of appreciation to the management in this regard. Similarly, inaugural and cultural programme of the conference was arranged at the Chowdaiah Memorial Hall, Bangalore. The Management made an excellent arrangement for the conduct of the conference activities and the Organising Committee thank them for the same.

The Organising Committee gratefully acknowledge the help extended in various capacities to this conference by AIR INDIA, Indian Airlines, State Bank of India, Post and Telegraph Department, Bangalore Telephones, SITA World Travels (India) Private Ltd., Bangalore, Travel Corporation of India, Bangalore, Indian Institute of Horticultural Research, Bangalore, Alkali and Chemical Corporation of India Ltd., Bangalore, Indo-American Hybrid Seeds, Bangalore, M/s. Raja Power Press, Bangalore, Apsara Printers, Bangalore, Pacprint (P) Ltd., Bangalore, Police authorities, All India Radio, Dooradarshan, various press representatives, Coffee Board, Kiran Electricals, other Industrial Organisations and Institutions. Thanks are also due to M/s. Hoechst Pharmaceuticals India Ltd., Bombay for presenting brief cases to the delegates and providing bus for transportation of delegates.

PROCEEDINGS OF THE SESSION XII – 'GENERAL DISCUSSIONS ON EXPERIENCES USEFUL TO INDIA' HELD AT THE EIGHTH CONFERENCE OF THE ASIAN-PACIFIC WEED SCIENCE SOCIETY

Venue: WEST END HOTEL, BANGALORE
Date : 27-11-1981 *Time:* 1445 to 1615 Hrs

Chairman : Dr. Santiago R. Obien (Philippines)
Co-Chairman : Dr. K. Krishnamurthy (India)
Rapporteur : Dr. Y. C. Panchal (India)

There was a lively and good deal of general discussion wherein all participants took part in the discussion on matters discussed at various sessions. Participants from all the countries including India gave their ideas and thoughts for overall upliftment of weed science in the Asian-Pacific regions and more particularly in India. Based on the various points suggested and from the sum up of the various technical sessions (16 sessions including this session), and after continued deliberations, following recommendations emerged at the conclusion of the 8th Conference.

RECOMMENDATIONS :

1. Knowledge on the period of crop weed competition in many crops is essential. Need to identify weed specific or plant type relationship with crop weed competition.
2. There is a need to develop integrated weed control schedule for field, plantation and orchard crops including aquatic weeds.
3. India has more number of worst weeds. More intensive research is needed to develop easy, effective and economical methods of weed control in respect of more problematic weeds like water hyacinth, nutgrass, *Cynodon dactylon, Parthenium, Oxalis, Cuscuta, Striga, Eupatorium,* wild oats, *Imperata cylindrica, Sorghum halepense, Phalaris minor.*
4. Further work needs to be done on the utility of planting density and competing legumes for weed control in wide spaced crops as seen in banana.
5. Research needs to be geared up on knowing the physiological changes in crop plants or weeds due to herbicidal applications. Use of additives for increased herbicidal efficiency needs more attention. Further basic studies are needed on physiology of weeds and herbicides from all approaches.
6. Attention may be paid on the utility of weeds for medicinal purpose, for biogas production, as green manure, use for impairing fertility in rats or antipollution tools.

7. More work needs to be done on the inhibitory effect or allelopathic effect of weeds.
8. Work may be intensified on the mode of translocation of herbicides in crops or weeds and on the resistance problems in crops and weeds to herbicides.
9. Eradication of problematic weeds in public areas.
10. Weed control in low rainfall areas be taken up.
11. Integrated method of weed control for perennial weeds.
12. Use of slow release herbicides for the control of perennial weeds.
13. Mode of action of herbicides may be studied in crops and weeds.
14. Government should take more responsibility in legislation of problematic weeds.
15. Farmers be given subsidy for use of herbicides.
16. Cost benefit analysis may be done to popularise the use of herbicides.
17. Herbicidal interactions be studied in a proper way to reduce its cost and pollution.
18. Vegetation in the field is changing due to introduction of high yielding varieties, this may be kept in view and studies be taken up for effective weed control and maintaining soil fertility.
19. Herbicidal applications should always be accompanied by herbicide residue estimates in soil and crop.
20. Replace the non-edible weeds with edible weeds so that more use could be made of weeds.
21. Weed Science education be strengthened. Suitable training programmes may be drawn up to create awareness about the magnitude of weed problem to extension workers and farmers.
22. There is need for greater degree of interaction among all concerned on weeds and herbicides — scientists, industry, extension persons.
23. Prepare useful projects and send for PL 480 support through I.C.A.R.
24. Need for continuity of persons to be in weed science as a life time career and not to change to other subjects.
25. Canals, tanks etc., be kept clean from aquatic weeds by mechanical methods and/or biological methods.
26. There is need for National Institute of Weed Science in India.

CHAIRMEN AND CO-CHAIRMEN OF THE SESSIONS

Session	*Date*	*Topic*	*Chairman*	*Co-chairman*
I & X	23.11.81	Invited papers	H. R. Arakeri (India) H. R. Arakeri (India)	K. C. Nag (India) S. Matsunaka (Japan)
II & VI A	23.11.81 24.11.81	New Herbicides & Appliances	A. K. Seth (UK)	P. Langeluddeke (Germany)
III A	24.11.81	Weed Control in Rice	S. K. De Datta (Philippines)	H. K. Pande (India)
III B	24.11.81	Physiology of Weeds & Herbicides	S. Matsunaka (Japan)	K. Ueki (Japan)
IV A	24.11.81	Papers of General Interest	Peter W. Michael (Australia)	Alan E. Duetsch (USA)
IV B	24.11.81	Allelopathy of Weeds	M. Sundaru (Indonesia)	V. S. Mani India
V A	24.11.81	Weed Control in Wheat	W.H. Vanden Born (Canada)	H. S. Gill India
V B	24.11.81	Weed Control in Plantation Crops	R. K. Nishimoto (USA)	C. Boonsrirat (Thailand)
VI B	24.11.81	Herbicides Residues & Interactions	Y. C. Panchal (India)	S. Sankaran (India) India
VII A	24.11.81	Weed Control in Sorghum, Maize, Pulses & Inter crops	R. N. Andersen (USA)	U. C. Upadhyay (India)
VII B	26.11.81	Biology of Weeds	T. I. Cox (New Zealand)	Leo E. Bendixen (USA)
VIII A & IX A	26.11.81	Aquatic weeds & their control	M. Soerjani (Indonesia)	Margaret Anne Ward (UK)

Session	*Date*	*Topic*	*Chairman*	*Co-chairman*
VIII B	26.11.81	Weed Control in Banana, Cotton, Potato, Sugarbeet & Sugarcane	W. T. Parsons (Australia)	S. Sankaran (India)
XI	27.11.81	Obnoxious Weeds & their control	U. Suwannamek (Thailand)	Alan E. Deutsch (USA)
XII	27.11.81	General Discussion on Experiences Useful to India	Santiago R. Obien (Philippines)	K. Krishnamurthy (India)

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GENERAL BUSINESS MEETING AND EXECUTIVE COMMITTEE MEETING OF THE ASIAN-PACIFIC WEED SCIENCE SOCIETY

November 27, 1981 – 4.20 p.m.
Bangalore, India

1. *Remarks from the President*
   a. We are in the final stage of the Conference. I hope everything went on to the satisfaction of all. If there are any lapses I will own them and credit for all success will go to the Organizing Committee and host of workers. It would be embarassing if I mention any of them by name, hence I abstain from doing so.
   b. I take this opportunity of thanking the Executive Committee members who rendered timely assistance in organizing this conference. Special thanks are due to Dr. Nishimoto, Secretary and Treasurer for prompt responses for my queries from time to time.
   c. Many country's organizations like New Zealand Society have sent their greeting and good wishes, which I am very happy to convey to you.
   d. During the last 2 years there were no special committees. I tried to collect some information about the weed situations in different States in India and in different countries in the region. Information is still incomplete. Attempts are being made to publish the same in 2 parts. Work is being done by Dr. Bhan.
   e. It is recommended that a maximum of about 100 papers be allowed for a 4-day conference.
2. P. Michel reported that the 7th Conference Proceedings will be available from him at U.S. $ 10.00.
3. *Secretary and Treasurer's Report.* The Society has a balance of $ 5872.58.

   Through the efforts of the APWSS Newsletter Editor P. Motooka, 5 Newsletters were produced and distributed since the last conference in Australia. The Editor is still having difficulty in obtaining news from the members. He urges your participation. All Newsletters were sent by air and the Executive Committee members redistributed these within their respective countries.

   The Society has 191 financial ordinary members and 7 industry sustaining members. The industry sustaining members are: Ancom Sdn. Bhd (Malaysia), Dow Chemical Pacific (Hong Kong), Dupont (Australia Ltd.), Hoechst (Germany), Kumiai Chemical Industry (Japan), Monsanto Agricultural Products Co. (USA), Elanco Products Co. (USA). Their generous financial assistance and support were acknowledged.

   The Secretary D. Plucknett resigned his post as he has been in Washington DC during the last few years. The treasurer also submitted his resignation as the Secretariat includes the Secretary and Treasurer. The Treasurer indicated a desire to move the Secretariat permanently to Asia, possibly the Philippines. However as the next conference will be held in the Philippines, it was thought to be an inopportune time to do so.

At the Executive Committee Meeting, several requests for funds were approved as follows: 1) $ 1,000 for the FAO/IWSS Workshop, Rome September 6-10, 1982. The workshop is designed to develop a manual on weed science for the less developed countries. The request was made by L. Matthews. 2) $ 1,000 to the Organizing Committee of the 9th APWSS Conference to defray initial expenses for the 9th APWSS Conference in Manila. 3) Provide up to $ 2,000 to the 8th APWSS Conference Organising Committee if they need additional funds for the 2nd volume of the Proceedings. (The Japanese Association for Phyto-Regulators provided the Organizing Committee with $ 1,000 to defray initial expenses of the 8th Conference). The general body agreed on these expenditures.

4. Constitutional changes were proposed in August 1981 via the APWSS Newsletter as follows:

A. Current Constitution: Item 7. Executive Committee

(i) President
(ii) Vice-President
(iii) Secretary
(iv) Honorary Treasurer
(v) Immediate Past President
(vi) Six Other members.

The Executive Committee shall have power to appoint new members to fill any casual vacancy and shall have power to co-opt not more than three other members.

Proposal for item 7.

Add: "With the exception of the Officers (i) through (v) of the Society, not more than one national of any member country is eligible for election to the Executive Committee."

B. Current Constitution: Item 20. Subscriptions.

The biennial subscription which is due at the begining of the financial year and which shall include all privileges including a copy of the proceedings of that year, shall be $ 8.00 or such sum as may be decided from time to time at any biennial or special meeting. The fee for student members would be half that for ordinary members. Non-members may be admitted to conferences on a daily fee which may be decided by the Executive Committee.

Proposal for Item 20.

Delete: "including a copy of the Proceedings of that year," in the first sentence of Item 20.

The proposed changes were approved by the general body.

5. President Dr. Arakeri thanked Don Plucknett for his services as Secretary of the Society.

6. Election of Officers. (1982-1983). The following were nominated and elected to the respective offices:

   President : B. L. Mercado

   Vice President : Vacant until 1985 conference site and host confirmed.

   Secretary : R. K. Nishimoto

   Treasurer : P. Motooka

   Executive Members:

   i) T. I. Cox (New Zealand)
   ii) M. H. Lambert (Pacific Islands)
   iii) P. W. Michael (Australia)
   iv) S. Matsunaka suggested for Japan (will be confirmed by the Japan Society of Weed Science)
   v) Soekisman Tjitrosoedirdjo suggested for Indonesia (will be confirmed by the Weed Science Society of Indonesia)
   vi) President or designee of Weed Science Society of Thailand.

   L. Mathews suggested that members be co-opted in South Korea and China. Considerable discussion on the composition and number of executive members occurred. M. Soerjani proposed that Executive members be chosen on the basis of leaders in topics to be focussed on at the next conferences (i.e., rice, cereals, weed biology, etc.). After some discussion, it was agreed that members should be presidents or designees of APWSS affiliate societies or have strong support of affiliate societies.

7. M. Soerjani was nominated as Honorary Member of the APWSS by L. Matthews for providing sound and effective leadership in developing weed science in Indonesia and Southeast Asia. The nomination was approved.

8. 10th Conference.

   New Zealand has provided an invitation to host the APWSS Conference in 1985. However, T. I. Cox indicated that they would prefer that other countries, which have not yet had an opportunity to host the APWSS Conference. Thailand was suggested. L. Matthews suggested that South Korea or China be considered. S. Matsunaka indicated that the 10th is important symbolically and Hawaii should be the site. S. Matsunaka will consider suggestions, make contacts and provide a recommendation.

9. On behalf of President B. L. Mercado, S. Obien invited the APWSS to Manila, Philippines during November 28 - December 2, 1983, for the 9th Conference. The first circular was distributed during the 8th Conference. He urged members to send suggestions of important discussion topics to the organizing committee's Chairman B. L. Mercado. S. Obien and K. Moody also serve on this committee.

Eighteen members were present at the business meeting.

The meeting was adjourned at 5.30 p.m.

1982-83 APWSS EXECUTIVE COMMITTEE

President

B. L. Mercado
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College of Agriculture
University of the Philippines
at Los Banos
College, Laguna, Philippines

Secretary

R. K. Nishimoto
Dept. of Horticulture
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Treasurer

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Past President

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Chairman
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Faculty of Agriculture
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New Zealand

T. I. Cox
Horticultural Research Centre
Private Bag
Levin, New Zealand

Pacific Islands

M. H. Lambert
South Pacific Commission
B. P. D5, Noumea, Cedex
New Caledonia

Indonesia

*Soekisman Tjitrosoedirdjo**
BIOTROP, P. B. No. 17
Bogor, Indonesia

Thailand

President or Designee,
Weed Science Society of
Thailand

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* Subject to confirmation by the respective weed science societies

81–82 APWSS INDUSTRY SUSTAINING MEMBERS

Ancom Sdn. Berhad
Dow Chemical Pacific Ltd.
Dupont (Australia) Ltd.
Eli Lilly and Company
Hœchst
Kumiai Chemical Industry Co. Ltd.
Monsanto Company

AUTHOR INDEX

PROCEEDINGS OF THE EIGHTH CONFERENCE OF THE ASIAN-PACIFIC WEED SCIENCE SOCIETY CONFERENCE, 1981 (VOL. I)

ERRATA

Page 1, Para 1, Line 2

Read as '48% of the fertilizer consumption and 68% of the total production of food grains

Page 1, Para 3, Line 4

Read as 'this increase, amounting to 427 kg/ha of grain is worthwhile. Market potential predictions'

Page 1, Introduction, Para 1, last line

Read as 'Anon., 1967'

Page 1, Introduction, Para 5, Line 3

Delete 'Makhdoom et al., 1974'

Page 4, Literature Cited

Read as 'Anonymous, 1967'

Page 14, Table 1

Read as 'LSD (P=0.05); LSD (P=0.05) for Mungbean yield is 0.21

Page 15, Table 2

Add LSD (P=0.05) – 0.21 and 5.3 for grain yield/ha and pods/plant. Delete 'NS for weed D.M./ha

Page 17, Abstract, Line 9

Read after '0.7 to 0.8' as 'kg/ha appeared optimal for control of wild oats in crop in'

Page 28, Table 1

Read as 'Machete EC 0.75 6 days after sowing'

Page 31, Table 4, Line 11

Read as under 20 DAS, Total No. '6 instead of 0'

Page 57 Introduction, Para 2, Line 9

Read as '(Nishimoto and Yee, 1980). Early application of diuron were injurious (Romanowski *et al.*, 1972). Thus

Page 75, Table 2

Read as 'q/ha instead of g/ha'

Page 83, Para 2, Line 33

Read as 'Rs. 916/ha'

Page 86, Table 1

Read as '40 days weed free after sowing' for T5

Page 86, Table 1

In T6 – shift the values against the correct columns

Page 87, Para 5, Line 8

Read as '16.07 q/ha' instead of 16.07 a.i./ha

Page 87, Para 5, Line 14

Read as 'application of atrazine 1 kg/a.i./ha + post-emergence application of 2,4-D'

Page 92, Results, Para 1, Line 1
Read as 'In 1976 at Palampur, C-228'

Page 95, Table 5, Column 5, Line 6
Read as '3.1[a]'

Page 114, Caption for Fig. 1
The standing crop as dry weight and the top to ratio for *E. crassipes* populations grown in three locations

Page 116, Caption for Fig. 2
Accumulation of nitrogen and phosphorus by *E. crassipes* populations

Page 117, Table 3, last line
Shift the values by one column for correct reading

Page 122, last line of the Table
Read as '*Ageratum conyzoides*' instead of 'Ageratum Conyzoides gatum'

Page 123, Table 2, Column 4, Line 10
Omit parquat and shift 100 in Column 7 to Column 8

Page 123, last line
Read as '*Ageratum conyzoides*' for AC

Page 144, Table 1, Column 1
Remove a in 3rd and 5th lines

Page 146, Table 1
Read as '*2.2 2.1*'

Page 150, Table 2, Line 1, last column
Read as '$e^{-0.0014x}$

Page 158, Table 3, line 1
Read as 'Extract'

Page 162, Table 1,
Read as '*Carduus nutans*'

Page 162, Table 1, Column 3, line 4
Read as '19108 instead 19018'

Page 164, conclusions, last line
Read as 'all but the far western areas appear climatically suitable for'

Page 165, Line 3, Isopleth[1]
Read as '[1] An index which integrates light, thermal and moisture indices for a defined period

Page 171 to 173
Read as 'pinnatifid instead of pinnatified and ssp for spp'

Page 172
Omit 'dimensions .... the region' before 'Results and Discussion'

Page 179, Para 2, Line 13
Read as 'the growth and development of broad leaf weeds as well. The differences in the height of *C. album*.

Page 200, Para 2, Line 5
Delete 'Moist ..... the seeds'

Page 202, Para 7, Line 8
Read as '0.02 instead 0.22'

Page 210. Cynodon dactylon, Line 17
Read as 'State. Agriculture practices in the land'

Page 223, Table 5, Line 11, column 5
Add 1 c and shift other values for correct reading

Page 233, Results, last line
Read as '1800^2' for 188 m^2

Page 262, Table 4, Barley 1978, Line 8
Read as '42.0 instead of 4.0

Page 273
Read as 'WONG PHUI WENG'

Page 283, Table 1, column 1, line 9
Read as 'Glyphosate alone 4.0 kg/ha'

Page 288, Para 3, Line 7
Read as 'The grain number per and thousand grain weight indicated'

Page 288, Para 3, Line 10
Delete 'tation was'

Page 289, Conclusions, Line 5
Read as 'activity with striga parasitisation, while chlorophyll content'

Page 329, Material and Methods, Line 2
Read as '17°35' 30" – 17°36' 02" N

Page 330
Delete 'para 3'

Page 349, Results and Discussion, Line 16
Read as 'Parthenin for Parthenium

Page 371, Abstract, Line 6
Read as 'GA_3, KNO_3, IAA

Page 398, Para 2, Line 6
Read as 'acetic acid : water (4 : 1.5 top layer), *n*-butanol : 2M NH_4OH (1 : 1) and *n*-butanol :

Page 428, Results, Para 1, Line 10
Omit 'as compared to .... over 96%)'

Page 434, Results and Discussion, last line
Read as 'essential for the activity against'

Page 449
Link '$CH(CH_3)_3$' to C in the structural formula

Page 466, Table 3, 90 DAT/DAS, 1975, Line 11
Read as '113.6 instead 116.3'

Figures for Page 102

Fig. 1 : Influence of herbicide on grain yield in rice (USA 1978)

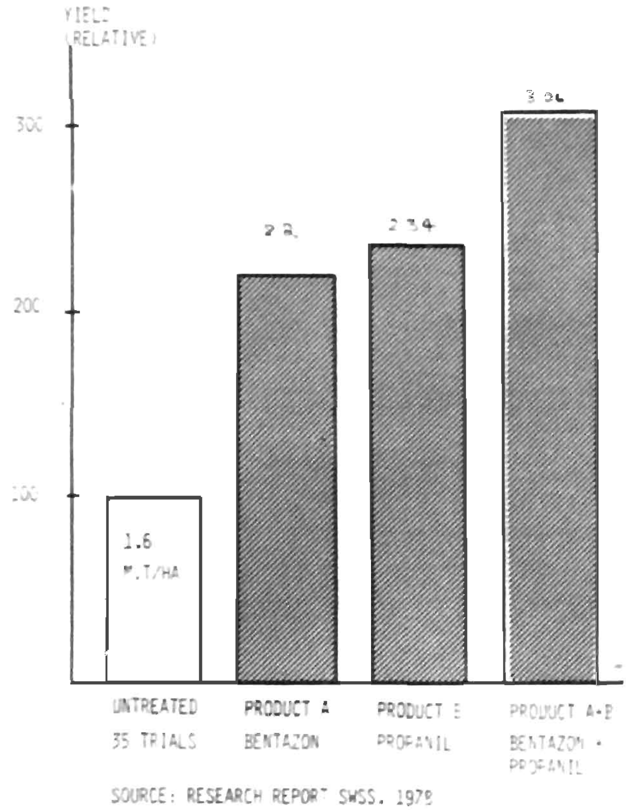
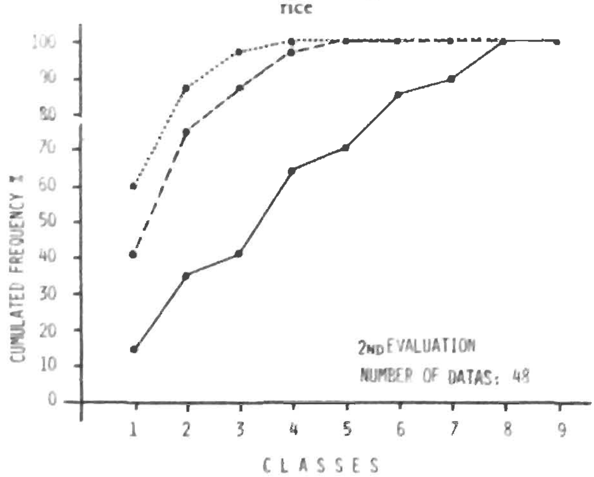


Fig. 2 : Activity of Bentazon + MCPA against *Cyperus difformis* in comparison to Bentazon in rice



X (%)		PRODUCTS
86	———	BENTAZON 4.0 L/HA *
98	– – –	BENTAZON + MCPA 3.0 L/HA *
99	········	BENTAZON + MCPA 4.0 L/HA *

CLASSES	% EFFICACY
1	100
2	99.9 - 97.5
3	97.4 - 95.0
4	94.9 - 90.0
5	89.9 - 85.0
6	84.9 - 75.0
7	74.9 - 65.0
8	64.9 - 32.5
9	32.4 - 0

* FORMULATED PRODUCT

Figures for Page 388

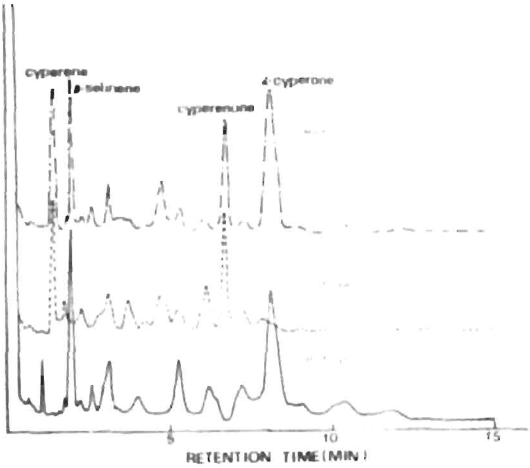


Fig. 1: Representative gas-chromatograms of essential oils in purple nutsedges.

column: 5% OV-17 chromosolb w, column temp.: 180°C. Detector: FID, Carrier gas: N_2

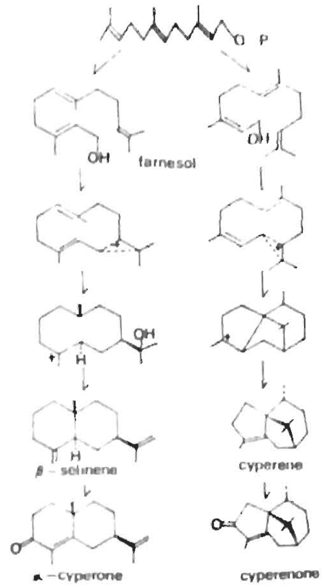


Fig. 2: Possible biosynthetic pathway of sesquiterpenes in purple nutsedge.

Fig. 3: Qualitative and quantitative variation in sesquiterpenes of purple nutsedge tubers.