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University of Agricultural Sciences
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PREFACE

The first conference of the Asian Pacific Weed Science Society was held at the East West Centre, Honolulu in 1967, in pursuance of the objective of APWSS of promoting basic and applied knowledge in the area of weed science that would help control weeds in agriculture and thus contribute towards increased production of food and other commodities so urgently required for alleviating hunger and want. Since then, seven meetings of workers in this area have been held at two-yearly intervals in the different countries of the Asian Pacific Region, the last one being at Sydney, Australia on November 26-30, 1979.

These forums have provided a valuable periodic opportunity for interchange of information and ideas on problems of weed management in agriculture as they obtain in their situations, and also gain a broader perspective in regard to the problem as a whole as relevant to the Asian Pacific Region. The published proceedings provide a wealth of information, serving as reference source to research workers and students in this important discipline in agriculture.

The present publication contains 91 articles accepted for presentation at the eighth APWSS Conference to be held on November 22-29, 1981 at Bangalore. An attempt has been made to put them into seven sections viz., Weed control in crops, Agronomic aspect of weed control, Biology of weeds, Obnoxious weeds, Physiology, New herbicides and herbicides residues and inreractions, based on the focus of work in each paper.

It is my privilege to acknowledge the guidelines received from the screening and the publication committees of the conference in the preliminary scrutinising of the abstracts. The help in this behalf from Drs. U. C. Upadhyay, H. S. Gill and V. M. Bhan is recorded.

The valuable help received in this task of editing from Dr. S. Sankaran, Professor of Agronomy, TNAU, Coimbatore and Dr. K. S. Krishna Sastry, Professor of Crop Physiology, Dr. G. Boraiah, Associate Professor of Botany, Dr. G. K. Veeresh, UNDP Professor of Entomology, Dr. G. Nagendrappa, Associate Professor of Chemistry, M/s. T. V. Ramachandra Prasad and C. D. Singh of the AICRP on Weed Control, all from the University of Agricultural Sciences, Bangalore is gratefully acknowledged.

The unfailing interest of the Organising Committee in general and Vice-Chancellor N. G. Perur, Dr. K. Krishnamurthy, Mr. K. Shankar, President, Secretary and Treasurer respectively and the University Librarian H. R. Ramachandra deserves special mention.

It is a pleasure for me to place on record the deligent work done by Mr. N. Gopalakrishna in proof correction and the general processing involved in seeing the material through print.

B. V. Venkata Rao
Editor and Chairman
Publication Committee

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PROCEEDINGS OF THE EIGHTH ASIAN PACIFIC WEED SCIENCE SOCIETY CONFERENCE

POTENTIAL OF WEED CONTROL IN WHEAT WITH 2, 4–D IN PAKISTAN

M. S. QURESHI
Dow Chemical Pacific Limited, Pakistan.

ABSTRACT

Wheat has a pivotal position in Pakistan's agrarian economy – it accounts for over 37% of the cropped area, 48% of the food grains. Similarly its consumption outstrips all other food grains and constitutes over 78% of the gross cereal intake.

An analysis of survey data shows wheat yields in Pakistan, averaging 1475 kg/ha, are relatively low compared with those in other countries. Lack of weed control is the major factor contributing to the low yields. Of the 5 million tons lost annually to pests, it is estimated weeds account for half this amount. Out of 28 weed species causing damage to wheat, 11 species contribute 85% of these losses.

Data is presented of trials conducted with butyl ester and dimethylamine formulations of 2, 4–D in the Sind and Punjab regions. It shows that an average yield increase of 29% is obtainable and most major broadleaf weeds are adequately controlled by 2, 4–D. Cost benefit studies show this increase, predictions show that if 20% of the wheat area is treated, 1 million tons of 2, 4–D would be required and an additional 576 thousand tons of wheat sufficient to feed 4.62 million people would be produced.

INTRODUCTION

Wheat production in Pakistan increased by 46% in 15 years from 1964 to 1979 as a result of the use of imported technology and higher inputs. However, because of a 59% increase in population during the same period and an increase in per capita daily wheat consumption from 244 to 340 g during the last decade, Pakistan has not been able to achieve self-sufficiency. In 1979 Pakistan produced only 9.92 million tons of wheat from 6.72 million ha and had to import 0.7 million tons. (Anon., 1979).

Because of demand of competing crops, the increase in wheat area as a strategy for increasing wheat production cannot be considered by the Pakistan Government. It must, therefore, meet its requirement by substantially increasing yield/ha. The yields are low at present but land, climate and irrigation facilities are ideal for growing wheat and Pakistan has potential to not only feed its own people but also to export surplus.

The reasons for low yields in Pakistan are attributed to many factors but one of the most important which goes unnoticed by the farmers is reduction of yield due to weeds.

In non-irrigated areas, the competition between weeds and crops is largely for water. A saving of 300 to 500 tons of water in an acre of soil is possible by keeping it free of weeds. Competition for nutrients is also severe. In irrigated tracts it can amount to about 7.7 kg N causing a reduction in grain yield of about 186 kg. Weeds in fallow land deplete the soil of both moisture and fertility. *Carthamus oxycantha* removes about 66 kg N from one ha. (Anon., 1967).

In Pakistan, these losses have been estimated between 11.3% and 60% (Haque, 1970; Makhdoom et al., 1974; Jalis and Brohi, 1978) of the crop yield,

Table 1 : Major weeds and their density.

Botanical Names	Family	Infestation %	2, 4–D susceptibility
Chenopodium album L.	Chenopodiceae	37.0	100%
Convolvulus arvensis L.	Convulvulaceae	16.5	90%
Melilotus alba Lamk.	Leguminoseae	6.2	100%
Euphorbia helioscopia L.	Euphorbiaceae	5.0	60%
Medicago denticulata Willd.	Leguminoseae	4.7	100%
Carthamus oxycantha Bieb.	Compositae	4.5	60%
Chenopodium murale L.	Chenopodiaceae	3.9	100%
Asphodelus tenuifolius Cav.	Liliaceæ	3.7	80%
Phalaris minor Retz.	Gramineae	2.5	0
Cyperus rotundus L.	Cyperaceae	2.0	25%
Avena fatua L.	Gramineae	1.0	0
Others	–	13.0	–

which is similar to losses reported in other countries e.g. 45% in Iraq (Al-Qaisi, 1972), 17% in Lebanon (Saghir and Aqiqullah, 1970) 30-40% in Jordan (Aresvik, 1976) and 20% in Turkey (Hepworth and Tezel, 1975).

Of the estimated 3.7 to 5 million tons lost annually to pests of all kinds, about half of these losses are caused by weeds. If these losses are reduced even by 25%, Pakistan would save about 1 million tons and the country will have a surplus of wheat within 1-2 years.

Major weeds and their population

An enormous increase in weed population in Pakistan has been noticed since the introduction of dwarf, high yielding varieties which need better inputs like higher seed rates and more fertilizers. A survey conducted by researchers in Pakistan recently has revealed that an average 280 weeds/sq m are found in wheat crops in farmers' fields. As high as 730 weeds/sq m were recorded in broadcasted wheat fields due to vacant patches and uneven crop growth (Khan, 1974; Jalis and Brohi, 1978; Khan, 1979). Out of 28 weed species commonly found, 12 weeds cause significant damage (Table 1).

Use of 2, 4-D for weed control

Wheat is a close sown crop making inter-row cultivation by mechanical means difficult and harmful to the root system. Therefore, handweeding is usually practised. Handweeding, however, is laborious, costly and time consuming. It takes one complete working day for 20 labourers to handweed one ha of wheat and costs US$ 20/ha (minimum wages US$ 1.0/day/worker in rural areas).

If weeding is delayed by the time the farmer is able to complete the first weeding of his field, another crop of weeds may be ready. Therefore, usually either large areas are left unweeded or there is inadequate weed control, resulting in damage to the crop. Using herbicides which are easy, effective, safe and economical is the most satisfactory alternative.

Despite the more recent development of many other herbicides, based on cost and effectiveness, the phenoxy herbicide 2, 4–D is most suited for Pakistan conditions. A study of the major weeds found in wheat shows that they are susceptible to 2, 4–D. (Table 2).

Unfortunately very little work on

Table 2. Effect of 2, 4–D on weed mortality, population density and grain yield.

Treatment	Average % mortality of different weeds								% weed count in check				Yield increase over weedy check (kg/ha)			
	CHA	FUI	AST	COA	RUC	MIA	MED	CAO	T1	T2	D1	D2	T1	T2	D1	D2
2,4–D ester	85	62	58	52	68	75	70	67	7	6	6	12	358	360	540	584
2,4–D amine	80	73	49	52	71	42	62	59	9	10	11	15	350	330	410	490
Weedy check	0	0	0	0	0	0	0	0								
Weed count/m^2									219	93	351	381				
Weedy check yield kg/ha													1632	1700	1136	1727

T1 = Trial at A.R.I., Faisalablad (Punjab) T2 = Trial at A.R.I., Tandojam (Sind)
D1 = Demo at farmers' fields (Punjab) D2 = Demo at farmers' fields (Sind)

weed control in wheat has been done in Pakistan. Recently, The Dow Chemical company, being one of the leading manufacturers of phenoxy herbicides has taken an active part in evaluating two 2,4–D compounds. Results of some of these trials and demonstrations and cost benefit ratios worked out on the findings are presented in the following pages.

MATERIAL AND METHODS

The trials and demonstrations reported here were carried out in two wheat crop seasons during winter of 1977-78 and 1978-79 with 2, 4–D 720 g/l as the butyl ester and 2, 4–D 720 g/l as dimethylamine salt at the dose of 0.45 and 0.72 kg a.i./ha respectively, applied at tillering stage. Location of the trials were Ayub Agricultural Research Institute, Faisalabad (Province of Punjab) and Agricultural Research Institute, Tandojam (Province of Sind), and demonstrations were arranged at farmers' fields in both the provinces.

Weed species present in trial demonstration plots were *Chenopodium album* (CHA), *Furmaria indica* FUI), *Asphodelus tenuifolius* (AST), *Convolvulus arvensis* (COA), *Rumex acutus* (RUA), *Mililotus alba* (MIA), *Medicago dentyculata* (MED), and *Carthamus oxycantha* (CAO). Trials were conducted in random block design with three treatments replicated 3 to 4 times. By using hand knapsack sprayer, 700 to 800 l of spray solution was used. Observations were recorded on mortality of weeds, weed count/m^2 and yield/ha.

RESULTS AND DISCUSSION

It was observed that 2, 4–D when applied at tillering stage gave encouraging results without any phytotoxic effect on the wheat plant. Mortality of weeds, weed populations of all the species present in the treated plots and grain yield are presented in Table 2. Wheat grain yield in the plots treated with 2,4–D ester increased by an average 460 kg/ha whereas plots treated with 2, 4–D amine showed an average increase of 395 kg/ha.

A cost benefit study calculated on data from these trials reveal that investment of US$ 3.30/ha on 2, 4–D can be rewarded with a return of US$ 62.0/ha in grain.

Market potential for 2, 4-D in Pakistan

On the basis of findings of this study, Pakistan certainly has a great need for 2, 4–D. This need is recognized already. Government agencies recommend use of 2, 4–D for control of weeds in wheat crop. Pakistan Agricultural Research, Council launched a vigorous campaign during 1980-81 to demonstrate use of herbicides in wheat. Although at present very small quantities of 2, 4–D are used in Pakistan, taking into consideration the Government approach towards chemical weed control in wheat and changing attitude of the farmers to derive maximum benefits out of the costly inputs, use of 2, 4–D is inevitable.

Under the present pesticide marketing system in Pakistan, considerable potential for use of 2, 4–D in wheat exists in the coming 3 to 5 years provided herbicide developers make an effort as is evident from the following particulars.

Total area: 6721000 ha; Potential area: 1344000 ha; Present 2, 4–D consumption: 35000 kg; 2, 4–D Potential market in Pakistan: 1344000 l; Market in US$: 3965000. Out of the total wheat area of 6.72 million ha, estimated share for 2,4–D up to 1985 is 20 per cent at cost of US$ 2.95/l.

CONCLUSION

By reviewing the problem of weeds in wheat, it has been ascertained that presence of weeds in such large numbers have nullified the positive effects of inputs. The problem has become so severe that in many cases it is almost counterproductive to go for inputs as the damage done by luxuriant growth of weeds by these measures, more than off-sets the advantage gained in increase per hectare yield.

Control of weeds in wheat with use of 2, 4–D products can reduce these losses and yield increase of 427 kg/ha are obtainable with an investment of around US$ 3.00/ha. Using the national average wheat yield of 1475 kg/ha, this amounts to a 29% increase. If this increase was achieved over 20% wheat area in Pakistan, an additional 576 thousand tons of wheat sufficient to feed 4.62 million people would be produced.

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EFFECT OF TERBUTRYN METOXURON AND 2, 4-D ESTER ON CONTROL OF WEEDS, GROWTH AND YIELD OF DWARF WHEAT C. V. HD 2122

G. C. TRIVEDI and M. R. BAJPAI
Agronomy Farm, S. K. N. College of Agriculture, Jobner, Durgapur, Rajasthan

ABSTRACT

The experiment was conducted at Agronomy Farm, S. K. N. College of Agriculture, Jobner, India, during the winter of 1979-80. The treatments comprised of hand weeding (35 DAS), unweeded control, two rates of Terbutryn (0.5 and 0.75 kg a.i./ha), three rates of metoxuron (1.25, 1.50 and 1.75 kg a.i./ha) and one rate of 2, 4-D ester (0.5 kg a.i./ha) applied at 35 days after sowing. Treatments were replicatd four times in RBD.

Terbutryn and metoxuron were effective in controlling the weed population and dry matter production of the broad leaved and grassy weeds. Application of terbutryn 0.75 kg a.i./ha and metoxuron 1.75 kg a.i./ha proved best in reducing weed population including *Chenopodium* spp.

Metoxuron 1.75 kg a.i./ha and terbutryn 0.75 kg a.i./ha produced 2959 kg and 3273 kg/ha grain yield respectively which were 32 and 39 per cent higher over unweeded control and 22 and 29 per cent higher than 2, 4-D ester treatment.

INTRODUCTION

Weeds are always a source of considerable loss in crop production. The estimation of losses vary to a great extent depending on the intensity of weed population, the weed species and the fertility status of soil. If weeds are not effectively controlled, about 4/5th of the applied nitrogen can be removed by weeds for their growth and development (Gill, 1979). Recent studies of Singh and Rathore (1976) and at Udaipur in Rajasthan (Anon., 1979) have given a new hope to keep wheat fields free from all types of weeds by the use of metoxuron and terbutryn which are chemically (N'-3 (3-chiro, 4 methoxy phenyl, N, N dimethy I, Urea) and 80 WP (2-(-tert-butyl amino) (-4-(ethyl amino)-6-(methyl) thio--s- triazine) respectively. The present study was initiated to determine effects of different herbicides and hand weeding on weeds and yield of wheat.

MATERIAL AND METHODS

The experiment was laid out at the Agronomy Farm, S. K. N. College of Agriculture, University of Udaipur, Jobner on a loamy sandy soil with a pH of 8.2, during winter 1979-80. The soil was low in available N and medium in available P_2O_5 and K_2O. The experiment consisted of 8 treatments, *viz.*, hand weeding (35 DAS), unweeded check and three herbicides with different doses *viz.*, terbutryn (0.5 and 0.75 kg a.i./ha), metoxuron (1.25, 1.50 and 1.75 kg a.i./ha) and 2, 4-D ester (0.5 L/ha). All the herbicides were applied as post-emergence. The experiment was laid out in a randomized block design with four replications. The net plot size was 5.0 m x 4.0 m. A common fertilizer dose of 125 N and 75 P_2O_5 kg/ha were applied at sowing.

RESULTS AND DISCUSSION

Studies on the Weed

Major weeds in the experiment plots

Table 1 : Effect of Terbutryne, Metoxuron and 2, 4 - D ester on population and dry matter accumulation of weeds.

Treatments	Weed population/sq m						Weed dry matter (kg/ha)			
	45 DAS		90 DAS		At harvest		45 DAS		At harvest	
	Che	O	Che	O	Che	O	Che	O	Che	O
Terbutryn 0.5 kg a.i./ha	65	9	19	19	88	37	18.7	1.6	224.0	9.5
Terbutryn 0.75 kg a.i./ha	28	15	10	5	13	11	5.1	0.9	74.2	3.5
Metoxuron 1.0 kg a.i./ha	44	19	54	22	73	44	8.3	1.5	207.5	10.19
Metoxuron 1.25 kg a.i./ha	41	9	36	23	82	39	8.7	1.7	160.2	6.51
Metoxuron 1.75 kg a.i./ha	27	11	9	6	14	17	4.5	0.8	71.00	4.31
2, 4-D ester 0.5 L/ha	72	11	46	40	76	74	8.7	2.0	213.2	9.45
Hand weeding at 35 DAS	79	8	48	30	92	55	9.2	1.8	194.2	5.26
Unweeded check	176	40	299	36	360	110	75.8	15.5	587.2	20.68
SEm ±	–	–	–	–	–	–	1.8	0.24	33.1	1.65
C. D. (P = 0.05)	–	–	–	–	–	–	5.33	0.69	96.0	5.79

*DAS Days After Sowing Che *Chenopodium* spp. O Other Weeds

were *Chenopodium album* L., *C. murale* L., *Cyperus rotundus* L., *Convolvulus arevensis* L., *Carthamus oxycantha* Beib. However, *Avena fatua* L. and *Phalaris minor* Retz. were not so much problematic in this area. Weed population was significantly higher in the unweeded plots than all other treatments. Among all treatments, metoxuron at the rate of 1.75 kg a.i./ha and terbutryn at the rate of 0.75 kg a.i./ha highest reduction in population of *Chenopodium* spp., and other weeds at all three stages (Table 1). Metoxuron at the rate of 1.75 kg a.i./ha, reduced 85 to 97 and 73 to 89 per cent population of *Chenopodium* spp. and other weeds over the unweeded plots. The similar trend was observed in terbutryn applied at the rate of 0.75 kg a.i./ha. Singh and Rathore (1976) also report that weed infestation was zero per cent at 45 days after sowing when terbutryn was applied at a rate of 1.0 kg a.i./ha as post emergence application in wheat. The number of weeds/m^2 was maximum in unweeded control followed by 2, 4-D ester and zero in terbutryn. At Udaipur, nearly same trend was observed in wheat by application of metoxuron 35 DAS at the rate of 1.25-1.75 kg a.i./ha.

Dry matter accumulation of weeds was significantly higher in unweeded plots than in other treatments. Metoxuron at the rate of 1.75 kg a.i./ha and terbutryn 0.75 kg a.i./ha proved best in reducing dry matter accumulation by *Chenopodium* spp., and other weeds at 45 DAS and harvest (Table 1). Study conducted at Udaipur, gave similar results in wheat (Anon., 1970).

Studies on the Crop

The results of experiment showed that yield attributing characters *viz.*, number of ears per plant and number of grains per ear were significantly influenced by the different treatments resulting in higher yield (Table 2). Higher doses of metoxuron at 1.75 kg a.i./ha and terbutryn reduced weed crop competition and produced 32 and 39 per cent higher grain yield over weeds check and 22 and 29 per cent more grain yield over 2, 4-D ester respectively (Table 2). Similar results have been reported by Rathore and Singh (1973), and Singh *et al.* (1974).

It is suggested that terbutryn at 0.75 kg a.i./ha and metoxuron at 1.75 kg 7

Table 2 : Effect of Terbutryn, Metoxuron and 2, 4-D ester on yield and its attributing characters of wheat.

Treatments	Grain yield kg/ha	Straw yield kg/ha	Grains/ear	Ears/plant
Tarbutryn 0.5 kg a.i./ha	2549	5222	48.2	5.9
Terbutryn 0.75 kg a.i./ha	3273	6996	56.7	7.8
Metoxuron 1.0 kg a.i./ha	2366	6214	46.7	5.7
Metoxuron 1.25 kg a.i./ha	2517	5743	47.8	5.5
Metoxuron 1.75 kg a.i./ha	2959	6647	56.4	7.4
2, 4-D ester 0.5 L/ha	2316	5040	47.1	6.0
Hand weeding at 35 DAS	2512	6243	44.3	6.2
Unweeded check	2002	4454	35.6	4.0
SEm ±	152	544	3.6	0.6
C. D. (P = 0.05)	443	1578	10.4	1.7

a.i./ha both applied 35 DAS proved most efficient in controlling weed population and weed growth, contributing to higher wheat yield.

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STUDIES ON THE EFFECTIVENESS OF CHEMICAL CONTROL OF *CHARA ZEYLANICA* KL. EX. WILLD. IN TRANSPLANTED RICE

P. VONGSAROJ, T. SANGTONG and A. NOTAYA
Weed Science Branch, Technical Division, Dept. of Agriculture, Thailand.

ABSTRACT

Control of *Chara zeylanica* Kl. ex. Willd. was studied with various herbicides viz. benthiocarb, bifenox, butachlor, CNP, copper sulfate, nitrofen, NaCl, 2,4-D and oxadiazon at the rate of 2, 2, 1, 2, 3, 2, 30, 1 and 1 kg a.i./ha respectively (except copper sulfate and NaCl as product) at Pakthongachai District, Nakornrassima Province in 1979. For an assessment, rice toxicity, rating of weed control, dry weight of chara m^{-2}, lists of other weeds and yield of rice were recorded. Oxadiazon tended to be more toxic to rice than other chemical while NaCl had no toxicity. Oxadiazon and benthiocarb controlled chara quite successfully.

INTRODUCTION

Chara infest a large area of paddy field in the Southern, Western and North-Eastern parts of Thailand (Vongsaroj et al., 1979). It competes with rice for nutrients and water which limits tillering, panicles and seeds per panicle. Spore is a reproductive organ for distribution of this weed (Barrett, 1978). Chara is going to have more suitable place to grow and it may be the main weed affecting rice production of Thailand in the near future in view of expansion of irrigation.

For the control of chara, copper sulfate has been used to inhibit the growth but it needs a number of applications. It is toxic to fish (Barrett, 1978). Mukherji (1968) conducted a trial on this weed and found that nitrofen did control chara. It was also found that other herbicides viz. oxadiazon and benthiocarb showed a tendency to control chara. In order to confirm these results a trial was undertaken.

MATERIAL AND METHODS

Ten methods of control was tried in a randomized complete block with 4 replications (Table 1). Plot size was 4 m x 5 m. The rice seeldings, Puang sawan, were transplanted with 3 plants/hill at the age of 30 days after seeding with the spacing of 25 cm x 25 cm. A fertilizer dose of 20 N and 25 kg P_2O_5/ha was applied at transplanting. Another dose of 25 kg N/ha was applied at panicle initiation. Herbicides were applied 7 days after transplanting. This trial was made at Pakthongchai district in which the infestation was present.

RESULTS AND DISCUSSION

The toxicity of herbicide to rice by visual observation at 20 days after herbicidal application was low for all herbicides (Table 1). Oxadiazon and nitrofen showed higher toxicity than other herbicides. Other herbicides as well as NaCl and copper sulfate were almost not toxic to rice.

As for effectiveness of weed control, it was found that oxadiazon, nitrofen and benthiocarb tended to show a good control of chara as seen from dry weight (Table 1). They also did control some

Table 1 : Toxicity, order of weed control and dry weight of chara and yield of rice.

Treatments	kg. a.i./ha	*Toxicity to rice	**Order of control	Dry wt. of chara – gm^{-2}	+ Yield at 14% moisture kg ha^{-1}
2, 4-D	1.0	2.0	2.0	42.15	71 bc
Oxadiazon	1.0	3.3	8.5	4.37	447 a
Nitrofen	2.0	2.9	8.0	8.17	432 ab
Benthiocarb	2.0	1.8	7.6	8.40	381 abc
Bifenox	2.0	2.4	6.4	28.52	406 abc
CNP	2.0	2.4	5.3	25.77	430 ab
NaCl	30.0 (product)	0	3.0	44.05	389 abc
Copper sulfate	3.0 (product)	1.5	3.4	45.00	347 c
Butachlor	1.0	2.3	4.8	39.75	414 abc
Weedy check	–	–	–	49.60	283 b

* Rice toxicity : 0 = no toxicity; 10 = rice completely killed

** Order of control : 0 = no control; 10 = excellent control • cv. = 10.6%

+Different subscripts indicate statistically different at 5%

Table 2 : Weeds found 40 days after herbicide application.

Treatments	Sphenoclea zeylanica	Eleocharis dulcis	Cyperus difformis	Fimbristylis miliacea	Jussæa linifolia	Monochoria vaginalis	Marsilea crenata
2, 4-D	/	–	–	–	–	–	/
Oxadiazon	–	/	–	–	–	–	–
Nitrofen	–	/	–	–	–	–	–
Benthicoarb	–	/	–	–	–	–	/
Bifenox	–	/	–	–	–	–	/
CNP	–	–	–	–	–	–	/
NaCl	/	–	/	/	/	/	/
Copper sulfate	/	/	/	–	/	–	/
Butachlor	–	/	–	–	–	–	/
Weedy check	/	/	/	/	/	/	/

/ = Present; – = Absent.

other seeds (Table 2). Other herbicides bifenox, CNP, butachlor and NaCl did not control chara. In the case of copper sulfate, it inhibited the growth as different from the earlier result (Barrett, 1978) since it was applied only once.

Dry weight of chara that was harvested at PI stage of rice plant and was found to be 4.37, 8.17 and 8.4 gm^{-2} in the case of oxadiazon, nitrofen and benthiocarb while the weedy check had 297.5 g/ha which confirm the result of Mukherji (1968) for control of chara by nitrofen.

Other weeds found in weedy check

were *Sphenoclea zeylanica* Gærtn., *Eleocharis dulcis* (Burm.f.) Henschel, *Cyperus difformis* Linn., *Fimbristylis miliacea* (L.) Vahl., *Jussœa linifoliæ* Vahl. *Monochoria vaginalis* (Burm. f.) Presl. and *Marsilea crenata* Presl. (Table 2). Nacl and copper sulfate did not control most of the weeds. *E.dulcis* and *M.crenata* were moderately resistant to most of the herbicides. Oxadiazon and nitrofen controlled all weeds except *E.dulcis.*

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WEED CONTROL IN UPLAND CROPS IN THE PHILIPPINES

F. BONGOLAN, G. J. WELLS and NIDA CABRADILLA
Betinan Research Station, Zamboanga del Sur, Philippines.

ABSTRACT

The effect of chemical and mechanical weed control methods on the yields of upland rice and mungbean were studied under rainfed conditions in the first cropping of 1980. Of the several herbicides tested, trifluralin applied post-sowing showed promise while hoeing between the crop rows was superior to the miniplow. In the second cropping, different combinations of these weed control methods were compared in soybean. Weed growth was less than in the upland rice experiment and so yield differences between weedy and weedfree treatments were small. However, trifluralin applied post-sowing, followed by hand-weeding was the most labour efficient method of weed control and resulted in a yield similar to that of the weedfree control. This and the hoeing method will be further developed for situations where the availability of labour is becoming a limiting factor of crop production.

INTRODUCTION

Competition from weeds in upland crops can severely reduce yields. In the Philippines, most farmers realize this and their crops are relatively free from weeds. However, the major upland crop is corn and the practice of off-baring and hilling-up, using a mould-board plough drawn by a carabao, between the widely spaced rows of this crop is an effective method of weed control. The increasing swing from corn to other crops, such as mungbean, soybean and upland rice, all of which are grown at a closer row spacing, has meant an increase in the cost of weeding because the plough can no longer be used.

Weeding is done by hand, using a short bladed bolo, but it is time consuming and so part of the crop suffers competition before the whole field can be weeded. In addition, many crops are weeded only once owing to a labour shortage. Therefore, new methods of weed control which will maximize effectiveness with the minimum of labour need to be developed for these crops.

Three experiments were conducted at Betinan Research Station in Zamboanga del Sur to compare the use of herbicides and inter-row cultivation with the traditional hand weeding for weed control in some upland crops. The soil type was a broken krasnozem of moderate fertility. This paper presents the results of these experiments and discusses the implication for further improvements of weed control practices for these crops.

MATERIAL AND METHODS

The first two experiments were sown to mungbean (cv. Pagasa) and upland rice (cv. IR 36) on 26 May in the first cropping period of 1980. Four replicates of a randomised block design were used and plot size was 2m x 5m. There were four rows of mungbean per plot spaced 50 cm apart with 5 cm between individual plants. For upland rice, there were eight rows per plot spaced 25 cm apart and the seed was drilled at 70 kg/ha. Inorganic

Table 1 : Chemical and mechanical weed control in rice and mungbean.

Treatments	Rice Yield t/ha	Mungbean Yield t/ha
1. Butachlor[a] pre-em	0.63	0.66
2. Metolachlor[b] pre-em	0.31	0.75
3. Trifluralin[c] pre-em	0.54	0.67
4. Diclofop methyl[d] post-em	0.61	0.74
5. Unweeded	0.36	0.72
6. Handweeded	2.01	0.95
7. Hœ	1.35	0.97
8. Miniplow	0.71	0.88
LSD	0.33	N.S.

a butacholr 1.8 kg ai/ha
b metolachlor 1.0 kg ai/ha
c trifluralin 0.4 kg ai/ha
d diclofop methyl 0.7 kg ai/ha

fertilizer was applied at the rates of 20-20-0 and 60-60-0 kg NPK/ha for mungbean and rice respectively.

The eight treatments were identical for both experiments (Table 1). The pre-emergence herbicides butachlor, metolachlor and trifluralin were sprayed immediately after sowing while diclofop methyl was sprayed 26 days later. In addition, all plots were sprayed with benomyl and monocrotophos during the vegetative stage to control fungal pathogens and insect pests while decamethrin was used to control insect pests during the reproductive stage. Grain yields were measured at maturity from all plots in both experiments. For mungbean, there were four harvests at weekly intervals commencing on 25 July while the upland rice experiment was harvested on 17 September.

The third experiment was sown to soybean (cv. UPL Sy2) on 17 October in the second cropping period. A randomized block design with four replicates was used. Plot size was 2m x 5m allowing four rows of soybean at 50 cm spacing per plot and plants were 10 cm apart within rows. Fertilizer of the rate of 20-20-0 kg NPK/ha was applied at sowing and plot management was similar to the earlier experiments.

There were 14 treatments (Table 2) comprising combinations of herbicide, hœ, miniplow and handweeding derived from the results of the first two experiments. Grain yield of the crop and weed growth were measured at crop maturity on 14 January 1981. All four rows of soybean were measured while weed growth was sampled using two quadrats per plot, each measuring 1m^2 in area. In addition, each mechanical weeding operation was timed so that comparative costs could be calculated.

RESULTS AND DISCUSSION

The grain yields of mungbean in the first experiment were not significantly different from each other (Table 1). There was little weed growth on the site and hence weed competition with the crop was less than usual. The handweeded treatment required only one weeding while the hœ and miniplow were also used only once before the crop canopy closed (Figure 1).

Figure 1. Weeding schedules for the mungbean (m) and rice (r) experiments.

Handweed m/r		r	r
Hœ m/r		r	
Miniplow m/r		r	r
sown	mungo harvest		rice harvest
May :	June :	July	Aug. : Sep.

In the upland rice experiment, weed growth was substantial as indicated by the large differences in grain yield between the handweeded and unweeded treatments (Table 1). Hœing between the crop rows give better weed control than the miniplow but, even so, the growth of weeds remaining in the crop rows decreased grain yield significantly. Of the pre-emergence herbicides, butachlor and trifluralin controlled some weeds but subsequent weed growth was substantial and large yield decreases resulted. Diclofop methyl applied post-emergence controlled the grassy weeds but, as a result, growth of the broadleaved weeds was encouraged and severe competition with the rice crop occurred. In addition, the crop itself appeared to have been stunted by this herbicide.

The soybean experiment in the second cropping of 1980 confirmed some of the tentative conclusions reached in the preliminary experiments. The use of either the hœ or miniplow was not effective in controlling weed competition within the crop rows and only where plots were handweeded early in the growing period was the soybean yield increased (Table 2). Although weed growth was not very great (up to only 3 t DM/ha), the effect of competition on grain yield was significant. The use of herbicides, such as trifluralin, which control mainly the grassy weeds, pave the way for an influx of broadleaved weeds which, if not controlled, can exert substantial competition against the crop (compare treatments 1 and 3 in Table 2).

The post emergence herbicide applications of diclofop methyl and terbutryne

Table 2: A comparison of weed control methods in soybean.

Treatments				Grain yield t/ha	Pods/ plant	Weed D. M. t/ha	Weeding time man days/ha
1. Trifluralin[a]		HW		0.99	21.6		15.6
2. Trifluralin		Hœ	HW	0.86	20.5		17.3
3. Trifluralin				0.82	19.9	1.82	
4. Butachlor[b]		HW		1.00	26.6		15.6
5. Butachlor		Hœ	HW	0.99	24.2		17.3
6. Butachlor				0.74	19.1	2.56	
7.	Diclofop methyl[c] + terbutryn[d]			0.00*	0.0*	n.a.	
8.	HW	HW (Weed free)		0.95	25.6		31.2
9.	Unweeded			0.84	20.6	2.97	
10.	Hœ		Hœ	0.81	23.9	1.81	16.6
11.	Miniplow		Miniplow	0.77	19.4	1.89	7.5
12.	Hœ	HW		0.91	25.4		23.9
13.	Hœ	Miniplow		0.83	20.0	1.83	12.1
14.	Hœ	Miniplow	HW	0.91	18.1		21.0
Sowing OCT	:	NOV					
L.S.D. (P = 0.05)					0.21	N.S.	

H.W handweed
* not included in analysis
n.a. not available

a. trifluralin 0.6 kg ai/ha
b butachlor 0.8 kg ai/ha
c diclofop methyl 0.7 kg ai/ha
d terbutryn 0.8 kg ai/ha

killed all soybean plants within two weeks of spraying. Some broadleaved weeds were also killed but some survived and went on to set seed normally. Such severe toxicity has been experienced before when these two herbicides were mixed but, on this occasion, they were applied separately.

The timing of each weeding operation in the soybean experiment was an attempt to assess the efficiency of the different implements. However, the data were obtained on small plots and care should be exercised in their interpretation. The mini-plow took an average of 1.8 minutes per plot to complete an operation while the hoe took 4.0 minutes and handweeding took 7.5 minutes. However, where plots were handweeded towards the end of November, when fewer weeds were present (Table 2), the time taken decreased to 4.3 minutes per plot. The total labour requirement for each treatment was then calculated (Table 2) and the results indicate that any time spent handweeding produced an economic increase in grain yield. Labour was costed at 10 per man/day and soybean at 3.5 per kg.

In the Philippines, weed growth is usually much greater during the wet season than during the dry season. It is therefore unlikely that, in many situations, as little as two handweedings will result in complete weed control for crops like soybean or upland rice. Because of the shortage of labour in rural areas, new methods of weed control must be developed for these crops. However, greater emphasis should be placed on the use of small cultivating implements in contrast to that of herbicides owing to the difficulty of accurately applying herbicides by hand and the unavailability of them to most upland farmers.

CONTROL OF WILD OATS (*AVENA LUDOVICIANA* DUR.) WITH DICLOFOP METHYL (ILLOXAN) IN IRRIGATED WHEAT

H. S. GILL and SAT PAUL MEHRA
Punjab Agricultural University, Ludhiana (Punjab), India.

ABSTRACT

The menace of wild oats (*Avena ludoviciana* Dur.) in irrigated wheat in the Punjab (India) is discussed. In field trials conducted during 1978-79, 1979-80 and 1980-81, diclofop methyl (0.70 to 1.25 kg ai./ha) post emergence at tillering stage of the crop gave a remarkable control of this weed. Its performance was superior to triallate (1.25 kg/ha) and barban (0.35 kg/ha) in this respect. Diclofop methyl gave a mean increase of 19.0 and 49.2% in grain yield over triallate and the unweeded crop, respectively during the first two seasons of these investigations. During 1980-81, diclofop methyl treated crop gave significantly higher grain yield than the barban plots, except diclofop methyl 1.08 kg/ha applied 30 days after sowing which though gave higher grain yield was on par with barban. Diclofop methyl at 0.7 to 0.8 mid tillering stage (30 days after sowing). For crop in maximum tillering stage (40 to 45 days after sowing) diclofop at 1.0 to 1.125 kg/ha appears adequate. Of the two formulations, diclofop 28 EC though used at lower a.i basis, gave better performance than the 36 EC formulation.

INTRODUCTION

Wild oats (*Avena ludoviciana* Dur.) is a serious grassy weed in irrigated wheat in Punjab and the adjoining states. This weed is adapted to light to medium texture well drained soils and is particularly serious in fields where wheat follows in rotation with maize, cotton, groundnut. The conventional method of hand weeding (hœing) has not been found so efficient for control of this and other grassy weeds with the result that a large area under wheat is infested with wild oats. Depending upon the intensity of infestation, 15 to 50 percent reductions in grain yield, are quite usual (Gill and Brar 1972; Gill *et al.* 1979). In view of this, studies on the herbicidal control of this weed are in progress for the last about 10 years. The results of three years' trials with diclofop methyl- a new wild oat herbicide, are presented in this paper.

MATERIAL AND METHODS

Field investigations were conducted in replicated trials during 1978-79, 1979-80 and 1980-81. The soil under the experiments was a loamy sand with the following physico-chemical characteristics in the top 15 cm soil profile.

Soil depth (cm)	Percentage of			pH	Organic carbon (%)
	Sand	Silt	Clay		
0-15	84	10	6	8.5	0.24

During 1978-79 and 1979-80, the experiment was sown on November 4, 1978 and November 8, 1979, respectively. During 1980-81, two sets of experiments were conducted; one trial was sown on Nov. 6, 1980 and the second on Nov. 26. The sowing of all the trials was done with a tractor drawn seed drill in

Table 1 : Effect of weed control treatments on intensity of wild oats, growth and grain yield of wheat.

Treatments kg. ai/ha	No. of wild oat panicles (m^{-2})			Dry wt. of wild oats (kg/ha)			Plant height (cm)			No. of ears/m row length			Grain yield kg/ha		
	78-79	79-80	Mean	78-79	79-80	Mean	78-79	79-80	Mean	78-79	79-80	Mean	78-79	79-80	Mean
T_1 Triallate emulsion 1.25 kg pre-plant	36	60	48	1210	1750	1480	92.3	76.3	84.3	61	50	55.5	3570	3562	3566
T_2 Trillate granules 1.25 kg (20 DAS*)	66	57	62	1090	1110	1100	91.4	76.4	83.9	62	55	58.5	3410	4073	3741
T_3 Diclofop-methyl 1.25 kg 25-27 DAS)	0	0	0	0	0	0	91.9	77.2	84.5	66	56	61.0	4240	4781	4510
T_4 Two hand weedings	38	62	50	590	1530	1060	92.0	75.9	84.0	63	52	57.45	3890	3635	3762
T_5 Unweeded crop (control)	82	97	89	1740	2050	1895	90.3	74.5	82.4	56	47	51.5	2460	2125	2292
C.D. ($P = 0.05$)	17	25	–	320	750	–	N.S.	N.S.	–	N.S.	7	–	600	1012	–

* DAS denotes days after sowing.

Table 2 : Effect of weed control treatments on intensity of wild oats and height, number of effective (fertile) tillers and grain yield of wheat.

Treatments kg. ai/ha	No. of wild oat panicles m^2	Dry weight of wild oats (kg/ha)	Crop plant height (cm)	No. of ears/ row length	Grain yield kg/ha
T_1 Diclofop-methyl 36 EC 1.25 kg (40 DAS*)	0	0	77.7	58	4035
T_2 Diclofop-methyl 36 EC 1.25 kg + 2,4-D 0.5 kg (40 DAS)	39	890	82.5	59	3750
T_3 Diclofop-methyl 36 EC 0.72 kg (30 DAS)	14	440	97.3	58	4035
T_4 Diclofop-methyl 36 EC 0.90 kg (30 DAS)	20	580	82.4	59	3557
T_5 Diclofop-methyl 28 EC 0.70 kg (30 DAS)	15	250	77.8	56	3823
T_6 Diclofop-methyl 36 EC 1.08 kg (30 DAS)	14	150	83.4	59	3193
T_7 Diclofop-methyl 28 EC 0.84 kg (30 DAS)	0	0	83.3	59	3681
T_8 Barban 0.35 kg (18 DAS)	150	2630	83.6	54	2847
T_9 Two hand weedings	100	1340	78.6	60	3229
T_{10} Unweeded crop (control)	221	4410	81.5	46	1916
C.D ($P = 0.05$)	113	1240	N.S.	6	627

* DAS denotes days after sowing.

Table 3: Effect of wild oat intensity and crop growth and grain yield of wheat.

Treatments (kg a.i./ha)	No. of wild oat panicles (m^{-2})	Dry weight of wild oats (kg/ha)	Crop plant height (cm)	No. of ears/ m row	Grain yield (kg/ha)
T_1 Diclofop-methyl 36 EC 1.0 kg (18 DAS)	21	320	75.3	63	3875
T_2 Diclofop-methyl 36 EC 1.0 kg (30 DAS)	17	480	77.5	59	3488
T_3 Diclofop-methyl 36 EC 1.0 kg (30 DAS) followed by 2,4-D 0.5 kg (40 DAS)	0	0	74.9	60	3488
T_4 Triallate 1.25 kg pre-plant	60	1580	73.7	55	3500
T_5 Triallate 1.25 kg pre-plant followed by 2,4-D 0.5 kg (40 DAS)	50	1320	76.2	53	3138
T_6 Two hand weedings	117	2620	79.5	60	2663
T_7 Unweeded crop (control)	235	6010	77.1	49	1675
C.D. (P = 0.05)	62	175	N.S.	7	904

* DAS denotes days after sowing.

rows 23 cm apart using a seed rate of 80 kg/ha. In all cases, wheat variety WL 711 was sown and recommended levels of N, P and K (120 kg N, 60 kg P_2O_5 and 30 kg K_2O/ha) were applied. Full dose of P and K and half dose of nitrogen was applied at the time of sowing and the remaining half of nitrogen was top dressed with first irrigation (3 weeks after sowing). The recommended irrigation schedule was followed. The schedule for spraying the herbicides is given in Tables 1, 2 & 3. Triallate was sprayed on a finely prepared seed bed free of clods and plant debris and soil incorporated to a depth of 3-4 cm with a bar harrow. Wheat was drill sown in these plots at a depth of 5 to 7 cm. Barban was applied 18 days after sowing (early post-em). When majority of the wild oat population was in 1.5 to 2.0 leaf stage (including coleoptile). The spraying of herbicides was done with a flat-fan nozzle with a spray volume discharge of 500 litre/ha.

RESULTS AND DISCUSSION

The data for 1978-79 and 1979-80 are given in Table 1 and for 1980-81 in Tables 2 & 3. The results are discussed under two headings.

(a) *Effect on weed intensity*

The differences in the number of wild oat panicles per m^2 and dry weight of wild oats at harvest were significant during 1978-79 and 1979-80 (Table 1). It was interesting to note that the application of diclofop-methyl gave remarkable control of wild oats and the treated plots presented a nearly wild oat free look. However, the triallate treated plots (T_1 & T_2 in Table 1) had a mean population of 48 and 62 panicles/m^2 which was nearly the same as in case of crop given two hand weedings. Thus, the bioefficacy of triallate was similar to the hand weeding treatment but its potential to control wild oats was very inferior to that of diclofop-methyl. A similar trend regarding the bioefficacy of diclofop-methyl versus triallate was observed during 1980-81 (Table 3). The use of triallate for control of wild oats in wheat has been recommended in the Punjab for the last 10 years or so. However, every year instances were not lacking where the stand of the wheat crop was severely damaged due to faulty application of triallate. Shallow incorporation of triallate to a precise depth of 3 to 4 cm followed by drill sowing of wheat at 5 to 7 cm depth are very essential to save the crop from the adverse effects of this herbicide. This much precision for its application is difficult to be attained by every farmer. However, diclofop-methyl has the advantage that it is effective as post emergence after first irrigation to the crop when nearly all the wild oats population has emerged. Further, this allows the farmer to make an assessment whether the level of wild oats population warrants the application of herbicide. This is important on economic consideration since the cost of herbicides in India is high.

During 1980-81 (Table 2) barban 0.35 kg a.i./ha applied 18 days after sowing wheat (1.5 to 2.0 leaf stage of wild oats) was included as the standard treatment. The performance of diclofop-methyl was distinctly superior to this product as evidenced by data on weed intensity (Table 2). The dry matter of wild oats in barban treated crop was 2630 kg/ha against an average of 330 kg/ha for diclofop-methyl treatments. The effective control of wild oats with diclofop-methyl has also been reported by Rœbuct and Trennery (1978); Anderson (1978) and Hœrauf and Shimabukuro (1979).

In our present investigations diclofop-methyl has been found to be primarily a wild oat killer; however, it killed young *Chenopodium* plants up to 3-4 leaf stage.

(b) *Effect on crop*

The differences in the height of crop plants among the different weed control treatments during the three years of investigations were non-significant. However, such differences in the number of affective tillers per metre row length were significant (except in 1978-79). The unweeded crop (weedy check) had the lowest number of effective tillers of wheat due apparently to adverse effect of high competition from weeds during the three years of these studies. In general, the treatments under diclofop-methyl, improved the number of effective tillers of the crop due to the elimination of wild oats competition with the crop. During 1980-81 (Table 3) the performance of triallate was inferior to diclofop-methyl in this respect.

The differences in grain yield among the different weed control treatments were significant during all the three years of these investigations. The unweeded crop (control) gave significantly lower grain yield than the other weed control treatments in all the experiments.

During 1978-79, diclofop-methyl at 1.25 kg a.i./ha though bracketed with the hand weeded crop (hœing), gave significantly higher grain yield than triallate (17.7% increase over triallate). During 1979-80 also maximum grain yield was recorded in case of diclofop-methyl and it was significantly higher than that attained for triallate (T_1), the hand weeded crop and the unweeded crop (control). Based on the data for 1978-79 and 1979-80, the diclofop gave on an average 20.9% increase in grain yield over triallate emulsion and 49.2% increase over the unweeded crop (weedy check). According to Anderson (1978), diclofop-methyl at 0.56 to 0.94 kg/ha gave 67 to 88% control of wild oats and 36 to 62% increase in grain yield. He concluded that 0.75 kg/ha is the optimum rate of diclofop-methyl for controlling wild oats in wheat. In the present trials during 1980-81 (Tables 2 & 3), the performance of diclofop-methyl was superior to other treatments. The differences in grain yield due to different rates of diclofop-methyl 36 EC (0.72, 0.90, 1.08 and 1.25 kg a.i./ha) were non-significant and 0.90 kg a.i./ha appears to be the optimal rate. Diclofop-methyl at 1.25 kg/ha induced burning of foliar tips of wheat and light yellowing of the leaves from which the crop recovered within about 3 weeks after treatment. In these studies, two commercial formulations of diclofop-methyl i.e. 36 EC and 28 EC were also evaluated at same commercial rates (2.5 & 3.0 1/ha) for their comparative bioefficacy. The 28 EC formulation though used at a lower active ingredient (a.i.) basis showed greater wild oat control potential than the 36 EC formuation (Table 2). In matter of grain yield also the 28 EC formulation gave a mean of 266 and 488 kg/ha.

The performance of diclofop-methyl was distinctly better than barban 0.35 kg/ha. All the treatments under diclofop-methyl (except where it was applied at 3.0 1 commercial/ha) gave significantly higher grain yield than barban (Table 2). These investigations also reveal some interesting observations on the time of application of diclofop-methyl. When applied 30 days after sowing (at early tillering stage of the crop), a lower rate of application (0.72 to 0.84 kg/ha) appears optimal. Its application at higher rate at this stage of the crop (early tillering stage) was observed to suppress the wheat grain yield by 488 kg/ha. Thus, under the agro-climatic conditions of Punjab, the rate of application of diclofop-methyl when applied at early tillering stage of the crop (30 days after sowing) appears to be 0.7 to 0.8 kg a.i./ha. The higher rate of application of this herbicide (1.25 kg a.i./ha) gave better yield when applied at the maximum tillering stage of the crop (40 days after sowing). It was further observed that tank mix application of diclofop-methyl with 2,4-D was compatible and no adverse effect on the growth and development of wheat was observed.

In some other studies on the effect of spray volume, it was observed that the level of wild oat control with diclofop-methyl was the same when spray volumes of 325 litres and 500 litres/ha were used.

The differences in the grain yield under diclofop-methyl 1.25 kg/ha sprayed with (as tank mix) and without 2,4-D at maximum tillering stage of the crop were non-significant (Table 2). In another trial sown on Nov. 26, 1980 (late sown crop) application of diclofop-methyl on 30 days old crop followed by application of 2,4-D at 40 days after sowing gave the same level of yield as obtained under diclofop-methyl alone (T_2 & T_3 in Table 3). These data, thus show that 2,4-D can be used with diclofop-methyl to enhance the weed control spectrum of the latter.

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EVALUATION OF OXYFLUORFEN IN POTATO AND TRANSPLANTED RICE

H. V. S. CHAUHAN and L. RAMAKRISHNAN
Indofil Chemicals Limited, Nirlon House,
Dr. Annie Besant Road, Bombay 400 025.

ABSTRACT

Trials were conducted at three different locations in Punjab and Haryana during 1979 and 1980 Potato season to evaluate the performance of goal 2E, a new herbicide. Dosages of Goal 2E ranging from 0.1 kg. a.i/ha to 0.3 kg a.i./ha were tested against commercial standards viz. Paraquat and nitrofen. Oxyfluorfen (Goal 2E) at all the dosages gave appreciable control of weeds viz. *Chenopodium album* , *Trianthema monogyna*, and *Phalaris minor*. However, Goal 2E gave poor control of *Cyperus rotundus*.

All the dosages of Goal 2E increased potato yields appreciably over unweeded control. In 1979, Goal 2E at 0.3 kg a.i./ha and in 1980 Goal 2E at 0.15 kg a.i./ha gave highest yields at 2 out of 3 locations.

In transplanted rice 1% granular formulation of Goal was tested at 2 locations in Punjab in 1979 and at 2 locations in Haryana during 1980. Varying dosages of oxyfluorfen (G) (0.1 to 0.2 kg a.i./ha) were tested along with commercial standards viz. butachlor, fluchloralin and nitrofen.

Oxyfluorfen (G) very effectively controlled weeds viz. *Echinocloa spp.* and *Cyperus spp.* and was comparable with commercial standard viz. butachlor.

In both season oxyfluorfen gave appreciably higher yields than unweeded control and was comparable with butachlor. All the dosages of oxyfluorfen tried were at par with each other.

INTRODUCTION

Oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy) -4- (trifluormethyl benzene) is a selective pre emergence herbicide for weed control in a variety of crops, and controls a wide spectrum of annual broad leaf weeds and a few grasses. The present investigations were undertaken to evaluate the efficacy of Oxyfluorfen on weed control in potato and paddy.

MATERIAL AND METHODS

Potato: Trials were conducted at the farmers' fields at two locations in Punjab and one in Haryana during 1979, and at three locations in Punjab during 1980. Dosage of Oxyfluorfen ranging from 0.10 kg. a.i./ha to 0.30 kg a.i./ha were compared with Nitrofen (Tok E-25) Nitrofen + Atrazine, Paraquat (Gramoxone) and unweeded control. The treatments were arranged in a randomized block design, with 4 replications at Khanna (A) and Khanna (B) in 1979 and at Amritsar and Hoshiarpur in 1980, and with 3 replications at Shahabad in 1979 and Jullundur in 1980. All the Herbicides except Paraquat were applied pre-emergence. Paraquat was applied post-emergence at 5 to 10% emergence of crop. Data were recorded on weed spectrum and yield of potato.

Paddy: In transplanted paddy two trials were conducted using a randomized block design with 3 replications in Punjab during 1979 and two trials with 4 replications in Haryana during 1980. Two formulations of Oxyfluorfen namely granular and E.C. were tested at dosages ranging from 0.075 kg a.i./ha to 0.2 kg a.i./ha respectively and were compared with other herbicides viz. Butachlor (Machete), Fluchloralin (Basalin), Nitrofen G. (Tok G.), Nitrofen EC (Tok E-25) and unweeded control. Whenever liquid formulations were used, the chemical was thoroughly mixed with dry sand using 60 kg sand per ha. All herbicides were applied pre-emergence, within 3 days after transplanting. Data on weed spectrum and paddy yield were recorded.

RESULTS AND DISCUSSION

Potato: Predominant weeds were *Chenopodium album*, and *Trianthema monogyna*, in trials conducted during 1979. At Khanna (A) location *Phalaris minor* was the most predominating weed. In trials conducted during 1980, main weeds present were *Cyperus rotundus, Chenopodium album* and *Trianthema monogyna.*

Oxyfluorfen very effectively controlled all the weeds present. Average of three locations indicate that the degree of weed control increased with increasing dosages of Oxyfluorfen. Oxyfluorfen gave significantly better weed control as compared to weedy check at all the rates tried, even at 65 DAS.

Treatment with Nitrofen, Paraquat and Nitrofen + Atrazine did not have a longer residual activity as very high number of weeds were recorded in these treatments at 65 DAS. Paraquat killed all the weeds which have emerged at the time of spraying but had negligible effect on weed emerging thereafter. At Khanna (A) very high number of *Phalaris minor* were recorded at 65 DAS because this weed came up at later stage, however it is interesting to note that Oxyfluorfen at 0.3 and 0.25 kg a.i./ha gave more than 90 and 80 percent control of this weed respectively even at 65 DAS.

During 1980, it was observed that Oxyfluorfen at 0.3 kg a.i./ha provided best overall control of weeds, and was significantly superior to control at both the stages of observation at all the 3 locations. All the herbicides provided significantly better overall control of weed at all the three locations. Paraquat provided a good control of *Cyperus rotundus* while

Table 1: Yield of potato as influenced by weed control treatments (1979 and 1980).

Treatment	Dose kg. a.i./ha	Yield q/ha Khanna (A) 1979	Khanna (B) 1979	Shahabad 1979	Mean 1979	Jullundur 1980	Amritsar 1980	Hoshiarpur 1980	Mean 1980
Oxyfluorfen	0.10	255.25	226.00	235.10	228.78	–	212.5	–	212.50
Oxyfluorfen	0.15	216.75	242.00	265.30	241.35	170.00	215.00	190.00	191.66
Oxyfluorfen	0.20	207.50	246.50	262.44	238.81	171.66	210.00	185.00	188.88
Oxyfluorfen	0.25	235.75	245.00	238.15	239.63	173.33	205.00	187.50	188.61
Oxyfluorfen	0.30	269.75	286.75	–	278.25	165.00	202.50	172.50	180.00
Nitrofen	1.56	216.00	248.50	237.30	233.93	176.66	197.50	186.25	186.80
Nitrofen + Atrazine	0.625 + 0.25	211.75	183.25	–	197.50	168.33	207.50	186.25	187.37
Gramoxone	0.60	198.50	152.25	227.73	192.82	161.66	192.50	175.00	176.38
Unweeded control		142.50	110.25	194.94	149.23	136.66	187.50	152.50	158.88
	S.Em ±	18.08	9.07	10.59		5.05	3.61	5.03	
	C.D (5%)	52.62	26.41	32.05		18.84	10.53	14.76	

Table 2: Yield of rice as influenced by weed control treatments (1979 and 1980).

Treatments	Dose kg. a.i./ha	Yield q/ha				
		1979		1980		Mean
		Ludhiana	Khanna	Kurukshetra	Masana	
Oxyfluorfen G	0.10	60.83	68.98	45.75	73.05	62.15
Oxyfluorfen G	0.15	–	–	46.20	71.45	57.60
Oxyfluorfen G	0.20	51.37	68.72	42.25	69.00	58.44
Oxyfluorfen EC	0.075	–	–	38.75	68.95	53.84
Oxyfluorfen EC	0.10	–	69.83	43.50	64.25	59.19
Nitrofen G	2.4	45.84	66.94	43.25	63.65	54.08
Nitrofen EC	0.625	52.74	67.67	37.75	65.80	55.98
Butachlor EC	1.25	53.25	71.61	47.00	74.80	61.66
Fluchloralin EC	0.675	50.08	72.88	43.25	70.70	59.22
Unweeded control		46.17	56.65	35.25	63.30	50.34
S. Em ±		3.29	3.24	2.56	3.18	
C.D. (5%)		N.S.	N.S.	7.40	N.S.	

all other treatments were not effective on this weed. However, Paraquat was inferior in the control of other weeds viz., *Trianthema monogyna* and *Chenopodium album* in comparison to other treatments. Treatments at different rates of Oxyfluorfen did not differ significantly amongst themselves at any of the locations and any stage of recording observations.

Yield of potato tubers was recorded from all the locations in both years and has been presented (Table 1). Data depicted shows that yield in all Oxyfluorfen treatments was significantly higher over control at all the locations in both years. Pooled yield average of 3 locations during 1979 shows that Oxyfluorfen at 0.30 kg a.i./ha gave highest yield, however during 1980 potato yields under this treatment showed slight reduction as compared with lower dosages. Nitrofen though was not very effective in weed control in comparison to Oxyfluorfen, but yield wise was quite close to Oxyfluorfen treatments. Nitrofen has been reported to increase potato yields, by different workers. Singh *et al.* (1972) have reported that TOK E-25 increases potato yields through some hormonal action.

Paddy: The predominating weeds in the trials conducted at 4 locations in two years (1979 and 1980) were *Echinochloa spp.* and *Cyperus spp.* All the treatments gave significantly better control of weeds as compared to control at all the locations in both the years except in the observation recorded at 35 DAS at Ludhiana in 1979. Oxyfluorfen at all the dosages provided remarkably good control of *Echinocloa spp.* and *Cyperus spp.* and was very close to standard treatment Butachlor. Fluchloralin though exhibited good control of *Echinocloa,* was poor in controlling *Cyperus spp.* both the formulations of Nitrofen were at par with each other and were inferior to Oxyfluorfen and Butachlor. It is interesting to note that EC formulation of Oxyfluorfen performed better than granular formulation when tried at the same dose. This is probably due to the reason that the chemical is more uniformly distributed by using higher quantities of sand to mix the chemical as compared to the ready-made granules used. Since very low quantities of EC are used it is desirable to dilute the chemical in water before mixing with sand otherwise it results in erratic performance as was observed at Kurukshetra during 1980.

Table 2 indicates that yield wise, treatments were significantly different only at one location, i.e. Kurukshetra during 1980. However, pooled mean of 4 trials shows that Oxyfluorfen G. at 0.10 kg. a.i./ha produced highest yields very closely followed by Butachlor, Fluchloralin and Oxyfluorfen EC at 0.1 kg a.i./ha in that order. Similar results have been obtained in All-India Coordinated Weed Control trials in transplanted rice (Anon. 1980).

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WEED CONTROL STUDIES WITH BUTACHLOR IN DIRECT SEEDED RICE IN SRI LANKA

H. P. M. GUNASENA and LEON M. ARCEO
Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka and Monsanto, Singapore Co. (Pte.) Ltd., Singapore.

ABSTRACT

In Sri Lanka where 75% of rice acreage is direct seeded, use of tillage and flooding with water are not satisfactory in controlling weeds. The herbicides that effectively control lowland rice weeds are gaining wider acceptance among farmers. 3, 4 – DPA and MCPA have been widely used as post-emergence herbicides. Machete Butachlor, a pre-emergent rice herbicide has shown considerable promise. Four trials with Machete in direct seeded rice were conducted in the wet and dry zones during May-September 1980 and October 80/February 1981. Three rates of Machete applied at 2 days before seeding and 6 days after seeding were evaluated. Machete tank mixed with 3, 4 DPA, 2, 4-D IPE and 24 D IBE was also evaluated. Results show that machete applied 2 days before seeding provided better crop tolerance than 6 days after seeding. Weed control and yield at 6 days after sowing application were slightly better than 2 DBS application. Machete at 2 days before sowing gave the highest yields among treatments.

INTRODUCTION

In Sri Lanka rice is largely cultivated under lowland direct seeded culture and thorough land preparation is one of the accepted methods of weed control. Weed control by this method is effective for about 3 weeks after which additional weedings have to be done (Moomaw *et al.*, 1966). The use of standing water is another important method practised for transplanted rice. However, when rice is established by direct seeding, water has to be drained off to allow the rice seeds to germinate. This facilitates the germination of rice and weed-seeds alike, and it is difficult to differentiate between them at the seedling stage (Gunasena, 1971). Rice is very sensitive to weed competition in the early stages of growth and failure to control weeds in the first 3 weeks after seeding reduces yield by 50% (Jayasekara and Velumurugu, 1966).

It is difficult to control weeds by preparatory tillage or standing water alone and very often a combination of several methods of weed control are required (Auma and Gunasena, 1971). A number of herbicides have been used in rice fields in Sri Lanka of which 3-4 dichloro propionanilide (3-4 DPA or Propanil) and 4-Chloro-2-Methoxyphenyl acetic acid (MCPA) have been widely used in the post emergence weed control. When they are used it is essential to drain off the water to expose the weeds and after spraying 5-6 hr of dry weather is necessary for the effective kill of the weeds. The time of application of these herbicides is also critical as they have the greatest effect when weeds are at a certain stage of growth (Gunasena, 1971). These requirements restrict extensive use as rice growing seasons usually coincide with periods of monsoonal rains.

As over 75% of the rice acreage in Sri Lanka is broadcast sown, there is a potential for an efficient low cost herbicide for use with direct seeded rice. As Machete

Table 1 : Experimental treatments.

	Rate, kg ai/ha	Time of application
Machete EC	0.75	2 Days Before sowing (DBS)
Machete EC	1.00	2 DBS
Machete EC	1.25	2 DBS
Machete EC	1.75	6 Days After Sowing (DAS)
Machete EC	1.00	6 DAS
Machete EC	1.25	6 DAS
Machete* + 2, 4-D Isopropylester (2, 4-D IPE)	1.00 + 0.8	6 + 25 DAS
Machete** + 3, 4 Dichloro propion anilide (3, 4 DPA)	1.00 + 3.0	19 DAS
3, 4 DPA	3.0	19 DAS
Machete + 3, 4 DPA	3.0	19 DAS
(a) Machete + 2, 4-D Isobutylester	0.75 + 0.5	2 DBS
(b) Machete + Propanil	0.75 + 2.0	16 DAS
Hand weeded	3 times	–
Unweeded control	–	–

* Sequential application ** Tank mixture

+ At Maha Iluppallama Machete + 2, 4-D IPE was applied at 25 DAS; Treatment a & b included in experiments II and IV.

2, 4-D IPE used only in experiments I & II.

(2-chloro diethyl-N-butoxymethyl acetanalide) has shown considerable promise, investigations were undertaken to test its effectiveness for direct seeded rice grown both in dry and wet zones of Sri Lanka.

MATERIAL AND METHODS

Four experiments were carried out at two locations, Peradeniya (450 m/amsl) in the wet zone and in farmer's fields at Maha Iluppallama (90 m/amsl) in the dry zone of Sri Lanka during May/September, 1980 and October/February 1981. The Peradeniya soil was a normal lowland paddy soil. The top 25 cm of the soil contained 42% clay and 25% silt. N status was moderately high (213 mg/100 g of soil). The available K, Ca and Mg were 0.24, 1.82 and 1.30 mg/100 g of soil. The pH was 5.3. The Maha Iluppallama soil was a humic gley containing 0.15% total N and 1.7% organic carbon. The available P, K, Ca Mg and Na contents were 2.5, 0.21, 10.4, 4.38 and 0.25 mg/100 g of soil respectively. The pH was 6.7.

The treatments were arranged in randomized blocks replicated 3 times (Table 1). Each plot measured 6 m × 3 m and was separated from the neighbouring plot by a bund 1 m wide and 0.25 m high.

Machete at 2 DBS was applied on partially drained plots. Then the plots were flooded to a depth of 3 cm for 2 days and water level subsequently increased to 5 cm. The plots were fully drained when applying Machete + 3, 4 DPA alone, and maintained for 24 hr and then flooded to 5 cm depth.

At both locations pre-sprouted seeds of the rice variety BG 34-8 were broadcast sown at the rate of 84 kg/ha. A basal dressing of a 3:30:10 NPK mixture was applied at 188 kg/ha at the final land levelling stage. Urea at 94 and 50 kg/ha was applied at 14 DAS and 42 DAS respectively and potassium as muriate of potash at 25 kg/ha was applied at 42 DAS.

Table 2: Effect of treatments on crop injury %, Experiment I & II, Peradeniya.

Treatment (kg ai/ha)		10 DAS	20 DAS		30 DAS		40 DAS	
		Expt II	Expt I	Expt II	Expt I	Expt II	Expt I	Expt II
Machete 0.75	2 DBS	8	1	4	8	–	1	–
Machete 1.0	2 DBS	8	5	3	10	–	2	–
Machete 1.25	2 DBS	4	16	–	10	–	10	–
Machete 0.75	6 DAS	3	4	26	4	36	2	56
Machete 1.0	6 DAS	38	20	53	3	56	2	66
Machete 1.25	6 DAS	72	45	65	13	68	6	80
Machete + 2, 4-D 1.0 + 0.8	6 DAS	82	94	92	96	98	70	99
fb	25 DAS							
Machete + 3, 4 DPA 1.0 + 3.0	16 DAS			7	1			
Machete + 3, 4 DPA 0.75 + 3.0	16 DAS							
3, 4 DPA 3.0	16 DAS							
Machete + 2, 4 D IBE 0.75 + 0.5	2 DBS		–	1	–			
Machete + Propanil 0.75 + 2.0	16 DAS		–	4	–			
Hand weeded								
Unweeded control								

In Treatment 7-2, 4-D IPE was used in Experiments I & IV; 2, 4-D IBE was used in Experiments II & IV.

All experiments were sampled in the early stages of growth. At each sampling a metal grid of 1500 cm^2 was used to remove samples from each plot. For each sample, % crop injury and grain yields were determined (when present). All weeds within the grid were removed, identified and counted.

RESULTS AND DISCUSSION

Visual observations

Crop injury %: The rice crop at Peradeniya showed a higher percentage of injury in both experiments than at Maha Iluppallamma (Table 2). At Maha Iluppallamma Machete + 2, 4-D IPE at 1.0 + 0.8 kg ai/ha applied at 25 DAS damaged 7% of the crop in experiment III and Machete + 2, 4-D IBE applied at 2 DBS showed 75% crop injury at 30 DAS in Experiment IV. When 2, 4-D IPE was sequentially applied at 6 and 25 DAS (Experiment I) at Peradeniya the crop had 96% injury at 30 DAS. This could be attributed to the toxic effect of 2, 4-D IPE being greater when applied at 6 DAS than at 25 DAS. 2, 4-D IPE has been reported to cause abnormalities in rice at the seedling stage. Auma and Gunasena (1971) reported the formation of 'Onion' leaves with leaf margins curled interiorly and tillers growing diageotropically when treated with 2, 4-D IPE at 6 DAS.

An increase in the rate of Machete increased crop injury at Peradeniya. However, extent of damage was less when applied at 2 DBS than at 6 DAS. The crop injury ranged from 1-16% and 4-80% when applied at 2 DBS and 6 DAS respectively. Machete at 1.25 kg ai/ha applied 2 DBS showed 16% crop injury at 20 DAS when compared with 94% when applied at 6 DAS. The crop recovered with time and 40 DAS low and medium rates of Machete showed 2% crop injury while the higher rate had 10% crop injury. The visible symptoms of crop injury were tip burn, distortion and twisting of leaves, marginal necrosis, brittleness of leaves and culms. These observations confirm the findings of Gunasena (1971) and Auma (1971). Machete + 3, 4-DPA or 3, 4-DPA alone applied at 19 DAS showed no crop injury.

Weed occurence: *Cyperus iria* L., *C. difformis* L., *Digitaria sanguinalis* L., *Fimbristylis litoralis* L., *Blyxa auberitii* Rich and *Monochoria vaginalis* (Burm F) Kunth were found at Peradeniya. Monocotyledonous weeds were most prominent and consisted of 35-73% of all weeds at 10-20 DAS in both experiments. The Dicotyledonous weeds, *Monochoria vaginalis* (Burm F) Kunth and *Blyxa aubertii* L., decreased with time. Sedges were prominent at 40 DAS in experiment I (51%).

A wider range of weed species was found at Maha Iluppallama than at Peradeniya. As in the wet zone monocotyledonous weeds were most abundant (69%). The prominent weeds at 10 DAS were *Cyperus spp.* (29%), *Oryzæ parrinis* L. (27%), *Ischimum rugosum Salis* (19%). *Frimbristylis litolaris* L. (13%) and *Echinochloa crusgalli* L. Beauv (9%). At 20 DAS the weeds of all species except that of *Oryzæ parrinis, E. crusgalli* increased and the same trend was maintained at 40 DAS. At 40 DAS *Cyperus spp* consisted of 44% of all weeds. The only dicotyledonous weed species found was *Eclipta alba* L.

The weed number/m^2 and distribution of species given in Tables 3, 4 and 5 show the effectiveness of herbicides in controlling weeds. The weeds numbers at 10 days were insignificant and herbicide effectiveness could not be established. However, in subsequent samplings the weeds were effectively controlled by herbicides compared with the unweeded control. At peradeniya sedges were effectively controlled by machete at all concentrations irrespective of its time of application, this effect being more pronounced in Experiment II. Machete tank mixed with 3, 4-DPA applied at 16 or 19 DAS provided the best weed control at Peradeniya. At Maha Iluppallama, weed control data of both experiments (Experiments III and IV) had a similar trend,

Table 3: Weed number/m^2, and distribution of weeds species (as % of total) Experiment I, Peradeniya.

Treatment	10 DAS				20 DAS				40 DAS			
Rate kg ai/ha	Total No.	% Mono	% Dicots	% Sedges	Total No.	% Mono	% Dicots	% Sedges	Total No.	% Mono	% Dicots	% Sedges
Machete 0.75 at 2 DBS	1	–	100	–	4	50.00	50.00	–	10	50.00	10.00	40.00
Machete 1.00 at 2 DBS	1	–	100	–	10	30.00	50.00	20.00	12	16.66	16.66	66.66
Machete 1.25 at 2 DBS	1	100	–	–	2	50.00	50.00	–	14	28.57	28.57	42.85
Machete 0.75 at 6 DAS	1	100	–	–	9	77.77	11.11	11.11	8	100.00	–	–
Machete 1.00 at 6 DAS	2	50.00	–	50.00	12	66.66	8.33	25.00	16	31.25	–	68.75
Machete 1.25 at 6 DAS	–	–	–	–	18	77.77	11.11	11.11	12	83.33	16.66	–
Machete + 2, 4-D IPE 1.0 + 0.8 at 6 DAS fb 25 DAS	–	–	–	–	0	–	–	–	3	33.33	–	66.66
Machete + 3, 4 DPA 1.0 + 3.0 19 DAS	–	–	–	100	9	11.11	22.22	66.66	4	50.0	25.00	25.00
Machete + 3, 4 DPA 0.75 + 3.0 19 DAS	1	100	–	–	3	33.33	33.33	33.33	5	60.00	–	40.00
3, 4 DPA 3.0 19 DAS	3	33.33	33.33	33.33	9	22.22	–	77.77	18	5.55	11.11	83.33
Hand weeding	0	–	–	–	0	–	–	–	0	–	–	–
Unweeded control	1	100	–	–	31	78.71	6.45	54.84	34	35.29	5.88	58.82

Table 4 : Weed number and distribution of weed species (as % of total) Experiment II, Peradeniya.

Treatment	10 DAS				20 DAS				40 DAS			
Rate kg ai/ha	Total No.	% Mono	% Dicots	% Sedges	Total No.	% Mono	% Dicots	% Sedges	Total No.	% Mono	% Dicots	% Sedges
Machete 0.75 2 DBS	0	–	–	–	1	100	0.00	0.00	2	100	–	–
Machete 1.0 2 DBS	0	–	–	–	6	50.00	33.33	16.67	13	84.61	0.00	15.38
Machete 1.25 2 DBS	0	–	–	–	0	–	–	–	15	80.00	6.67	13.33
Machete 0.75 6 DAS	2	50.00	50.00	–	0	–	–	–	1	100	–	–
Machete 1.0 6 DAS	2	50.00	50.00	–	2	–	100	–	3	100	–	–
Machete 1.25 6 DAS	0	–	–	–	1	–	100	–	3	100	–	–
Machete + 2, 4-D 1.0 + 0.8 6 DAS fb 25 DAS	0	–	–	–	0	–	–	–	0	–	–	–
Machete + Propanil 1.0 + 3.0 16 DAS	1	100	–	–	2	–	100	–	2	100	–	–
Machete + Propanil 0.75 + 3.0 16 DAS	1	–	100	–	0	–	–	–	0	–	–	–
Propanil 3.0 16 DAS	0	–	–	–	4	25.00	75.00	–	5	40.00	60.00	–
Machete + 2, 4-D 0.75 + 0.5 2 DBS	1	100	–	–	1	–	–	100	0	83.33	16.67	–
Machete + Propanil 0.75 + 2.0 16 DAS	3	–	–	100	0	–	–	–	0	–	–	–
Hand weeded	0	–	–	–	0	–	–	–	0	–	–	–
Unweeded Control	7	28.57	14.29	57.14	34	64.71	26.47	8.82	44	61.36	34.09	4.55

Table 5 : Weed number/m^2 and distribution of weed species (as % of total) Experiment III, Maha Iluppallama.

Treatment	10 DAS				20 DAS				40 DAS			
Rate kg ai/ha	Total No.	% Mono	% Dicots	% Sedges	Total No.	% Mono	% Dicots	% Sedges	Total No.	% Mono	% Dicots	% Sedges
Machete 0.75 2 DBS	29	96.55	3.448	–	26	88.46	3.85	7.69	23	86.95	4.34	8.69
Machete 1.00 2 DBS	6	83.33	16.66	–	31	90.32	6.45	3.22	19	94.74	–	5.26
Machete 1.25 2 DBS	4	75.00	25.00	–	9	77.77	11.11	11.11	6	83.33	–	16.66
Machete 0.75 6 DAS	8	100.00	–	–	7	100.00	0.00	–	4	75.00	25.00	–
Machete 1.00 6 DAS	16	100.00	–	–	6	83.33	16.66	–	2	–	100.00	–
Machete 1.25 6 DAS	3	100.00	–	–	1	100.00	0.00	–	4	50.00	50.00	–
Machete + 2, 4-D IPE 1.0 + 0.8 6 DAS fb 25 DAS	11	100.00	–	–	3	33.33	66.66	–	3	66.67	33.33	–
Machete + 3, 4 DPA 1.0 + 3.0 19 DAS	119	70.58	0.84	28.57	117	59.83	1.70	38.46	12	91.66	8.33	–
Machete + 3, 4-DPA 0.75 + 3.0 19 DAS	138	69.56	1.45	28.98	43	53.48	–	46.51	6	83.33	16.67	–
3, 4 DPA 3.0 19 DAS	103	67.97	1.94	30.09	94	31.91	–	68.08	23	34.78	4.35	60.87
Hand weeding	93	79.57	1.07	19.35	86	41.86	1.16	56.97	4	50.00	50.00	–
Unweeded control	124	62.90	0.87	36.29	135	45.92	1.48	52.59	364	35.71	1.10	63.18

Table 6: Effect of treatments on grain yield of rice (mt/ha).

Treatments (kg ai/ha)	Peradeniya		Maha Iluppallama	
	Expt. I	Expt. II	Expt. III	Expt. IV
Machete 0.75 2 DBS	2.22	4.60	3.72	5.00
Machete 1.0 2 DBS	2.18	4.35	4.10	5.89
Machete 1.25 2 DBS	2.17	4.37	4.19	5.07
Machete 0.75 6 DBS	2.47	4.23	4.44	4.90
Machete 1.00 6 DBS	1.97	3.19	4.56	4.82
Machete 1.25 6 DBS	2.55	3.20	4.92	4.86
Machete + 2, 4-D IPE 1.0 + 0.8 6 DAS fb 25 DAS*	2.06	2.16	5.38	5.35
Machete + 3, 4 DPA 1.0 + 3.0 19 DAS	2.65	3.46	5.80	5.80
Machete + 3, 4 DPA 0.75 + 3.0 19 DAS	2.57	3.35	5.38	5.43
3, 4 DPA 3.0 19 DAS	2.33	3.30	4.55	4.76
Machete + 2, 4 D IBE 0.75 + 0.5 2 DBS	–	3.00	–	5.70
Machete + 3, 4 DPA 0.75 + 2.0 16 DAS	–	3.80	–	4.86
Hand weeded	3.02	4.59	5.28	5.80
Unweeded control	1.78	1.23	2.46	3.00
L S D (P = 0.05)	N. S.	N. S.	1.39	1.46
C V (%)	18.9	12.4	10.8	12.00

* Applied at 25 DAS at Maha Iluppallama.

hence the detailed data are presented only for Experiment III. More weeds spp. as well as numbers were present at Maha Iluppallama than at Peradeniya. Machete controlled sedges completely at 10 DAS at all concentrations, trend being maintained until 40 DAS. Machete tank mixed with 3, 4 DPA applied at 19 DAS was more effective than 3, 4 DPA alone and killed sedges completely at 40 DAS. In general all herbicides controlled weeds compared with the unweeded control.

Grain yield of rice: The grain yields were consistently higher at Maha Iluppallama than at Peradeniya (Table 6). The grain yield differences between treatments were not significant at Peradeniya. In Experiment I, highest grain yield was recorded for the hand weeded treatment (3.02 mt/ha) immediately followed by Machete + 3, 4 DPA at 1.0 + 3.0 kg a.i./ha (2.65 mt/ha) and Machete + 3, 4 DPA at 0.75 + 3.0 kg ai/ha (2.57 mt/ha) applied at 19 DAS. In Experiment II, the hand weeded treatment yielded 4.59 mt/ha, while Machete at all rates applied 2 DBS and Machete at 0.75 kg ai/ha applied 6 DAS yielded over 4 mt/ha of grain being higher compared to all other treatments.

The differences in grain yields were significant in both experiments at Maha Iluppallama. In Experiment III, Machete + 3, 4 DPA at 1.0 + 3.0 kg ai/ha applied at 19 DAS gave the highest yield (5.80 mt/ha). Machete + 3, 4 DPA at 0.75 + 3.0 kg ai/ha applied at 19 DAS, and Machete + 2, 4 D IPE applied at 25 DAS gave equal yields (5.38 mt/ha). Hand weeded control yielded 5.28 mt/ha. In Experiment IV, Machete at 1.0 kg/ha applied at 2 DBS gave the highest yield (5.89 mt/ha) and other rates of Machete applied 2 DBS yielded over 5 mt/ha. Machete + 3, 4 DPA at 1.0 + 3.0 kg ai/ha applied at 19 DAS and the hand weeded control had equal yields (5.80 mt/ha).

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WEED CONTROL STUDIES IN SUGARBEET

GOVINDRA SINGH, D. SINGH and B. SINGH
Department of Agronomy, G. B. Pant University of Agriculture and Technology, Pantnagar, Nainital, 263145, India.

ABSTRACT

Field experiments were carried out to study the critical period of weed control in sugarbeet and effect of different herbicides on the growth of associated weeds, yield and quality of sugarbeet (*Beta vulgaris* L.). The major weed population in the experimental field consisted of broad leaf annuals (*Chenopodium album, Melilotus alba, M. indica, Vicia sativa* and *Fumaria parviflora*) and grassy annuals (*Polypogon monspeliensis, Phalaris minor* and *Avena* spp.). On an average, weed infestation caused 49 to 93% reductions in the beet root yields depending upon the intensity of weeds during different years. When sugarbeet fields were kept free of weeds for the first 60 days after planting, the beet root yields obtained were almost similar to those obtained from the fields kept free of weeds for the entire crop season.

Pre-emergence applications of pyrazon (3.0 kg/ha) consistently controlled the weeds effectively and produced yields at par with that of weedfree treatment. Pre-emergence application of ethofumesate was also effective in controlling the weeds. Combined application of benzthiazuron and metamitron; and Merpelan AZ and metamitron was more effective than their applications separately. None of the herbicides affected the sucrose content of beet roots.

INTRODUCTION

Weeds pose a serious problem in the cultivation of sugarbeet and 35 to 90% reductions in the beet root yields have been reported due to weeds (Bhan and Maurya, 1975; Singh and Singh, 1975; Dawson, 1977; Singh *et al.*, 1978). Studies have shown that pre-emergence application of pyrazon [5 - amino - 4 - chloro - 2 - phenyl -3 (2H) - pyridazinone] at the rate of 2.0 kg /ha^{-1} along with post-emergence application of phenmedipham (methyl-m -hydroxy carbanilate - m - methyl carbanilate) at 1.5 kg/ha^{-1} controlled weeds of sugarbeet fields effectively and produced beet root yields at par with that of weed-free condition without affecting sucrose content in beet roots (Singh *et al.*, 1978). Manual weedings though accomplish job effectively, it is necessary to determine how long after planting sugarbeet weeds must be controlled in order to minimize the manual operations and avoid yield reducing competition with the weeds.

The objective of the research reported in this paper was to know the critical period of crop-weed competition and to test new herbicides for their rates and methods of application for weed control in sugarbeet fields.

MATERIAL AND METHODS

Field experiments were conducted at the Crop Research Centre, Pantnagar during winter sessions of 1979-80 and 1980-81 on a silty clay loam with a nearly neutral reaction, 0.94% organic carbon, 24.1 kg ha^{-1} of available P and 132.6 kg ha^{-1} of K. 'Ramonskaya' variety of sugarbeet was planted on flat beds in rows 50 cm apart with 20 cm plant to plant spacing maintained by thinning. Experiments were planted during the first fortnight of November, in both the years. A randomized block design with 3-4 replications was used.

The herbicides tested were ethofumesate (2-ethoxy,-2,3-dihydro 3,3-dime-

Table 1 : Yield, number of roots, sucrose content of beet root and dry weight of weeds as influenced by different herbicides during 1979-80 and 1980-81.

Treatment	Rate kg ha^{-1}	Root yeild t ha^{-1}		No. of roots ,000 ha^{-1}		Sucrose %		Dry wt. of weeds gm^{-2} 60 DAS[1]	
		1979-80	1980-81	1979-80	1980-81	1979-80	1980-81	1979-80	1980-81
Benzthiazuron	3.0	25.7	46.0	90	73	14.2	13.7	29.4	23.3
Benzthiazuron + Metamitron	3.0 + 3.0	52.7	51.3	99	85	14.3	14.3	10.6	16.6
Metamitron	3.0	40.5	67.1	92	79	13.6	14.2	10.6	9.9
Merpelan AZ + Metamitron	2.0 + 3.0	54.8	68.2	98	82	14.1	14.3	5.3	11.1
Merpelan AZ	2.0	26.5	41.1	93	83	14.3	14.0	37.3	114.7
Benzthiazuron + Weeding 30 DAS[1]	3.0	29.8	59.1	94	89	13.9	14.0	14.0	10.6
Ethofumesate	1.0	37.0	43.3	95	67	13.5	13.7	40.0	101.3
Ethofumesate	2.0	58.3	69.2	99	87	13.5	14.3	14.0	25.3
Pyrazon	3.0	60.1	64.5	96	85	14.0	14.0	4.6	12.0
Weedings 30 & 60 DAS[1]	–	44.6	62.1	93	85	14.0	13.5	2.5	93.3
Weedfree	–	64.0	71.3	99	94	13.8	13.8	0.0	0.0
Weedy	–	11.5	21.5	62	47	13.7	13.7	50.6	138.7
S. Em ±		1.7	3.2	5	4	0.4	0.2	3.7	4.2
C. D.		5.9	9.4	15	12	N. S.	N. S.	10.8	12.2

[1] DAS = days after sowing

thyl - 5 - benzofuranyl methane sulphonate), benzthiazuron [N-(-benzthiazolyl)-N'-methylurea], metamitron [4-amino-3-methyl-6-phenyl-1, 2, 4-triazin5(4H)one (IUPAC) and Merpelan AZ, a combination product of isocarbamid (1-isobutylcarbomoyl-imidazolin-2-one) and lenacil (3-cyclohexyl-5,6-trimethyleneuracil). Ethofumesate and Merpelan AZ were applied as pre-emergence. Benzthiazuron was tested as pre-emergence treatment, while metamitron was tested as post-emergence treatment. Pyrazon as pre-emergence treatment was included as standard treatment.

RESULTS AND DISCUSSION

The relative intensity of weeds in the experimental plots was assessed on the basis of weed count in weedy plots. On an average, more than 58% of total weed population consisted of annual broad leaved weeds (*Chenopodium album* L. 28.2%, *Melilotus alba* L., 8.6%, *M. indica* L. 11.2%, *Anagallis arvensis* L. 3.2%, *Vicia sativa* L. 2.2% and *Fumaria parviflora Lamk* 4.5%), while grassy annuals constituted more than 33% of the total weed population (*Polypogon monspeliensis* L. 16.7%, *Phalaris minor* Retz. 14.8% and *Avena spp*. 2.3%).

Herbicide trial

Ethofumesate at 2.0 kg/ha produced beet root yields significantly higher than the weedy check and at par with that of weedfree treatment. Beet root yields at 1.0 kg/ha were significantly lower than the yields at 2.0 kg/ha of ethofumesate in both the years. The number of beet

Table 2: Effect of crop-weed competition on sugarbeet and associated weeds.

	Beet root yield t ha^{-1}	No. of beet roots ,000 ha^{-1}	Sucrose % in beet roots	Dry wt of weeds gm^{-2}		
				60 DAS[3]	90 DAS[3]	120 DAS[3]
			1979-80			
Free of weeds for the first						
30 days[1]	44.4	83	16.7	32.1	93.4	112.8
60 days[1]	62.0	97	15.8	–	–	–
90 days[1]	62.6	96	15.2	–	–	–
120 days[1]	63.1	97	15.7	–	–	–
150 days[1]	63.5	94	15.6	–	–	–
Weedfree up to harvest	63.7	99	15.2	–	–	–
Weeds infested for the first						
30 days[2]	52.0	92	16.2	–	–	–
60 days[2]	40.4	73	15.8	54.5	–	–
90 days[2]	21.7	67	16.1	60.7	175.8	–
120 days[2]	9.4	51	15.6	59.8	169.7	387.2
150 days[2]	8.9	47	16.1	67.5	171.6	398.7
Weeds infested up to harvest	8.7	45	16.0	58.9	185.9	395.9
S. Em ±	1.6	5	0.6			
C. D.	5.1	15	N. S.	–	–	–
			1980-81			
Free of weeds for the first						
30 days[1]	54.7	89	13.8	29.8	73.5	143.2
60 days[1]	73.2	91	15.1	–	3.2	5.8
90 days[1]	80.0	98	14.8	–	–	2.5
120 days[1]	74.2	95	13.7	–	–	–
150 days[1]	74.0	92	14.1	–	–	–
Weedfree up to harvest	79.6	97	13.9	–	–	–
Weeds infested for the first						
30 days[2]	73.9	93	14.1	–	–	–
60 days[2]	61.5	89	13.9	49.8	–	–
90 days[2]	29.5	67	14.0	55.2	161.7	–
120 days[2]	15.1	52	14.1	47.6	163.8	376.2
150 days[2]	16.1	53	13.8	52.8	169.5	381.2
Weeds infested up to harvest	14.7	51	14.0	51.2	165.7	372.5
S. Em ±	2.6	3	0.4	–	–	–
C. D.	7.6	9	N. S.	–	–	–

[1] and weeds infested till harvest; [2] and free of weeds till harvest; [3] DAS = days after sowing.

roots were reduced at 1.0 kg/ha due to poor weed control which is evident from the dry weight of weeds recorded 60 days after sowing of sugarbeet (Table 1).

Benzthiazuron and Merpelan AZ were tried in combination with metamitron. Post-emergence application of metamitron over pre-emergence application of benzthiazuron and Merpelan AZ increased the weed control and beet root yields also increased significantly (Table 1). Pre-emergence application of pyrazon (3.0 kg/ha) consistently gave beet root yields at par with that of weedfree treatment. Weed control in this treatment was excellent (Table 1).

None of the herbicides tested could cause any significant variation in the sucrose content of sugarbeet roots.

Crop-weed competition trial

Competition with the weeds for entire crop season resulted in 81.5% reduction in the beet root yields. When crop was kept free of weeds for the first 60 days after sowing the yield of beet roots obtained was almost similar to that of complete weedfree treatment (Table 2). Increase in duration of weedfree period beyond 60 days could not increase beet root yields. Emergence of weeds after 60 days of sowing was very low and crop developed closed canopy which did not permit much growth of these weeds which is evident from the data on weed dry weights (Table 2). When crop was kept free of weeds for the first 30 days only the yield was significantly lower than the yields of weed free treatment for entire crop season. In this case the population of weeds emerging 30 days after sowing was quite high and dry weight of weeds was also high because the crop could not provide enough canopy to suppress these weeds by this time.

Yield reducing competition occurred only after 30 days of sowing of sugarbeet. When crop was allowed to grow with with uncontrolled weeds for the first 30 days, the beet root yields obtained were at par with that of complete weedfree treatment in 1980-81 (Table 2). Every successive increase in the duration of weed competition beyond 30 days of sowing caused significant reduction in the beet root yield, number of beet roots and increase in the dry weight of weeds.

CONCLUSION

The different periods of weed-competition did not affect the sucrose content of sugarbeet roots.

Weeds reduced sugarbeet root yields as well as number of beet roots tremendously without affecting the sucrose content of roots. Pre-emergence application of pyrazon (3.0 kg/ha), pre-emergence application of ethofumesate (2.0 kg/ha) and combined application of Merpelan AZ (2.0 kg/ha) pre-emergence and metamitron (3.0 kg/ha post-emergence) can be recommended for weed control in sugarbeet. The critical period of weed control in sugarbeet lies between 30 and 60 days after sowing. Any weed competition during this period would cause beet root yield reduction.

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CHEMICAL CONTROL OF WEEDS IN RUBBER STOCK NURSERIES

SOEPADIYO MANGOENSOEKARJO and NURDIN
Balai Penelitian Perkebunan Medan (RISPA), P.O. Box 104, Medan, Sumatra, Indonesia

ABSTRACT

With the ever-increasing cost of labour, herbicides are being used economically by some estates as adjuncts to hand weeding in nurseries of rubber stock seedlings. Hand weeding involves a lot of labour and besides damage to seedlings due to lack of care. The development of pre-emergence herbicides opened the possibility of chemical weeding in rubbber nurseries. Experiments comparing the performances of seven pre-emergence and one post-emergence herbicides with hand weeding and no weeding at all, indicated that the formulations which were most promising for good weed control and relatively safe on rubber seedlings, were linuron, napropamide, cyanazine and simazine at 1.5 kg a.i/ha and diuron 1.0 kg a.i/ha at planting and paraquat + diuron 1.5 l product/ha applied two to three months after planting. These herbicides suppressed weed growth for four to five months.

INTRODUCTION

With the rapid diversification of plantation agriculture in Indonesia, the hectarage of rubber planting in the last few years has progressively increased. Budded stumps are prepared in large central nurseries. The control of weeds which is so important for vigorous growth of seedling stocks is a major problem. Pre-emergence herbicides are of very great interest because their use can eliminate the need for weeding in nurseries during the first three months when labour is urgently needed elsewhere for land clearing and planting and at a time when growth of the young seedlings is very sensitive to damage from weed competition. Chemical weeding has become an established practice in some countries to overcome the shortage of labour for manual weeding. Bare nursery ground is usually the aim and it can be relatively easily achieved by the use of herbicides as opposed to the expensive manual weeding. However herbicides such as diuron at 2 kg a.i/ha, cannot be used in nurseries even during its preparation, since these chemicals are phytotoxic to rubber seedlings (Mangoensoekarjo and Kandan, 1974). The same result in Thailand was reported by Boonsrirat and Paardekooper (1971), that diuron at 3.0 kg product/ha or higher may cause dieback and stunted growth, but at 1.5 kg product/ha it caused no apparent damage. A rate of 0.75 kg/ha has since been recommended in Thailand (Rubber Research Centre, Thailand, 1974).

Although a number of pre-emergence herbicides have been given limited use in rubber stock nurseries in Indonesia, it is only post-emergence herbicides such as paraquat that are commonly applied. But whereas contact herbicides can control weeds for only a short duration, pre-emergence herbicides can offer a prolonged period of control. The use of pre-emergence herbicides in rubber nurseries and their effect on young seedlings was investigated in Sri Lanka (Jeevaratnam

Table 1: Treatments and rates of herbicides.

Common name	Chemical name	rate a.i. kg/ha
Diuron	3-(3, 4-dichlorophenyl)-1, 1-dimethylurea	1.0
Linuron	3-(3, 4-dichlorophenyl)-1-methoxy-1-methyl-urea	1.5
Methabenzthiazuron	N-Benzothiazol-2-yl-NN-dimethylurea	1.5
Cyanazine	2-{[4-chloro-6-(ethylamino)-*s*-triazin-2-yl] amino} -2-methylpropionitrile	1.5
Terbumeton	2-*tert*-butylamino-4-ethylamino-6-methoxy-*s*-triazine	1.5
Simazine	2-chloro-4, 6-bis (ethylamino)-*s*-triazine	1.5
Napropamide	2-(α-nephthoxy)-N, N-diethylpropionamide	1.5
Paraquat + Diuron (1:1)	1, 1'-dimethyl-4, 4'-bipyridinium dichloride + 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea	1.5
Hand weeding *(b)*	–	–
Control (no weeding)	–	–

a Paracol 1.5 l product/ha sprayed four months after planting
b Hand weeding at two weeks interval

and Kanthasamy, 1962 and Kasasian, 1962), in Thailand (Boonsrirat and Templeton, 1974), and in Malaysia (Fiaz, 1979).

The trial reported in this paper aimed to study the effectiveness of selected pre-emergence herbicides on the control of weeds in a nursery of rubber seedlings for use as stocks.

MATERIAL AND METHODS

The field trial was a Randomized Block Design of ten treatments replicated four times. It consisted of seven pre-emergence herbicides and one post-emergence herbicide with handweeding and no weeding (control) in plots of 3 m by 4 m size. Treatment details are given in Table 1.

Treatments were applied with hand operated knapsack sprayer fitted with a blue (1.575 mm) polijet tip nozzle at a constant pressure of 1.0 kg/cm^2 controlled with a gauge and walking speed of 2 to 3 km/hour using a stopwatch. The spray volume was maintained at 600 l water/ha.

The trial was established in January – 1980 on a portion of the rubber stock nursery in Paya Pinang Estate, North Sumatra, Indonesia. The soil was a well drained podsol, with a pH of 6.2, a C/N (humus) content of 8.4 and a soil texture of 39% sand, 38% clay and 23% silt. The monthly rainfall during the trial from January to July was 103, 63, 93, 59, 102, 131 and 155 mm respectively. The clumps of grasses and other weeds were removed manually prior to application of the pre-emergence herbicides. The herbicides were sprayed one week before planting of the germinated seedlings which had a stem height of about 7 cm.

Observations included a visual assessment of any physical injury or toxic symptoms on the seedlings due to herbicide application, the percentage of weed regeneration at monthly intervals, and height and girth (at 5 cm above soil level) measurements of the seedlings. The experiment was continued for 24 weeks.

RESULTS AND DISCUSSION

No physical injury on toxicity symptoms were observed at four weeks after spraying or at the final observation.

Table 2: Stem height and diameter of rubber seeding.

Treatments	Height						Diameter					
	6 Weeks		14 Weeks		24 Weeks		6 Weeks		14 Weeks		24 Weeks	
	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%
Diuron	29.8	(99.3)	60.0	(102.3)	91.0	(102.1)	3.1	(101.0)	6.0	(104.4)	9.6	(102.7)
Linuron	30.4	(101.3)	60.8	(103.6)	92.8	(104.2)	3.1	(101.4)	5.9	(103.0)	9.4	(101.1)
Methabenzthiazuron	31.6	(105.2)	61.0	(104.0)	95.7	(107.4)	3.1	(101.7)	5.9	(101.7)	9.6	(103.5)
Cyanazine	31.5	(105.0)	62.0	(105.8)	93.2	(104.6)	3.1	(101.7)	5.9	(102.6)	9.3	(100.3)
Terbumeton	29.0	(96.6)	51.9	(88.6)	80.6	(90.5)	2.9	(95.9)	5.2	(90.0)	8.4	(89.8)
Simazine	28.7	(95.7)	58.1	(99.0)	87.9	(98.6)	2.9	(96.9)	5.6	(97.0)	8.7	(93.0)
Napropamide	31.9	(106.3)	61.3	(104.5)	91.2	(102.4)	3.1	(101.6)	5.8	(100.0)	8.9	(95.7)
Paraquat + diuron	31.7	(105.5)	60.8	(103.8)	92.1	(103.4)	3.1	(101.1)	5.7	(98.3)	9.2	(98.4)
Hand weeding	30.0	(100.0)	58.6	(100.0)	89.1	(100.0)	3.0	(100.0)	5.8	(100.0)	9.3	(100.0)
Control (no weeding)	30.3	(101.0)	61.8	(105.4)	87.5	(98.6)	3.0	(99.2)	5.9	(102.2)	8.4	(89.8)
	N.S.		N.S.		N.S.		N.S.		N.S.		N.S.	
CV (%)	6.9		7.2		9.0		3.4		6.9		10.2	

N.S. = non significant

Table 3: Percentages of weed generation *.

Treatments	4 weeks	8 weeks	12 weeks	16 weeks	20 weeks	24 weeks
Diuron	1.3	3.3 ac	7.5 bc	2.5 bd	25.6 bc	48.8 b
Linuron	1.0	2.5 bc	6.3 c	17.5 cd	19.5 bc	53.3 b
Methabenzthiazuron	2.0	3.0 ac	17.5 ab	37.5 ac	43.8 ab	67.5 ab
Cyanazine	1.3	1.5 c	6.0 c	13.8 cd	22.5 bc	56.3 ab
Terbumeton	0.5	1.3 c	1.8 c	3.5 d	3.5 c	8.3 c
Simazine	0.8	2.0 bc	5.5 c	19.3 cd	24.3 bc	55.0 ab
Napropamide	1.0	2.5 bc	5.0 c	13.8 cd	19.5 bc	46.3 b
(Paraquat + diuron)	0.8	3.0 ac	20.0 a	53.8 a	1.5 c	6.3 c
Hand weeding	2.0	5.3 a	5.0 c	13.8 cd	22.5 bc	1.0 c
Control (no weeding)	2.7	4.5 ab	23.8 a	50.0 ab	62.5 a	85.0 a
	N.S.					
CV (%)	12.9	22.8	26.2	19.5	21.0	20.3

* Original data, analysed of variance based on values transformed to Arcsin Any two means in one column followed by the same letter are not significantly different at the 5% level. N.S. = non significant

Further, there were no significant effects of the herbicides on establishment of the seedlings determined by either heights and stem diameter measurements. There were indications however that seedling height and stem diameter growth was promoted by methabenzthiazuron (up 7.4% and 3.5% respectively) and depressed by terbumeton (down 9.5% and 10.2% respectively), effects which could lead to differences in the time when seedlings would be ready for budding (suitability for budding is largely a matter of stem diameter at budding height – small stems are not worth budding because of the poor vigour of the subsequent scion growth). It will be noted that the effect of no weeding at all only reduced stem diameter by 10.2% but this effect could be assumed to become far more serious in the next few months (Table 2).

Table 3 shows the effects of the pre-emergence herbicides on the weed regeneration. All herbicides except methabenzthiazuron maintained a very good to excellent level of weed control during the first four months with regeneration ranging from about 2.5 to 19.3%. It is generally considered that a 40% coverage by weeds is maximum tolerable before taking corrective action. Thus methabenzthiazuron gave effective control for only three months. However, it seemed that this formulation has some stimulating effect on the seedling growth but it did not reach a significant level.

Paraquat + diuron sprayed four months after planting at a time when there was a 53.8% weed coverage, gave good control for the next two months without any adverse effects on seedling growth.

Diuron at the low dosage of 1.0 kg a.i/ha showed no adverse affects on the growth of the seedlings in contrast to other trials with higher rates of application. The lower dosage gave very good weed control during the first four months. Although terbumeton gave almost total weed control during six months, it had detrimental effects on rubber seedling growth as had already been observed by earlier workers.

Major weeds emerging four months after spraying with diuron, linuron, cyanazine and simazine were *Ageratum conyzoides* L., *Passiflora fœtida* L., *Oxalis barrelieri* L., and *Cleome rutidosperma* D.C. With use of methabenzthiazuron, terbumeton and napropamide, the principal weeds emerging were *Axonopus compressus* (Swartz) Beauv, *Centotheca lappaca* (L) Desy, *P. fœtida* L. and *Urena lobata* L. Major weeds in the non-weeded plots (control) were *Paspalum conyungatun* Breg., *A. compressus* (Swartz) Beauv, *C. lappaca* (L) Desy, *Ottochoa nodusa* (Kunth) Dandy, *Digitaria adscendens* (HBK) Henr., *A. conyzoides* L., *P. fœtida* L., *O. barrelieri* L., *U. lobata* L. and *C. rutidosperma* D.C.

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CONTROL OF GRASSY WEEDS IN WHEAT (*TRITICUM ÆSTIVUM* L.) THROUGH PROMISING HERBICIDES UNDER MID-HILL CONDITIONS

N. N. ANGIRAS and S. C. MODGAL
Department of Agronomy and Agrometeorology, H. P. Krishi Vishwa Vidyalaya, Palampur-176 062.

ABSTRACT

A field experiment was conducted to study the comparative efficacy of some promising herbicides in controlling weeds like *Avena fatua*, *Phalaris minor* and *Lolium temulentum* during 1978-79 and 79-80 in a randomized block design with three replications. Among the herbicides under study, methabenzthiazuron at 1.44 kg/ha, metoxuron at 1.5 kg/ha (both as post-emergence) and terbutryne at 1.25 kg/ha (as pre-emergence) controlled the weeds effectively in wheat crop during both the years. Isoproturon at 1.75 kg and 2.25 kg/ha (as post-emergence) gave the best control of grassy weeds in the second year of experimentation. None of the herbicides controlled *Lolium temulentum* effectively except diclofop at 0.9 kg/ha (post-emergence) and isoproturon under higher doses of application. The triallate and nitrofen herbicides were effective only in controlling wild oats and wild canary grass, respectively. Diclofop (pre-emergence), triallate (pre-sowing) + nitrofen (pre-emergence) and methabenzthiazuron (pre-emergence) though controlled the weeds but had phytotoxic effect on the wheat crop.

INTRODUCTION

Dwarf varieties being responsive to high fertilizer and irrigation levels have created the micro-ecological conditions within the crop favourable to the growth and development of weeds, particularly grasses like Little Canary Grass (*Phalaris minor* Retz.), Wild Oats (*Avena fatua* L.) and Darnel Rye Grass (*Lolium temulentum* L). The grassyweeds present more competition to the wheat crop since their feeding zone in soil is same as that of the crop. Intense morphological similarities of grassy weeds with wheat plants during vegetative phase; high reproductive rate, early seed shedding behaviour, seed dormancy and indiscriminate movement of wheat from infested to non-infested areas, defies the mechanical methods of weed control (Gill *et al.,* 1979). The herbicides like triallate, nitrofen and 2, 4-D, due to their narrow spectrum and different times of application increase the cost of treatment and are less effective in controlling the mixed weed flora. The present investigation was therefore undertaken during winter 1978-79 and 1979-80 to compare the relative effectiveness of broad spectrum herbicides for control of all the three grassy weeds in wheat under mid-hill conditions of Himachal Pradesh.

MATERIAL AND METHODS

The acidic soils of the experimental plot was silty clay loam with low, and medium content of N, P and K, respectively. During the year 1978-79 crop experienced 12.0 to 33.2°C and 3.2 to 22.4°C maximum and minimum temperatures respectively, and 603 mm rainfall. Whereas during 1979-80 the crop experienced 12.2 to 32.0°C and 2.6 to 20.0°C maximum and minimum temperatures respectively, and 322 mm rainfall. The herbicides under study were methabenzthiazuron [1,3-dimethyl-3-(2-benzothiazolyl)-urea], triallate (*S*-2,3,3-trichloroallyl, di-isopropyl-thiocarbamate), nitrofen (2, 4 - dichlorophenyl*p*-nitrophenyl ether), terbutryn (2-*tert* - butylamino - 4 - ethyl - amino - 6 - methylthio-1,3,5-triazine), metoxuron[*N'*-(3 - chloro - 4 - methoxyphenyl) - *N*, *N*-dimethylurea], metribuzin[4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4H)-one], diclofop (2-[4-(2,4-dichloro-phenoxy)-phe- noxy]propanoic acid), paraquat (1, 1'-dimethyl-4, 4'-bipyridinium ion) and isoproturon [3-(4-isopropylphenyl)-1, 1-dimethylurea).

The data with respect to effective tillers, grain yields, dry-matter of weeds, toxicity and control ratings are presented in Table 1 and of species wise weed count, and weed control efficiency in Table 2.

RESULTS

Crop Studies: A significant reduction in effective tillers per plant was recorded in both the years in triallate 1.25 kg/ha pre-sowing, terbutryn at 1.25 kg/ha post-emergence and methabenzthiazuren at 1.8 kg/ha pre-emergence, metribuzin 0.5 kg/ha pre-emergence diclofop 0.9 kg/ha pre-emergence, triallate 1.25 kg/ha pre-sowing + nitrofen 1.25 kg/ha pre-emergence and unweeded control plots over weed free check (Table 1). Spikelength and 1000 grain weight did not differ significantly.

During 1978-79, maximum biological yield was obtained with paraquat 0.6 kg/ha (post-emergence to weeds and pre-emergence to crop) and metoxuron 1.6 kg/ha post-emergence which were at par with all other treatments except triallate alone and in combination with nitrofen, metribuzin 0.5 kg/ha pre-emergence and Diclofop 0.9 kg/ha pre-emergence, which had phytotoxic effect on the crop as evident from the toxicity ratings (Table 1). But during 1979-80, isoproturon 2.25 kg/ha post-emergence treatments produced significantly higher grain yield over 2 hand weedings and were at par with weed free check. The effect of rest of the herbicides was at par with 2 hand weedings.

Weed Studies: In both the years methabenzthiazuron pre- and post-emergence, metoxuron pre- and post-emergence, diclofop pre- and post-emergence, Triallate pre-sowing + nitrofen pre-emergence, isoproturon 1.75 kg/ha and 2.25 kg/ha post-emergence, 2 hand weedings and weed free check treatments scored the high control ratings. All the treatments in 1978-79, except nitrofen, paraquat, and unweeded control produced significantly lower drymatter of weeds in comparison to 2 hand weedings (Table 1). In 1979-80, all treatments except terbutryn pre- and post-emergence, and linuron pre-emergence, produced significantly lower dry matter of weeds as compared to unweeded control.

Species-wise weed count indicated significant control of *Phalaris minor* Retz. by nitrofen, terbutryn pre-emergence, methabenzthiazuron pre- and post-emergence and isoproturon at 1.75 and 2.25 kg/ha post-emergence over 2 hand weedings. All the herbicides controlled *Avena fatua* L., effectively over unweeded check but triallate pre-sowing and isoproturon 1.75 kg/ha post-emergence were most effective. *Lolium temulentum* was effectively controlled by diclofop 0.9 kg/ha pre-emergence, or post-emergence, metribuzin 0.5 kg/ha pre-emergence and isoproturon 2.25 kg/ha post-emergence over 2 hand weedings. Maximum weed control efficiency was achieved with weed free check during both years, followed by triallate, diclofop, metoxuron post-emergence, metribuzin, linuron, methabenz-

Table 1 : Effect of weed control treatments, yield components and grain yield of wheat (Variety Sonalika) and dry matter of weeds.

Weed control treatment kg/ha	Effective tillers per meter		Biological yield kg/ha	Grain yield kg/ha	Drymatter of Weeds kg/ha		Control ratings		Toxicity ratings	
	1978-79	1979-80	1978-79	1978-79	1978-79	1979-80	1978-79	1979-80	1978-79	1979-80
Methabenzthiazuron 1.8 pre. em.	39.7	33.7	5668	1292	2302	63.1	8.0	8.7	2.4	6.1
Methabenzthiazuron 1.44 post. em.	43.7	52.3	6468	2185	1541	84.8	7.8	7.3	2.4	1.0
Triallate 1.25 pre-sowing	39.0	34.0	3667	1276	503	25.2	6.8	5.5	3.4	3.6
Nitrofen 1.25 pre-em.	43.7	43.7	5301	1456	2903	340.9	6.0	5.7	2.4	1.3
Terbutryn 1.6 pre-em.	49.3	47.7	5051	2287	1912	808.1	5.4	2.3	2.6	1.0
Terbutryn 1.25 post-em.	37.3	35.7	5501	1808	2144	1212.1	5.4	1.8	2.4	1.8
Metoxuron 1.8 pre-em.	47.3	42.0	5951	1357	2041	1111.1	7.0	1.3	2.6	2.0
Metoxuron 1.5 post-em.	46.7	47.3	7285	1615	1324	959.5	7.6	4.5	2.6	1.0
Metribuzin 0.5 pre-em.	32.7	–	3667	–	2020	–	3.6	–	3.0	–
Diclofop 0.9 pre-em.	30.7	–	3134	–	848	–	7.6	–	4.0	–
Linuron 0.75 pre-em.	45.3	38.7	6335	1490	1672	909.1	6.0	1.4	2.0	1.5
Triallate 1.25 pre-sowing + Nitrofen 1.25 pre-em.	26.3	–	2834	–	1044	–	8.2	–	6.4	–
Paraquat 0.6 post. em. to weeds pre-em. to wheat	50.0	42.3	7785	1558	2512	214.6	7.8	5.7	1.0	1.3
Diclofop 0.9 post-em.	–	42.0	–	1742	–	50.5	–	8.3	–	2.5
Isoproturon 1.75 post-em.	–	50.0	–	1941	–	63.1	–	9.0	–	1.0
Isoproturon 2.25 post-em.	–	51.3	–	2286	–	101.0	–	9.0	–	1.0
Weed free check	52.3	51.0	6451	2390	628	37.5	8.8	9.5	1.0	1.0
Unweeded control	29.7	41.3	4768	524	2316	1477.3	2.2	1.0	1.0	1.0
Two hand weeding	46.0	49.0	5701	1650	1162	17.5	7.8	8.0	1.0	1.5
S. E. (d)	4.7	6.6	872	211	412	474.9	–	–	–	–
C. D. (5%)	9.7	13.4	2515	449	1190	969.6	–	–	–	–
C. V. (%)	14.1	10.6	28.21	15.39	29.2	–	–	–	–	–

Control ratings : 1 = No control, 10 = complete control, Toxicity ratings: 1 = No toxicity, 10 = complete toxicity. Pre-em = Pre-emergence, Post-em = Post-emergence.

Table 2: Effect of herbicides on species wise weed count, and weed control efficiency (WE).

Weed control treatments kg/ha	Species-wise weed count per square meter *Phalaris minor*		*Avena fatua* L.		*Lolium temulentum* L.		W E. (%)	
	1978-79	1979-80	1978-79	1979-80	1978-79	1979-80	1978-79	1979-80
Methabenzthiazuron 1.8 pre-emergence	5.9	7.0	7.5	9.4	10.5	13.4	56.9	58.7
Methabenzthiazuron 1.44, post-emergence	5.1	1.4	7.8	3.1	9.8	10.1	61.0	16.0
Triallate 1.25 pre-sowing	9.1	8.8	1.2	2.6	4.9	6.7	77.0	54.5
Nitrofen 1.25 pre-emergence	3.1	2.6	13.4	8.6	11.7	6.3	29.4	56.8
Terbutryn 1.6 pre-emergence	2.9	6.9	9.1	8.8	9.4	6.8	62.7	38.0
Terbutryn 1.25 post-emergence	10.5	8.1	10.8	9.1	5.6	4.7	50.6	32.9
Metoxuron 1.8 pre-emergence	8.5	9.0	10.9	10.1	5.8	5.8	51.8	18.3
Metoxuron 1.5 post-emergence	7.9	6.3	8.4	7.1	3.1	5.7	69.6	51.7
Metribuzin 0.5 pre-emergence	8.9	–	8.4	–	2.0	–	67.0	–
Diclofop 0.9 pre-emergence	6.9	–	8.3	–	2.4	–	74.0	–
Linuron 0.75 pre-emergence	6.6	8.9	10.6	8.9	3.9	8.1	63.4	17.4
Triallate 1.25 pre-sowing + Nitrofen 1.25 pre-emergence	7.3	–	5.0	–	5.2	–	77.4	–
Paraquat 0.6 post-emergence to weeds & pre-emergence to wheat	8.6	9.6	9.9	8.4	5.3	8.0	57.4	24.4
Diclofop 0.9 post-emergence	–	6.0	–	5.0	–	1.4	–	76.5
Isoproturon 1.75 post-emergence	–	5.7	–	4.5	–	4.5	–	73.7
Isoproturon 2.25 post-emergence	–	3.1	–	6.8	–	1.4	–	78.4
Weed free check	5.7	4.8	7.2	1.4	1.8	2.4	81.6	89.2
Un-weeded control	13.1	9.8	13.4	11.2	10.9	7.8	–	–
2 Hand weedings	7.9	6.9	7.1	6.7	3.8	2.0	73.0	64.8
S. E. (d)	0.8	1.2	0.7	1.1	0.7	1.1	–	–
C. D. (5%)	1.6	2.5	1.4	2.2	1.4	2.3	–	–
C. V. (%)	12.9	22.9	9.8	19.2	14.3	23.2	–	–

Weed count values have been analysed after subjecting the original values to $\sqrt{X+½}$ transformation.

thiazuron in the first year and Diclofop post-emerence in the second year.

DISCUSSION

The superior effect of paraquat in giving highest biological yield during 1978-79 is attributed to the reduction in crop-weed competition by killing the initial flush of weeds without any phytotoxic effect on the crop, but 1979-80 the occurrence of rainfall immediately after herbicide application caused leaching of the herbicide and hence caused mild toxicity to germinating seedlings. Methabenzthiazuron as post-emergence gave comparatively higher biological and grain yield over 2 hand weedings but less than paraquat and metoxuron in the first year, and isoproturon in the second year due to its poor efficiency in controlling *Avena fatua* L. and *Lolium temulentum* L. Gill *et al.* (1978) also reported poor control of *Avena fatua* L. by post-emergence application of methabenzthiazuron. Pre-emergence application of terbutryn gave significantly higher yield by controlling *Phalaris minor* Retz. and *Avena fatua* L. effectively but its post-emergence application reduced the effective tillers coupled with poor control of *Avena fatua* L. The similar phytotoxic effect of post-emergence terbutryn on wheat has been reported by Gill *et al.* (1979). Metoxuron as post-emergence gave higher yield due to its effective control of all the three weed species over its pre-emergence application.

Application of isoproturon at 1.75 kg/ha and 2.25 kg/ha gave significantly higher yield by controlling all the three weeds effectively without any phytotoxic effect on the crop. Gill *et al.* (1979) also reported likewise. Post-emergence application of diclofop controlled *Lolium temulentum* and other grassy weeds without phytotoxicity to the crop. Lev. (1979) earlier reported the sensitivity of grassy weeds to post-emergence application of diclofop in the order of *Avena* = *Lolium* > Phalaris.

CONCLUSION

Among the herbicides under study, isoproturon at 1.75 kg/ha and 2.25 kg/ha post-emergence controlled all the grassy weeds effectively without any phytotoxic effect on wheat crop. The other promising herbicides identified were methabenzthiazuron 1.44 kg/ha post-emergence, metoxuron 1.5 kg/ha post-emergence, terbutryn 1.25 kg/ha pre-emergence, and diclofop 0.9 kg/ha post-emergence.

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LOW DOSE ATRAZINE EFFECTS ON WEED CONTROL IN MAIZE APPLIED IN MIXTURE WITH ALACHLOR OR EPTC IN A MAIZE - WHEAT AGRO-SYSTEM

JANMEJAI SHARMA, R. M. SINGH and O. P. GUPTA
Agricultural Research Station, Durgapura, Jaipur-302 015, India;
Agricultural Experiment Station, University of Udaipur, Udaipur - 313 001;
Agricultural Research Station, Sriganganagar - 334 001, respectively.

ABSTRACT

Uncontrolled weed growth in maize grown on a vertisol caused 66.6% reduction in its grain yield. Pre-or post-emergence application of a mixture of alachlor at 1.5 kg/ha plus atrazine at 0.25 kg/ha, or 0.5 kg/ha alachlor with 0.25 kg/ha atrazine, respectively, followed by a row-cultivation provided a season-long, broad-spectrum control of weeds in maize without any residual phytotoxicity to the rotation crop of wheat. These herbicide mixture treatments produced more maize grain yields and proved more economical than the conventional methods of handweeding the crop, and was at par with hitherto recommended herbicide treatment of pre-emergence atrazine at 1 kg/ha. Additionally, because of 1/4th the usual dose of atrazine used in our experiments, the alachlor, atrazine mixture proved completely safe to the rotation crop of wheat sown after harvesting maize. This has solved the crux of the problem of often observed phytotoxicity of atrazine to the rotation crops under conditions of intensive cultivation.

INTRODUCTION

In India, pre-emergence treatment with atrazine at 1 to 2 kg/ha and 1 or 2 interrow-cultivations 4 to 6 weeks later have almost come to stay as standard package of practices to control weeds in maize (Sidhu *et al.* 1975). However, when maize is rotated with a crop like wheat in the same year, there is always a risk of carry-over phytotoxicity of atrazine to the rotation crop under varying agro-climatic conditions of the situation (Gupta, 1973). Therefore, alternative herbicide treatments including atrazine at very low dose of 0.25 kg/ha would provide effective early weed control in maize without any possibility of carry-over toxicity to the wheat (*Triticum æstivum*).

The objective of the two years' field studies reported here was to develop effective herbicide mixture, employing a very low dose of atrazine of 0.25 kg/ha and EPTC or alachlor, for obtaining initial 4 to 6 weeks weed control in maize without any residual adverse effects on the rotation crop of wheat.

MATERIAL AND METHODS

Two field experiments were conducted with maize crop one at Udaipur (India). During 1975 and 76, and the other in 1976 in an agrosystem of maize-wheat rotation. The soil of the experiment site was vertisol with org. matter: 1.39%, pH 8.3 and CEC 18.2 meq/100 g. The rainfall during the maize crop was 487 mm during 1975 and 644 mm during 1976.

Experiment No. 1 comprised 21 treatments in a randomised block design with 3 replications. These treatments were: pre-plant EPTC (S-ethyl dipropylthiocarbamate) at 1.5 kg/ha, pre-emergent alachlor [2-chloro-2', 6'-diethyl-N-(methoxymethyl) acetanilide] at 1.5 kg/ha, post-emergent alachlor at 0.5 kg/ha mixed with 5 l /ha of NPO (non-phytotoxic oil). Each herbicide was evaluated with and without atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] at 0.25 kg/ha. The post-emergent herbicides were applied 7 to 10 days after planting maize. These six herbicides combination were tested on maize planted, with or without treating its seeds with crop protectants, activated carbon and R-25788 (N, N-diallyl-2, 2-dichloroacetamide). Besides, there were three checks in the experiments, (i) pre-emergent atrazine at 1 kg/ha, (ii) handweeding and (iii) unweeded. In all treatments except weedy check, a manual hœing to simulate mechanical inter cultivation was done 22 to 40 days after planting maize depending upon the time when weeds began to establish in individual treatments.

Activated carbon was coated to the seeds of maize by dipping them in its 40% gum solution for 5 min. and then shaking the seeds further with thin layer of activated carbon. R-25788 was applied by simply shaking maize seeds with it at 50 g/10 kg seeds.

Experiment No, 2 was conducted as a corollary to Experiment no. 1 to filter out the role of NPO in post-emergence herbicide mixtures. Treatments in this experiment were (i) post-emergent alachlor at 0.5 kg/ha with 5 l NPO, (ii) atrazine at 0.25 kg/ha with 5 l NPO, (iii) alachlor + atrazine with 5 l NPO, (iv) alachlor + atrazine without NPO, (v) NPO alone at 5 l/ha, (vi) handweeding, and (vii) unweeded check.

In both the experiments, hybrid maize (Ganga-5) was sown in the last weed of June each year and it was harvested at 100 days. After about a month after harvesting maize, wheat (var. HD 1925) was sown in the original field layout to study the carry-over effects, if any, of herbicides used in maize crop.

The major weed flora associated with maize crop in the experiments was *Echinochloa crusgalli* (L.) Beauv; *E colonum* (L.) Link; *Dactyloctanium ægypticum* (L.) Beauv; *Trianthema portulacastrum* L; and *Digera arvensis* Fork.

RESULTS AND DISCUSSION

I. *Effects on weeds:* Unweeded maize plots were found to be infested with a heavy weed growth of 1250 to 3180 kg/ha. Over 75% of this dry matter was accumulated by weeds during first 45 days of the crop growth itself. Average whole season dry matter weight of weeds in herbicide treated plots was 370 to 2050 kg/ha, against 3180 kg/ha found in the weedy check plot, and 760 kg/ha in the handweeded plot. A similar trend of herbicide effects on weeds was observed also at 20 days and 45 days stages of crop growth (Table 1). Of the various herbicide treatments, single herbicide treatments involving EPTC or alachlor were found least effective in controlling weeds in maize. But when these herbicides were applied in combination with a low dose of atrazine (0.25 kg/ha) there was a great enhancement in their weed control efficacy. With EPTC, atrazine complemented in broad leaf weed control, particularly of *Trianthema portulacastrum* and *Digera arvensis* as also reported earlier by Buchanan and Hiltbold (1973). With post-emergent alachlor, atrazine seemed to exert synergistic effect against both grass and broad leaf weed. Among the two sets of atrazine mixtures with EPTC or alachlor, post-emergent alachlor at 0.5 kg/ha with atrazine at 0.25 kg/ha and 5 l NPO proved significantly superior to pre-plant EPTC at 1.5 kg/ha with atrazine at 0.25

Table 1 : Effect of treatments on dry matter yield and nitrogen uptake by weeds and maize crop and its residual effect on wheat.

Treatments	Dry matter yield (kg/ha) of weeds			Nitrogen uptake (kg/ha at harvest		Maize yield (kg/ha)	Residual effect
	Days after planting			Weed	Crop		Wheat yield (kg/ha)
	20	45	95				
Herbicides							
EPTC 1.5 * (PP)	460	1260	2020	35.9	73.0	2030	3770
EPTC 1.5 + atrazine 0.25 * (Pre)	230	840	1120	18.9	82.7	2250	3830
Alachlor 1.5 * (Pre)	150	210	640	10.8	95.2	2450	3770
Alachlor 1.5 + atrazine 0.25 * (Pre)	70	130	370	5.8	113.7	2990	3870
Alachlor 0.5 * + NPO (Post)	530	1520	2050	35.3	69.8	1850	3970
Alachlor 0.5 + atrazine 0.25 * + NPO (Post)	160	220	710	10.4	116.0	2860	3910
S. Em. ±	34	67	91	N. A.	N. A.	76	70
P = 0.05	96	187	259			224	N. S.
Protectants							
No Protectant	260	720	1120	19.1	90.2	2330	3850
Activated carbon	280	680	1140	19.6	91.3	2440	3850
R-25788	260	700	1190	11.8	92.1	2450	3850
S. Em. ±	24	47	56	N. A.	N. A.	54	31
P = 0.05	N. S.	N. S.	N. S.			N. S.	N. S.
Additional checks							
Weedy check (WC)	850	2480	3180	60.4	44.3	1000	3960
Hand weeded thrice	840	430	760	11.7	90.4	2270	3970
Atrazine 1 * (Pre)	150	140	390	6.7	114.1	2830	3480
P = 0.05							
Atrazine v/s WC	Sig.	Sig.	Sig.	N. A.	N. A.	Sig.	Sig.
Atrazine v/s HW	Sig.	N. S.	N. S.	N. A.	N. A.	Sig.	Sig.
Atrazine v/s Herbicides	136	265	363	N. A.	N. A.	316	279

Key : * = kg/ha, PP = Pre plant, Pre = Pre-emergence, Post = Post-emergence, N. S. = Not significant, Sig. = Significant, N. A. = Not analysed.

Table 2: Effect of treatments on weed dry matter yield and yield of maize-1976.

Treatments (postemergence)	Weed dry matter yield (kg/ha) Days after planting			Grain yield (kg/ha)
	20	45	90	
Alachlor 0.5 * + NPO	460	990	1130	1600
Atrazine 0.25 * + NPO	200	410	520	1730
Alachlor 0.5 + Atrazine 0.25 *	140	200	330	2010
Alachlor 0.5 + Atrazine 0.25 * + NPO	40	200	330	2200
NPO 51*	520	970	1100	1500
Handweeded	520	320	350	1840
Weedy check	520	1290	1250	1440
S. Em. ±	26	35	55	67
P = 0.05	78	105	163	200

Key: * = kg/ha.

kg/ha treatment. An equally effective treatment from the weed control point of view was pre-emergence mixture of 1.5 kg/ha alachlor and 0.25 kg/ha atrazine (Table 1). In fact, when full crop period weed growth was considered this pre-emergence mixture of alachlor and atrazine showed minimum weed growth (37 kg/ha) as compared to post-emergent alachlor-atrazine mixture treatment (71 kg/ha).

Crop protectants (activated carbon and R-25788) were not found to modify the weed control efficacy of herbicides (Table 1).

In Experiment No. 2 it was found that initially up to 20 days after planting maize, alachlor and atrazine with NPO provided significantly better weed control than when the mixture was applied without NPO (Table 2). But four weeks later to planting maize, the mixture of alachlor and atrazine proved equally effective in controlling weeds, both with or without NPO throughout the crop period. The NPO alone had no effect in controlling weeds as compared to weedy check. This experiment clearly revealed that low dose of alachlor and atrazine were complimentary to effecting a very good weed control and that NPO was not essential to be added to mixture when a row cultivation was to follow the herbicide treatment.

II. *Effect on crop* (Maize): Each quintal of dry matter in weeds produced during the first 45 days of crop growth, reduced maize grain yield by 70 kg/ha ($Y = 28.81 - 0.7x$). This amounted to an overall reduction of 1830 kg/ha in the maize production over hitherto standard treatment of pre-emergent atrazine at 1 kg/ha. In terms of N uptake it amounted to 60.4 kg/ha nitrogen lost in weeds. When weeds were controlled with pre-emergent atrazine at 1 kg/ha, this nitrogen loss was cut to 6.7 kg/ha and its uptake by the maize crop rose from 44.3 kg/ha in weedy check to 114.1 kg/ha in atrazine treatment plots. Each kg N lost in weeds was found to pull down maize grain yield by 32 kg/ha ($Y = 30.14 - 0.32x$).

Besides pre-emergent atrazine at 1 kg/ha, other herbicide treatments involving the EPTC and alachlor also increased the grain yield of maize significantly (1850 to 2990 kg/ha) over a weedy check (1000 kg/ha). Of these herbicide treatments, pre-emergent application of alachlor (1.5 kg/ha) plus atrazine (0.25 kg/ha) gave the highest maize grain yield (2990 kg/ha) followed closely by an yield (2860 kg/ha) obtained with post-emergent mixture of alachlor (0.5 kg/ha) and atrazine (0.25 kg/ha). These two alachlor-atrazine treatments proved significantly superior to all other weed control treatments of Experiment No. 1, and were at par with pre-emergent atrazine (1 kg/ha). Alachlor or EPTC alone produced significantly lower maize grain than the standard treatment of pre-emergent atrazine (1 kg/ha).

Further, it was interesting to note that handweeded maize plot produced less grain yield than the pre-emergent or early post-emergent alachlor plus atrazine treatments (Table 1). The difference in yield was 180 to 720 kg/ha. This showed that in maize, weeds present during the first three weeks of crop growth, before handweeding was done, were detriment to the crop growth.

In Experiment No. 2, the maize grain yield was also the highest in treatment involving post-emergent alachlor (0.5 kg/ha) atrazine (0.25 kg/ha) with or without NPO (2000 to 2200 kg/ha).

III. *Residual effects on wheat*: Residual effects of pre-emergent atrazine applied at 1 kg/ha were found carried over to wheat crop. This was depicted by a significant reduction (490 kg/ha) in the grain yield of wheat in atrazine (1 kg/ha) treated plots in comparison to non-herbicide plots of maize (Table 1). Other herbicide treatments produced 3770 to 3910 kg/ha wheat grain, which was at par with wheat yield of non-herbicide plots of maize (Table 1).

Of the different efficient weed control systems, pre-or post-emergence use of a mixture of alachlor and atrazine were found more remunerative than the presently recommended weed control system of pre-emergence atrazine (1 kg/ha).

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HERBICIDE STUDIES FOR WEED CONTROL IN *CARICA PAPAYA*

R. K. NISHIMOTO
Department of Horticulture, University of Hawaii, 3190 Maile Way, Honolulu, Hawaii 96822 U. S. A.

ABSTRACT

Two field experiments were conducted to determine the safety of several herbicides to direct-seeded *Carica papaya* L., papaya. Pendimethalin [*N*-(1-ethylpropyl)-3, 4-dimethyl-2, 6-dinitrobenzenamine] and oryzalin (3, 5-dinitro-N^4,N^4-dipropylsulfanilamide) appeared sufficiently selective on a silty clay soil but caused severe injury to *C. papaya* on an Aa lava soil.

In three other experiments, directed spray applications of oryzalin at 2.2 to 9.0 kg ha^{-1} did not injure *C. papaya* when first applied 6 and 7 months after transplanting or to recently transplanted trees. Repeated oryzalin applications approximately every 4 months did not reduce yield on three soil types even when repeated at 9.0 kg/ha^{-1}. Oryzalin provided good residual pre-emergence control of many annual weed species at 2.2 kg ha^{-1}.

Currently, no pre-emergence herbicide is registered for use in *C. papaya* established for less than 1 year.

INTRODUCTION

C. papaya is a herbaceous tree crop that is either direct-seed or transplanted and products harvestable fruit approximately 1 year from direct-seeding or about 10 months from transplanting. The crop continues to produce fruit more or less continuously and is grown commercially for 3 to 4 years.

Currently chemical weed control practices in Hawaii primarily involve directed or spot sprays of paraquat, and soil-applied diuron [3, (3, 4-dichlorophenyl)-1, 1-dimethylurea]. Diuron is the only soil-residual herbicide currently registered and used in *C. papaya*, but its use is limited to established trees older than 1 year (Nishimoto and Yee, 1972). Thus, no soil-residual pre-emergence herbicide can be used until *C. papaya* is established for 1 year.

Previous studies showed that glyphosate could be safely used in *C. papaya* and that it controlled perennial weed species not controlled by paraquat (1,1-dimethyl-4,4'-bipyridinium ion) (Nishimoto *et al.* 1973; Nishimoto and Hibbard, 1979). However, glyphosate is not yet registered for use in *C. papaya* in the United States.

Of many pre-emergence herbicides evaluated for direct-seeded *C. papaya*, only a few were sufficiently selective for further studies (Nishimoto *et al.*, 1973). Flourodifen (4-nitrophenyl α, α, α-trifluoro-2-nitro-*p*-tolyl ether) showed excellent selectivity and nitralin (4-methylsulfonyl-2,6-dinitro-*N*, *N*-dipropylaniline) was fairly selective for *C. papaya*. Both herbicides are no longer being manufactured.

The studies reported herein were conducted to evaluate some pre-emergence herbicides not previously evaluated for direct-seeded *C. papaya* and *C. papaya* shortly after transplanting. These studies include several herbicides, but emphasize oryzalin (3,5-dinitro N^4, N^4-dipropylsulfanilamide).

MATERIAL AND METHODS

Five experiments were conducted; two for direct-seeded *C. papaya* and three for transplanted *C. papaya*. These experiments were conducted on four different locations and soil types. All herbicides were applied in 374 liters of spray mixture per ha with a hand-held sprayer using nitrogen propellant at 2.1 kg cm^{-2} pressure.

All experiments had three replications using a randomized complete block design. Crop and weed control assessments varied; crop injury was visually evaluated by determining the per cent stand and vigor reduction, or rating assessments were evaluated visually by rating weed control or determining the percent weed cover.

Yield data are expressed as weight per tree, since diseased trees were rogued occasionally at the Kapaa site and the yield data adjusted accordingly. Mean separation was by the Bayes L S D (Waller and Duncan, 1969).

Direct-seeded C. papaya : Experiments were conducted at waimanalo on a Waialua silty clay (Vertic Haplustolls) with 4% organic matter and at Malama Ki on Aa lava rock. All herbicides were applied to 0.9 m by 7.6 m plots on the same day that *C. papaya* seeds were planted in single rows on the Waialua silty clay loam, while herbicides were applied to 1.5 m by 15.3 m plots 3 days after seeding on the Aa lav. Herbicides evaluated in these Experiments include oryzalin, ethalfluralin [*N*-ethyl - *N*- (2 - methyl - 2 - propenyl) - 2, 6 - dinitro- 4 - (tri-fluoromethyl) benzenamine], pendimethaline, (N - 1 - ethylpropyl - 3, 4 dimethyl - 2, 6 - dinitrobenzeneamine) metolachlor (2-chloro-*N*- [2-ethyl-6-methylphenyl) -*N* 2-methoxyl-1-methylethyl) acetamide], alachlor [2-chloro-2'6'-diethyl-*N* - (methoxymethyl) acetanilide], and oxadiazon [2-*tert*-butyl-4-(2,4-dichloro)-5-isopropoxyphenyl-Δ^2-1,3,4-oxadiazolin-5- one]. At least 120 seeds were planted per row. Overhead sprinkler irrigation was used at Waimanalo, while rainfall of about 235 cm annually supplied water at the Malama Ki site. Transplanted *C. papaya* – Only oryzalin was tested for use in transplanted *C. papaya* on three soil types. Experiments were conducted at Malama Ki on Aa lava, Kapaa on a Halii gravelly silty clay (Typic Gibbsihumox) with about 6% organic matter, and Poamoho on a Wahiawa silty clay (Tropeptic Eutrustox) with about 2% organic matter. At Malama Ki and at Kapaa, oryzalin was applied as a directed spray to the base of *C. papaya* established for 6 and 7 months respectively. These sites received no supplemental irrigation to about 229 cm of rainfall at Kapaa and 234 cm at Malama Ki. At Poamoho, oryzalin was applied as a directed spray immediately after transplanting. Furrow irrigation supplemented the 114 cm average annual rainfall at Poamoho. Since this was the first series of tests with oryzalin and phototoxiciry of oryzalin to *C. papaya* was unknown, oryzalin was applied at different times after trasplanting to provide a preliminary indication of a safe interval period. Oryzalin applications were repeated approximately every 4 months to determine their effects on growth and yield of *C. papaya*.

Each plot was 3 m by 14.6 m, with a single row of 8 trees per plot spaced 1.8 m apart. Paraquat was applied to weeded controls as needed.

RESULTS

Direct-seeded C. papaya : Surface applications of oryzalin, ethalfluralin and pendimethalin appeared sufficiently selective for direct-seeded *C. papaya* on a Waialua silty clay soil; good to complete

Table 1 : Effect of several herbicides on direct-seeded *C. papaya* and control of two species at the Waimanalo site.

Treatment (kg ha⁻¹)	Crop injury rating	Stand reduction		Vigour reduction		*Amaranthus* spp.[2] control	*E. indica*[2] control
January 24, 1978	Feb. 14	Feb 16	Mar 14	Feb 16	Mar 14	Mar 14	Mar 14
		%					
Oryzalin 1.1	1.3 d[3]	23 cd	23 ef	10 f	3 e	4.8 a	5.0 a
Oryzalin 2.2	1.3 d	27 cd	35 cdef	20 ef	5 e	5.0 a	5.0 a
Oryzalin 4.5	1.7 d	47 bc	57 bc	47 cde	38 bcd	5.0 a	5.0 a
Ethalflural in 1.1	1.0 d	0 d	5 f	7 f	0 e	4.5 a	4.5 a
Ethalfluralin 2.2	1.0 d	20 cd	17 def	10 f	3 e	5.0 a	5.0 a
Ethalfluralin 4.5	1.7 d	37 cd	53 bcd	17 e	17 c	5.0 a	5.0 a
Pendimethalin 0.8	1.0 d	0 d	8 ef	0 f	3 e	4.0 a	5.0 a
Pendimethalin 1.7	1.0 d	7 d	8 ef	7 f	8 de	4.2 a	5.0 a
Pendimethalin 3.4	1.0 d	20 cd	45 bcde	13 ef	42 bcd	5.0 a	5.0 a
Metolachlor 2.2	1.0 d	10 cd	20 de	20 ef	8 de	5.0 a	5.0 a
Metolachlor 4.5	1.0 d	13 cd	28 cdef	47 cde	37 bcd	5.0 a	5.0 a
Metolachlor 6.6	1.7 d	47 bc	52 bcd	60 bcd	50 bc	5.0 a	5.0 a
Alachlor 2.2	2.7 c	53 bc	65 abc	70 abc	55 b	4.8 a	5.0 a
Alachlor 4.5	3.5 b	83 ab	77 ab	90 ab	70 ab	5.0 a	5.0 a
Oxadiazon 4.5	5.0 a	100 a	100 a	100 a	100 a	5.0 a	5.0 a
Weeded control	1.0 d·	0 d	0 f	0 f	0 e	5.0 a	5.0 a
Unweeded control	1.0 d	0 d	5 f	0 f	3 e	1.0 b	1.0 b

[1] Injury rating scale : 1 = no injury, 2 = slight injury, 3 = moderate injury, 4 = severe injury, 5 = dead.
[2] Weed control rating scale : 1 = no control, 2 = slight control, 3 = moderate control, 4 = good control 5 = complete control.
[3] Means in the same column followed by the same letter are not different by the Bayes LSD test at $P < 0.05$.

Table 2 : Effect of oryzalin and pendimethalin on direct-seeded *C. papaya* and control of *A. conyzoides* at Malama Ki.

Treatment (kg ha⁻¹)	No. of plants per row	Crop injury rating	*A. conyzoides* control[2]
March 1, 1979	April 16	April 16	April 16
Oryzalin 1.1	25.3 ab[3]	3.8 a	4.0 b
Oryzalin 2.2	21.0 ab	4.3 a	4.2 b
Oryzalin 4.5	8.0 ab	4.1 a	4.5 ab
Oryzalin 8.9	2.0 b	4.5 a	5.0 a
Pendimethalin 1.1	30.7 ab	3.8 a	4.0 b
Pendimethalin 2.2	15.3 ab	4.2 a	4.3 b
Weeded control	38.3 a	1.0 b	–
Unweeded control	38.0 a	1.0 b	1.3 c

[1] Injury rating scale : 1 = no injury, 2 = slight injury, 3 = moderate injury, 4 = severe injury, 5 = dead.
[2] Weed control rating scale : 1 = no control, 2 = slight control, 3 = fair control, 4 = good control, 5 = complete control.
[3] Means followed by the same letter in the same column are not different by the Bayes LSD at $P < 0.05$.

Table 3 : *C. papaya* yield response to repeated applications of oryzalin at three locations.

Treatment (kg ha⁻¹)	Yield (kg per tree)					
	Malama Ki[1] Mar-Nov 1979		Kapaa[2] Sep 1978-May 1979		Poamoho[3] Sep 1978-Sep 1979	
	Grade 1	Total	Grade 1	Total	Grade 1	Total
Oryzalin 2.2	17.9 a[4]	24.1 a	38.6 a	46.5 a	98.9 a	115.3 a
Oryzalin 4.5	17.3 a	23.0 a	29.4 a	35.2 a	98.3 a	112.0 a
Oryzalin 8.9	10.8 a	15.9 a	41.0 a	47.7 a	99.3 a	112.3 a
Weeded control	13.2 a	19.0 a	32.1 a	37.8 a	101.3 a	118.3 a

[1] Oryzalin was applied on October 26, 1978; March 1, 1979; July 10, 1979; November 16, 1979; *C. papaya* was transplanted on May 3, 1978.

[2] Oryzalin was applied on June 19, 1978; October 12, 1978; February 20, 1979; *C. papaya* was transplanted on November 23, 1977.

[3] Oryzalin was applied on November 23, 1977; January 23, 1978; June 23, 1978; October 19, 1978; February 13, 1979, June 13, 1979; *C. papaya* was transplanted on November 21, 1977.

[4] Means in the same column followed by the same letter are not different by the Bays LSD test at $P<0.05$.

Table 4 : Effect of repeated oryxalin applications on residual control of several weed species at Kappa.

Treatment[1] (kg ha⁻¹)	Percent weed cover March 11, 1980	Major weed species remaining
	(%)	
Oryzalin 2.2	4 b[2]	*Ageratum conyzoides, Euphorbia hirta*
Oryzalin 4.5	3 bc	*Ageratum conyzoides, Euphorbia hirta*
Oryzalin 8.9	1 c	*Ageratum conyzoides*
Weeded control	100 a	*Borreria lævis, Ageratum conyzoides, Euphorbia hirta*
Unweeded control	100 a	*Paspalum conjugatum, Paspalum urvillei, Ageratum conyzoides, Borreria lævis, Euphorbia hirta, Stachytarpheta cayennensis*

[1] Oryzalin was applied on June 19, 1978; October 12, 1978; February 20, 1979; and June 26, 1979. Paraquat was applied to weeded controls and oryzalin treatments as needed to avoid weed competition up until June 26, 1979. No herbicides were applied thereafter. Paraquat was also applied to unweeded controls up until 3 months after transplanting papaya in March 1978.

[2] Means followed by the same letter are not different by the Bayes LSD test at $P<0.05$.

control of *Amaranthus spp. Eleusine indica* (L.) Gærtn., and goosegrass was obtained with 1.1 kg ha^{-1}, 1.1 kg ha^{-1} and 0.8 kg ha^{-1} respectively and none to little injury observed at twice these rates (Table 1). Direct-seeded *C. papaya* had intermediate tolerance to metolachlor. Alachlor and oxadiazon caused severe injury or death at all rates evaluated.

Oryzalin and pendimethalin were further tested for direct-seeded *C. papaya* on Aa lava soil, where severe injury resulted from all rates evaluated (Table 2).

Transplanted C. papaya: Where oryzalin was evaluated for transplanted *C. papaya*, no injury to *C. papaya* was observed at all three locations (no data presented). This included the Poamoho location, where the first oryzalin application was made immediately after transplanting, and a total of six applications were made over a 2 year period.

Further, no yield reduction was observed with all rates of the repeated oryzalin applications at the three locations with different soil types (Table 3).

Oryzalin gave good to complete control of many annuals: *Amaranthus spp., E. indica* (Table 1), *Ageratum conyzoides* L., ageratum (Table 2), *Portulaca oleracea* (L.), purslane, and *Borreria lævis* (Lam.) Griseb., buttonweed (Table 4).

Repeated oryzalin applications and paraquat spot applications provided excellent long-term weed control. Nearly 9 months after the last repeated oryzalin and paraquat applications, 96% to 99% of the plot area was free of weeds (Table 4). Where oryzalin was not included, and only paraquat applied, 100% of the plot was covered with weeds, predominantly *B. lævis*. Where no herbicides were applied for 2 years, more species of weeds were present.

DISCUSSION

These results indicate that oryzalin can be safely applied after transplanting *C. papaya*, but not immediately after direct-seeding *C. papaya*. Presumably, oryzalin could also be used effectively for established direct-seeded *C. papaya*.

It appears that oryzalin can be effectively used as a directed spray to transplanted *C. papaya* at all growth stages. However, since recently transplanted *C. papaya* tolerance to oryzalin was tested in only one experiment, further studies are being conducted to confirm the tolerance of recently transplanted *C. papaya* to oryzalin applications. Oryzalin preemergence in young *C. papaya* orchards should become a valuable weed control tool in Hawaii; currently, the only preemergence herbicide registerd for use in *C. papaya* is diuron, and its use is limited to *C. papaya* established for 1 year.

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PERENNIAL WEEDS IN THE MAJOR CROP FIELD OF BANGLADESH

M. ABDUL GAFFER
Department of Agronomy, Bangladesh Agricultural University,
Mymensingh, Bangladesh.

ABSTRACT

Weed is a serious problem in crop production in Bangladesh where the edaphic and climatic conditions are congenial for the growth of numerous species of obnoxious weeds in arable lands. In a weed survey, 88 species of weeds belonging to 30 families were found growing in the cultivated land of the country. Out of them, 22 species of perennial weeds comprising of 11 families were identified. The farmers of Bangladesh employ the age-old practices to control weeds. The methods are the manual implementation method in which weeds are either uprooted by hand pulling or mud buried by foot-treading or destroyed by hand implements like spade, sickle, neere and lately and occasionally by hand weeder. Chemical method of weed control is also practised but it is limited at the different Government Farms and Research Stations.

INTRODUCTION

Weeds have been a problem in farming from the time immemorial. Weeds seriously compete with crop plants for their growth requirements, reduce quality and yield of crops, and increase cost of product which ultimately reduce the net return. An estimate of the Agricultural Service Department Commitee, U.S. Chamber of Commerce shows that the losses caused by weeds exceed the combined losses of the other three groups of agricultural pests, viz., (a) plant disease (b) insects, rodents and predatory animals (c) disease (Robbins *et al.* 1952). In Japan the decrease in yield of rice crop due to weed infestations has been reported to be 20 to 40 in transplant crops and 70 to 90 per cent in direct seeded upland rice (Matsubayashi *et al.* 1963.)

Although statistical data are not available to ascertain the exact extent of losses caused by weeds infestation of crops in Bangladesh, the volume of these losses may be comprehended to be very high. This is because of the fact that the climatic and edaphic conditions of Bangladesh encourage exuberant growth of numerous species of weeds that heavily infest crops to offer them a very tough competition.

If not properly controlled, these weeds may reduce crop yields to any extent. For effective weed control, it is therefore, essential to identify all the species of weeds more particularly perennial weeds that infest different crops in Bangladesh and to employ speedier and cheaper means for controlling them. Numerous herbicides are now being profitably used in many countries and more so in Bangladesh. The paper presents the results of experiments of some important crops which have so far been done at the Bangladesh Agricultural University (Mian and Gaffer, 1971; Gaffer and Rikabader, 1975; Karim and Iqbal 1980; Mian and Rahman, 1969).

RESULTS

Weeds of Bangladesh: In a survey 88 species of weeds belonging 30 families

Table 1 : Perennial weeds of Agricultural University Farm.

Scientific name	Family	Bengali name
Cynodon dactylon	Gramineæ (Poaceæ)	Durba ghas
Chrysopogon aciculatus	"	Premkata
Imperata cylindrica	"	Ulu
Saccharum spontaneum	"	Kash
Sporobolus diander	"	Benajoni
Sporobolus indicus	"	Chenga chopa
Cyperus rotundus	Cyperaceæ	Badail
Cyperus strigosus	"	Shakata khagra
Eleocharis plantaginea	"	Chochalo cheshra
Scirpus mucronatus	"	Chechra
Colocasia esculenta	Araceæ	Kachu
Pistia stratiotes	"	Tokapana
Eichhornia crassipes	Pontederiaceæ	Kachuri pana
Monochoria hastata	"	Boro nukha
Rumex obtusifolius	Polygonaceæ	Titamarich
Desmodium trifolium	Leguminosæ	Tripatrishak
Oxalis europaea	Oxalidaceæ	Amrul shak
Hydrocotyle asiatica	Umbelliferæ	Thunkuni
Impomoea aquatica	Convolvulaceæ	Kalmishak
Physalis heterophylla	Solanaceæ	Foska begun
Solanum carotinense	"	Kata begun
Dryopteris filix-mas	Polypodiaceæ	Dekishak

Table 2 : Infested weed species, their stand m^{-2} of the experimental jute field and their control by fluchloralin (Karim and Iqbal, 1980).

Weed species	Weed stand in control plots m^{-2}	% of total weed vegetation in control plots	% of weeds controlled by Basalin (fluchloralin) 1.75 l/ha
Echinochloa crusgalli (L.) Beauv.	139.88	34.89	91.15
Cyperus rotundus L.	126.97	31.67	9.75
Scirpus mucronatus L.	75.32	18.78	53.88
Cynotis axillaris D. Don.	16.46	4.10	9.78
Cynodon dactylon (L.) Pers.	13.99	3.49	3.07
Protulaca oleracea L.	10.22	2.54	7.33
Elusine indica Giacert.	7.32	1.83	58.88
Parapholis incurva Linn.	5.92	1.48	7.26
Eclipta prostrata Hassk.	4.84	1.21	13.22

were found growing in the arable land of Bangladesh Agricultural University Farm. The perennial weeds with scientific name and family are given in Table 1. These weeds are deemed to be some of the species that grow in other parts of the country too. So further exhaustive survey is necessary to acquire a comprehensive knowledge of the weed flora. Chemical weed control is mostly restricted to the jute and rice field in Bangladesh.

Nine weed species were found to

grow in the experimental jute field of which the number of stand/unit area of *Echinochloa crusgalli*, *Cyperus rotundus* and *Scirpus mucronatus* constituted about 85% of the total weed vegetation and the rest 6 species such as *Cyanotis axillaris*, *Cynodon dactylon*, *Portulaca oleracea*, *Eleusine indica*, *Parapholis incurva* and *Eclipta prostata* constituted about 15% (Table 2). *E.crusgalli* was found to be controlled from 81 to 92%, *Eleusine indica* from 51 to 59% and *Scirpus mucronatus* from 52 to 85% under the different doses of fluchloralin. The other infested species of weeds including *C.rotundus* were either not sensitive or slightly sensitive to fluchloralin. Seven species of weeds were found to grow in the control plots (Table 3). Of these seven species, *Scirpus mucronatus*, *Monochoria hastata* and *Jussiea ducurrens of*

Table 3 : The species of weeds that infested the boro rice (spring rice) crop and their control by nitrofen (Mian and Gaffer, 1971).

Scientific name	Family	Total weed vegetation by number of stands (%)	Intensity of infestation*	Weed killed by nitrofen at 2.8 kg a.i./ha^{-1} (%)
Scirpus mucronatus L.	Gramineæ	39.92	3.12	94
Monochoria hastata L.Solm.	Pontederiaceæ	18.72	1.46	100
Jussiea decurrens	Onagraceæ	17.60	1.41	100
Leersia hexandra	Gramineæ	7.48	0.58	100
Parapholis incurva Linn.	Gramineæ	4.96	0.38	84
Polygonum hydropiper L.	Polygonaceæ	4.84	0.37	100
Echinochloa crusgalli L.	Gramineæ	4.72	0.37	100
Others		1.76	0.13	85

* Weed plants / Crop plants ratio i.e. number of weed plants competing with a hill of crop plant.

Table 4 : Weed vegetation in aus field and per cent of weed killed by different weed killers (Mian and Rahman, 1969).

Botanical name	Number of weed stands /acre	% of total weed vegetation	% of weed killed by				
			Propanil	Rogue	Planavin	Prefix	2,4-D
Echinochloa colonum	3,05,851	57	100	97	94	0	0
Echinochloa crusgalli	1,51,214	29	100	98	96	0	0
Murdania nudiflora	19,291	4	0	0	83	0	50
Cynodon dactylon	14,624	3	0	0	50	0	0
Cyperus rotundus	9,645	2	0	0	0	0	0
Commelina bengalensis	4,978	1	0	0	67	0	4
Eleusine indica	4,978	1	0	0	100	0	0
Amaranthus spinosus	4,978	1	0	0	100	0	0
Other weeds	9,645	2	0	0	0	0	0
Total	5,25,204	100	86	83.7	88.8	0	4

were predominant, constituting about 76% of the entire weed vegetation. Of the 7.82 stands of weeds that competed with one hill of rice plant, about 6 were these species. The herbicide gave excellent control of all species of weeds except of few stands of *Scirpus mucronatus* and *Parapholis incurva.* Table 4 shows 8 different species of weeds, their extent of vegetation and controlled by different herbicides. It is evident that *Echinochloa colonum* and *E. crusgalli* were the two species that predominated the entire weed vegetation, constituting 86%. Both of the weeds belonging to the same family (poaceæ) as of rice, look more of less like rice plants in their early stage of growth and they have almost the same growth habits and growth requirements as those of rice plants. Consequently they offered much more competitions to crop plants than did the other weed species. The per cent mortality of weeds by different herbicides varied in themselves and also with weed species. Propanil and rogue completely or excellently killed all stands of *E.colnum* and *E.crusgalli* but they did not kill any of the other weed species. It may be noted that propanil and rogue, containing the same active ingredient and only varying in percentage composition and makes, exhibited almost similar weed control effects. Planavin, on the other hand, killed more or less all the weed species present with varying success except *Cyperus rotundus.* All herbicides proved ineffective in controlling *C.rotundus.* While prefix failed to kill any of the weeds. 2,4-D gave a fair control of *Murdania nudiflora* only.

According to Mian and Gaffer (1968), the principal weeds of transplanted aman fields are: *Fimbristylis miliacea, Mardelia quadrifolia, Jussiea decurrens, Monochoria hastata, Cyperus michelianus Ipomoea reptans, Cyperus corymbosus, Scirpus mucronatus, Eleocharis obtusa, Alternanthera sessils, Leersis hexandra* and *Parapholis incurva.* Tok granule (nitrofen) at 38.5 kg/ha gave good weed control as efficiently as did manual implemental (mechanical) method.

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WEED CONTROL IN DIRECT SEEDED UPLAND RICE

S. S. KOLHE and B. N. MITTRA
All India Co-ordinated Research Programme on Weed Control
Agricultural Engineering Department, Indian Institute of Technology (IIT)
Kharagpur - 721 302, India.

ABSTRACT

Three field experiments were conducted to study the critical period of crop weed competition and develop an integrated and effective weed control practices, combining chemical, manual and mechanical methods, for direct seeded upland rice in the rice growing region of West Bengal. It was found that first 30 DAS was the most critical period for crop weed competition. The crop grown under weed free condition for 30 DAS gave the maximum grain yield. Post-emergence application of propanil 2.0 kg a.i./ha at 20 DAS and soil application of urea was most effective in increasing the crop yield and minimizing the crop competition. In the integrated approach, the post-emergence application of propanil at 20 DAS followed by hoeing between the rows and hand weeding within rows at 40 DAS, minimised crop weed competition thereby increased the grain yield appreciably and was most economical.

INTRODUCTION

One of the major causes of low yield of upland rice is severe weed competition. The failure of crop germination due to moisture stress, uneven stand and poor growth rate of rice offer better chances for weeds to grow more profusely and vigorously than rice crop. Moreover, tillage operations become difficult or ineffective due to frequent rainfall during the wet season in the high rainfall regions where considerable area is sown with rice. In India, weeds cause considerable loss of the produce every year ranging from 10 to 100 % under the various practices of rice cultivation (Mani et al., 1968; and Pillai and Rao, 1974). In direct seeded upland rice, reduction in yield due to weeds is often reported as more than 50 % (Pande and Bhan, 1966; Madrid et al., 1972; Mukhopadhyay et al., 1972 and Pillai and Rao, 1974). Among the methods of weed control, the age old practice of handweeding is slow, cumbersome, laborious and the weeding gets delayed causing sufficient damage to the crop. Moreover, there are chances of regeneration of new shoots from roots or rhizomes that are left behind in the field. In order to find an effective and economically feasible method of weed control, systematic studies were planned.

MATERIAL AND METHODS

Experiments were conducted at Agricultural Engineering Department, Indian Institute of Technology, Kharagpur during the years 1978-79 and 1979-80. The soil was sandy-clay-loam in nature having pH 5.3, available N 0.041 to 0.045%, available P 0.004 to 0.005%, and available K 0.030 to 0.069%. Dry seeding was done in rows 20 cm apart at the rate of 100 kg/ha. The experiments were laid out in randomised block design with three replications. In the first experiment on crop-weed competition, the rice variety Cauvery was selected and grown as test crop.

Weed free condition for different periods of 10, 20, 30, 40, 50, 60 days after seeding (DAS), weed free throughout (weed free check) and unweeded check formed the treatments. In the second experiment on compatibility of herbicide fertilizer mixture for simultaneous foliar nutrition and weed control, Pusa 3-33 was grown as test crop. Nitrogen was applied through soil as well as foliar spray as per treatments. Herbicides butachlor, nitrofen and propanil were applied as post-emergence at 20 DAS. Handweeding was done on 20 and 40 DAS. In the third experiment on different methods of weed control, rice variety Bala was a test crop. Butachlor was applied as pre-emergence at 3 DAS. Whereas, MCPA and propanil were applied as post-emergence at 20 DAS. The handweeding and hoeing were performed either alone or in combination at 20 and 40 DAS according to the treatments. In all the experiments, the crop was fertilized with 60:30:30 kg N, P_2O_5 and K_2O/ha, respectively. Weeds were collected from three places, by using 1 m quadrat per plot. The nitrogen uptake by crop and weeds was determined by micro-kjeldahl method.

RESULTS AND DISCUSSION

Infestation of *Cassia tora* L., *Commelina benghalensis* L., *Cynodon dactylon* Pers., *Cyperus iria* L., *Cyperus rotundus* L., *Digitaria sanguinalis, Echinochloa colonum* Link, *Echinochloa crusgalli* Beauv., *Fimbristylis miliacea* Vahl., *Phyllanthus niruri* L., *Setaria glauca, Borreria leaevis, Oxalis acetosella* L., was noted in all the experiments. In general, the grassy weeds and sedges were found to be predominant throughout the growing period of the crop.

1. *Crop-weed competition*

The dry matter of weeds was signifi-

Table 1 : Effect of crop-weed competition and performance of upland rice.

Treatments	Height, cm	No. of panicles m	Panicle/ length, cm.	No. of grains/ panicle	Grain wt, g	Grain yield, kg/ha	Straw yield, kg/ha	Dry matter of weeds, kg/ha
T_1 - Unweeded control	58.67	38.00	18.90	24.40	21.07	483	542	382.6
T_2 = Weed free crop for 10 DAS	59.57	42.33	17.47	15.87	21.08	603	858	369.7
T_3 = Weed free crop for 20 DAS	64.07	58.33	17.80	57.47	21.30	1467	2483	205.5
T_4 = Weed free crop for 30 DAS	56.00	89.67	18.70	59.73	21.19	2767	2950	66.7
T_5 = Weed free crop for 40 DAS	60.00	84.67	19.50	64.87	21.16	2933	3333	30.8
T_6 = Weed free crop for 50 DAS	58.03	77.00	19.83	58.07	20.92	2342	2517	16.8
T_7 = Weed free crop for 60 DAS	55.47	95.00	19.17	58.52	20.61	2458	2800	10.6
T_8 = Weed free crop for all season	60.13	89.00	18.50	59.93	21.48	2725	3200	–
SE (m) ±	–	7.87	–	4.57	–	267	288	9.54
CD at 5%	–	23.87	–	13.91	–	810	872	28.91

cantly low when weed free condition was maintained for 30 DAS or longer periods. In other words, the crop-weed competition reduced considerably when the weed free period was 30 DAS or more. By reducing the weed free period from 30 to 20 or 10 DAS there was considerable increase in dry matter of weeds. In fact weed free period for the 10 DAS was found to be comparable to the unweeded control which recorded maximum dry matter of weeds. This revealed that by reducing the period of weed free condition there was simultaneous increase in weed growth causing greater crop-weed competition ultimately affecting the grain yield adversely (Table 1).

The crop yield remained almost at par with each other under all the treatments where weed free condition was maintained for at least 30 DAS. The weeds which appeared after 30 days of weed free period could not compete with the crop, hence the crop growth and thereby the yield remained unaffected. On the contrary, there was significant reduction in yield when weeding was terminated after 10 and 20 DAS. This was due to severe weed competition at later stages of crop growth as apparent from the dry matter of weeds at harvest under these two treatments. The yield attributes mainly number of panicles per metre and number of grains per panicle were affected most by the crop weed competition as evident from negative correlation observed between weed dry matter and these yield components. Therefore, it is imperative to maintain a weed free condition at least up to 30 DAS.

2. *Comptability of herbicide fertilizer mixture for simultaneous foliar nutrition and weed control*

Handweedings followed by foliar application of urea was significantly superior in reducing the dry matter of weeds to a minimum and was found to be at par with those of handweeding followed by soil application of urea and propanil followed by soil application of urea or butachlor followed by foliar application of urea. Among the herbicide treatments, post-emergence application of propanil 2.0 kg a.i./ha followed by soil application of urea was found to be most effective. Unweeded control recorded the maximum dry matter of weeds indicating the severe weed competition.

Handweedings followed by foliar application of urea was significantly superior to rest of the treatments and gave maximum grain and straw yields. This treatment also recorded the maximum number of panicles per unit area, length of panicle and 1000 grain weight. This was due to less crop-weed competition with added advantage to the crop by the foliar application of urea. Two handweedings followed by soil application of urea was the next best treatment for increasing grain yield. Among the herbicidal treatments, post-emergence application of propanil at 2.0 kg a.i./ha followed by soil application of urea recorded the maximum grain yield which was associated with the maximum number of panicles per unit area, length of panicle and 1000 grain weight (Table 2). This justifies the superiority of herbicide application with soil application of urea as compared to other treatments in the direct seeded upland rice.

3. *Comparative efficiency of weed control methods*

Herbicides butachlor and propanil both at 2.0 kg a.i./ha alone or in combination with handweeding within rows and hœing were effective in reducing the weed competition in terms of dry matter of weeds and significantly superior to un-

Table 2: Effect of different weed control treatments on various characters of paddy.

Treatment	Height, cm	Panicles/ m^2	Panicle length cm	1000 grain wt., g	Grain yield, kg/ha	Straw yield, kg/ha	Dry matter of weeds/ g/m^2
1. Unweed control	42.37	115.67	14.67	19.70	1543	2523	300.67
2. Handweedings + soil application of urea	68.03	529.67	21.10	21.70	4107	7778	162.89
3. Handweedings + foliar application of urea	70.53	582.33	21.60	21.97	4332	8172	153.11
4. Propanil + foliar application of urea	63.77	421.33	18.97	21.36	3585	6305	206.11
5. Propanil + soil application of urea	66.07	459.33	19.27	21.70	3775	6457	184.89
6. Butachlor + foliar application of urea	51.43	281.33	17.23	20.43	2853	4583	193.55
7. Butachlor + soil application of urea	54.93	307.67	17.13	20.57	2988	4675	236.44
8. Nitrofen + foliar application of urea	59.37	345.33	17.67	20.95	3222	5297	213.11
9. Nitrofen + foliar application of urea	58.23	326.67	17.23	20.88	3118	5125	200.22
10. Nitrofen + soil application of urea	60.10	368.67	17.77	20.05	3327	5930	241.77
SE (m) ±	0.87	7.59	0.17	0.31	50	83	14.56
C.D. 5%	2.59	22.55	0.50	0.92	149	246	43.27

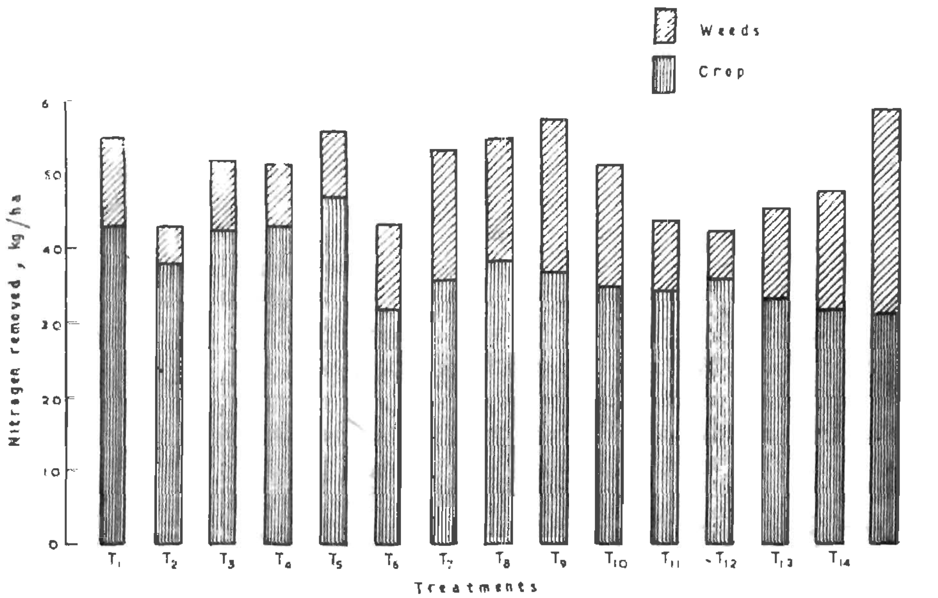

FIG. I NITROGEN REMOVED BY CROP AND WEEDS (EXPERIMENT No. 3) weeded control where the dry matter of weeds was maximum. However, pre-emergence application of butachlor at 2.0 kg a.i./ha in combination with handweeding within rows and hœing recorded the minimum dry matter of weeds and was at par with pre-emergence application of butachlor 2.0 kg a.i./ha (T_1), post-emergence application of propanil at 2.0 kg a.i./ha alone (T_3) and in combination with handweeding within rows and/or hœing (T_4 and T_5) (Table 3).

While comparing the treatments where weeds within rows were controlled in one and not in the other, there was difference in grain yield. This difference in yield was observed in spite of removal of weeds between the rows. This justified the necessity of controlling weeds within rows either manually or chemically. The data pertaining to yield and its attributes revealed that post-emergence application of propanil 2.0 kg a.i./ha in combination with handweeding

Table 3 : Effect of different weed control treatments on weed growth, yield components, yield and economics.

Treatments	Height, cm	No. of panicles/m	No. of grains/panicle	1000 grain weight, g	Grain yield, q/ha	Straw yield, q/ha	Dry matter of weeds, kg/ha: Broad leaved	Dry matter of weeds, kg/ha: Narrow leaved + sedges	Dry matter of weeds, kg/ha: Total	Additional return over unweeded control, Rs/ha
T_1 Butachlor	53.00	43.67	77.24	18.257	20.93	43.67	15.80	29.93	45.73	920.51
T_2 T_1 + HW within rows and hœing at 40 DAS	52.17	51.00	62.05	18.497	23.12	40.33	13.00	22.77	35.77	717.14
T_3 T_1 + Hœing at 40 DAS	52.50	33.00	76.67	18.028	17.43	42.49	22.83	15.57	38.30	315.38
T_4 Propanil	50.33	46.00	63.33	18.704	21.96	40.06	10.30	60.47	70.77	998.34
T_5 T_4 + HW within rows and hœing at 40 DAS	51.17	47.00	67.19	20.258	25.52	45.94	6.30	59.80	66.10	1077.12
T_6 T_4 + Hœing at 40 DAS	50.67	44.67	63.90	18.518	21.77	35.75	3.67	79.97	83.63	647.81
T_7 MCPA	40.33	32.67	59.52	16.313	13.39	31.33	0.00	183.33	183.33	(-)152.59
T_8 T_7 + HW within rows and hœing at 40 DAS	44.67	30.00	73.18	17.785	18.00	33.17	0.00	115.10	115.10	(-)24.46
T_9 T_7 + Hœing at 40 DAS	42.67	33.33	69.14	17.745	15.97	32.66	0.00	153.63	153.63	(-)91.96
T_{10} HW at 20 DAS	51.00	42.00	54.65	18.866	20.79	39.20	6.27	81.43	87.70	687.18
T_{11} HW at 20 and 40 DAS	50.50	49.00	65.71	19.220	22.10	38.05	0.00	83.03	83.03	501.06
T_{12} HW within rows and hœing at 20 DAS	51.00	40.67	66.57	18.458	18.97	38.49	0.00	90.53	90.53	408.78
T_{13} HW within rows and hœing at 20 and 40 DAS	49.67	43.67	64.52	18.624	21.29	36.08	4.57	80.30	84.87	233.01
T_{14} Hœings at 20 and 40 DAS	50.83	38.00	59.57	17.862	17.77	35.89	6.23	132.94	139.17	165.14
T_{15} Unweeded control	43.67	25.33	52.03	17.847	12.76	29.16	34.07	262.63	296.70	–
SE (m) ±	2.72	4.87	–	0.53	2.31	2.49	2.38	14.85	16.70	–
CD 5%	7.88	10.10	–	1.53	6.70	7.21	6.89	43.00	40.35	–

Butachlor, Propanil and MCPA were applied 2.0 kg a.i./ha.

within rows and hœing was the best treatment and gave maximum grain and straw yields. This was due to the low crop-weed competition and better uptake and utilization of nitrogen by the crop (Fig.1). Greater uptake of nitrogen by the crop helped in increasing the yield by increasing the number of panicles and 1000 grain weight (Das et al., 1976). This treatment further provides scope in economising the use of herbicide which may be required to kill the weeds within rows and not between rows. Comparable crop yield was also obtained under the treatments of pre-emergence application of butachlor at 2.0 kg a.i./ha alone (T_1) or in combination with handweeding within rows and hœing (T_2) and two handweedings (T_{11}). Post-emergence application of MCPA at 2.0 kg a.i./ha alone or in combination with handweeding within rows and/or hœing was least effective in controlling weeds and reduced the yield considerably (Table 3.) This was due to heavy infestation of grassy weeds and sedges against which MCPA is ineffective (Thakur et al., 1967). Moreover, sod. MCPA proved toxic to the plants and reduced the yield significantly (Pande et al., 1966).

Post-emergence application of propanil at 2.0 kg a.i./ha in combination with handweeding within rows and hœing was most effective in minimising the crop-weed competition and increasing the crop yield. In addition, this treatment gave highest additional return (Table 3) and also proved economically most profitable. Similar results are also reported by Thakur et al., (1967). The weeds of direct seeded upland rice can be controlled most effectively and economically if a suitable herbicide is applied in combination with manual and mechanical methods. This eventually would prove to be helpful in increasing the level of production. In all these experiments, *Cyperus iria* L., *Cyperus rotundus* L. and *Echinochloa crusgalli* Beauv. were the predominant weeds. Any method which effectively controlled these weeds, proved to be of greater benefit to the crop and there was increase in grain yield to the extent of 200%.

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EFFECT OF HERBICIDES ON YIELD, WATER USE EFFICIENCY AND NUTRIENT ECONOMY IN RAINFED MAIZE

JITENDRA PANDEY, K. D. N. SINGH and N. N. SHARMA
Rajendra Agricultural University, Pusa, Bihar, India.

ABSTRACT

Results of a field experiment carried out at Rajendra Agricultural University, Pusa, Bihar, revealed that weed control treatments gave significant increase in grain yield over control. Herbicides proved slightly better in wet year as compared to hand weeding but the reverse was true in a low rainfall year. Fe content of weeds was exceptionally higher.

Weeds removed 41.69, 18.97 and 66.77 kg N, P_2O_5 and K_2O ha^{-1} besides 117.6, 44.8, 189.7 and 4765 g each of Zn, Cu, Mn and Fe ha^{-1} respectively. Weed control proved helpful in arresting nutrient depletion to the extent of 50 per cent or slightly more. Water use efficiency was higher in the treated plots, whereas weed control efficiency of all other treatments, except 0.5 kg ha^{-1} alachlor, was almost at par.

INTRODUCTION

Maize (*Zea mays* L.) is one of the staple food of majority of the population in Bihar. It is grown both in *kharif* and *rabi* seasons and occupies about a million hectares annually. But its yield during *kharif* season is very low as compared to the *rabi* owing to weed competition for fertility and moisture.

Guleria and Singh (1979) reported that weeds when allowed to compete till harvest depleted 60 N, 12 P_2O_5 and 124 K_2O kg/ha. Thus it is of utmost importance to save the wasteful loss caused by weeds. Hand weeding is the only method in vogue for controlling weeds. But most of the time weeding is done after the critical period of competition on account of incessant rains and non-availability of labour. This results in ineffective weed control and lower crop yields. The present investigation was carried out to find out the suitable weed control measures, their effect on crop yield, fertiliser and water use efficiency.

MATERIAL AND METHODS

An experiment with seven weed control treatments (Table 2) was carried out in a randomized block design for two consecutive years in 1979-80 and 1980-81 at Tirhut College of Agriculture, Dholi (Muzaffarpur), Bihar. One extra treatment penoxalin was included in 1980-81. The treatments were replicated six times.

Composite variety of maize, 'Laxmi' was sown in 5 July, 1979 while hybrid variety, Ganga Safed-2 was sown on 23 June, 1980. Nitrogen, phosphorus and potassium were applied at 120, 60 and 20 kg N, P_2O_5 and K_2O/ha in the form of urea, D.A.P. and muriate of potash respectively. Half of the nitrogen and full dose of P_2O_5 and K_2O were applied at sowing in the lines. The remaining half of the nitrogen was applied in two equal splits at knee high and tasselling stages. Herbicides were sprayed two days after sowing as pre-emergence.

Soil of the experimental plot was sandy loam with a pH of 8.4, organic carbon of 0.45%, EC of 0.42 mmhos/cm., $CaCO_3$ of 30.8% available P_2O_5 of 38 kg/ha and available K_2O of 250 kg/ha.

Observations on weeds were recorded on 80th day of the sowing placing two quadrat of 0.5 m x 0.5 m. Weed data showed considerable variation, hence the data were subjected to square root transformation $\sqrt{(X + ½)}$. Weed samples collected from each plot at harvest were composited treatmentswise and samples were analysed for nutrients content. Nitrogen was analysed by modified Kjeldahl's method, phosphorus and potassium were analysed using colorimeter and Flame Photometer respectively as described by Jackson (1973). Zn, Fe, Cu and Mn were analysed in triacid extract by Atomic Absorption Spectrophotometer. Consumptive use efficiency was calculated by Blaney and Criddle formula (1950) and water use efficiency was worked out by the formula, yield/consumptive use. Weed control efficiency was calculated by the formula, $\frac{DWC - DWT}{DWC}$, where DWC and DWT are dry weight of weeds in unweeded control and treated plots. Meteorological data for crop season are given in Table 1.

RESULTS AND DISCUSSION

Weed flora: The weed flora of the experimental field comprised of *Dactyloctenium ægyptium* (Beauv), *Echinochloa colonum*, *Eragrostis spp.* and *Paspalum distichum* among the annual grasses, *Euphorbia hirta*, *Eclipta alba* Hassk, *Digera arvensis* Forsk, *Cleome viscoa* L., *Physalis minima* L. and *Biothytum sensitivum* DC among broad leaf weeds, and *Cyperus rotundus* L. *Cynodon dactylon* Pers, *Fimbristylis* dicotoma L. and *Sorghum halepense* (L). Pers among the rhizomatus weeds. Grassy and rhizomatus weeds were predominating, occupying the bulk of weed population (90%), whereas the dicot weeds were sparse (10%).

Yield: It is seen from the Table 2 that in both the years weed control treatments brought about significant increase in grain yield as compared to control (unweeded). In 1979-80, hand weeding proved superior to atrazine application at 0.5 kg/ha, which was at par with the rest of the treatments. Results of 1980-81 were in accord with the results of 1979-80, except that none of the treatments proved inferior to hand weeding. Herbicides, viz. alachlor and penoxalin gave slightly higher yield. Results are in accordance with the findings of Mani et al. (1970) and Gill et al. (1973). Higher yield in weed control treatments may be attributed to decreased weed competition and increased water and nutrient availability (Chowdhary and Mani, 1973; Guleria and Singh, 1979).

Variation in yield in different years is due to variation in climatic parameters. Heavy rainfall during 1980-81 resulted in lower yield/ha.

Weed dry weight: Dry matter accumulation in weed was similar in both the years. It was not affected due to variation in climatic parameters. In both the years, weed control treatments brought down dry matter accumulation significantly compared to control. In 1979-80, simazine and atrazine 1.0 kg/ha and alachlor 2.0 kg/ha reduced the dry matter accumulation to the extent of hand weeding, but in 1980-81 hand weeding proved inferior to herbicides. This is perhaps due to higher rainfall during the growth period, July to September, which helped in faster regeneration and greater dry matter accumulation. Observation of Rai and Yadav (1976) was similar. Herbicides differed significantly among themselves in reducing dry matter accumulation in weeds. Alachlor at 1.0 kg/ha and atrazine

Table 1 : Meterological data for year 1979 and 1980.

Month	Temperature (°C)				Rainfall (mm)		Relative humidity %	
	1979		1980		1979	1980	1979	1980
	Min.	Max.	Min.	Max.				
June	25.1	39.9	25.9	33.6	51.5	195.2	50.2	64.0
July	25.8	32.1	25.5	32.0	573.2	510.5	79.7	64.2
August	26.4	33.3	25.6	31.9	68.2	350.7	72.3	63.1
September	24.4	33.5	25.2	32.2	123.0	215.5	72.8	62.3
October	21.2	30.9	21.3	30.7	135.7	72.5	80.1	68.7

Table 2 : Effect of weed control treatments on grain yield, weed dry weight, water use and weed control efficiency.

Treatments	Dose a.i. kg/ha	Grain yield (g/ha)			Weed dry weight (g/0.25 m^2)		Water use efficiency (kg/ha.mm)		Weed control efficiency	
		1979-80	1980-81	Mean	1979-80	1980-81	79-80	80-81	79-80	80-81
T1-Atrazine	0.50	35.2	18.8	27.0	7.24	6.86	8.23	3.95	31.20	40.47
T2-Atrazine	1.00	39.7	20.1	29.2	6.72	6.46	9.23	4.23	40.63	47.13
T3-Simazine	0.75	39.0	20.0	29.5	6.38	6.28	9.12	4.19	41.48	50.00
T4-Alachlor	1.00	33.3	20.9	27.1	7.44	6.57	7.80	4.39	28.02	45.35
T5-Alachlor	2.00	37.0	23.1	30.0	6.88	6.28	8.67	4.80	40.63	47.13
T6-Penoxalin	1.00	–	22.0	22.0	–	6.38	–	4.62	–	40.47
T7-Hand weeding*	–	41.3	21.6	31.4	6.88	6.70	9.67	4.53	48.73	43.19
T8-Control	–	27.2	12.0	19.6	8.77	8.91	6.36	2.52		
S. Em.±	–	2.7	1.7	–	0.03	0.006				
P = 0.05	–	7.6	4.9	–	0.08	0.018				

* Hand weeding 20 and 40 days after sowing
Atrazine-2-Chloro-4-(ethylamino)-6-(isopropylamino)-s-trizine
Simazine-2-Chloro-4,6-bis(ethylamino)-s-triazine
Alachlor-2-Chloro-2,6'-diethyl-N-(methoxymethyl)acetanilide
Penoxalin-N-(l-ethylpropyl)3,4-dimethyl-2,6-dinitrobenzenamine

Table 3 : Effect of weed control treatments on major nutrient content and their removal by weeds (Average of 2 years).

Treatments	Weed dry weight (kg ha^{-1})	% nutrient content			Nutrient removal (kg/ha)		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
T1 – Atrazine	2009	1.361	0.590	1.88	27.34	11.85	37.76
T2 – Atrazine	1756	1.401	0.592	1.85	24.60	10.39	32.48
T3 – Simazine	1698	1.421	0.588	1.95	24.13	9.98	33.11
T4 – Alachlor	1980	1.395	0.589	1.98	27.62	11.66	39.20
T5 – Alachlor	1791	1.411	0.599	2.01	25.27	10.73	35.99
T6 – Penoxalin*	1800	1.404	0.601	2.00	25.27	10.82	36.00
T7 – Hand weeding	1696	1.482	0.594	1.96	25.13	10.07	33.24
T8 – Control	3135	1.330	0.605	2.13	41.69	18.97	66.77

* Data are based on one year observation.

Table 4 : Effect of weed control treatments on micronutrient content and their removal by weeds (Average of two years).

Treatments	Content (ppm)				Removal (g/ha)			
	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe
T1 – Atrazine	31.5	14.3	79.7	1570	63.3	28.7	160.1	3154
T2 – Atrazine	30.9	14.3	80.7	1565	54.3	25.1	141.7	2748
T3 - Simazine	31.5	14.3	80.6	1560	53.5	24.3	136.8	2449
T4 – Alachlor	31.7	14.3	79.3	1565	62.8	28.3	157.0	3099
T5 – Alachlor	31.0	14.3	80.5	1562	55.5	25.6	144.2	2797
T6 – Penoxalin*	31.2	14.3	81.8	1560	56.2	25.7	147.2	2808
T7 – Hand weeding	28.1	14.3	63.6	1400	47.7	24.2	107.9	2374
T8 – Control	37.5	14.3	60.5	1520	117.6	44.8	189.7	4765

* Data are based on one year observation.

at 0.5 kg/ha proved inferior to the rest of the herbicide treatments in both the years.

Water use and weed control efficiency : In both the years, water use efficiency was higher in treated plots as compared to control but it varied in different years. This is due to variation in yield. Except alachlor at 1.0 kg a.i./ha and atrazine 0.5 kg a.i./ha, all other treatments helped the crop to utilize soil water more efficiently as compared to control. Weed control efficiency was similar in both the years.

Nutrient content and removal : It is seen from the Tables 3 and 4 that Fe content in weeds was exceptionally high. It is about five to eight times higher than the crop. Mann (1969) reported that Fe content of maize varied from 15.8 to 18.7 ppm in grain and 137.6 to 160.4 ppm in straw. Content of other nutrients are comparable to maize crop (Das and Singh, 1979). Nutrient content was affected due to weed control treatments. Except K, content of all other nutrients was slightly lower in hand weeded and control plots as compared to herbicides.

Weeds removed higher amount of both major and micronutrients (Table 3 and 4). Among the micronutrients, Fe removal was the highest and was to the extent of 4765 g/ha. Weed control treatments resulted in 50 per cent saving of nutrients.

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WEED FLORA IN RELATION TO SEASON AND LOCATION, AND ECONOMICS OF WEED CONTROL, IN POTATO, IN THE HILLS AND PLAINS OF NORTH-WESTERN INDIA

J. T. NANKAR[1] and MUKHTAR SINGH[2]
[1] Department of Agronomy, Marathwada Agricultural University
Parbhani, 431 401, India.
[2] Department of Agronomy, Punjab Agricultural University, Ludhiana, 141 004, India.

ABSTRACT

Field studies were carried out during 1973-74 and 1974-75, in summer at Simla (hills) and in autumn and spring at Jullundur (plains) to assess the composition and intensity of weed flora in potato, and their effect on crop yield, and economics of weed control were worked out. At Simla, *Echinochloa colonum* and *Setaria* glauca were the principal monocot weeds and *Oxalis latifolia* and *Galinsnga purviflora,* were the dominant perennial and annual dicot weeds, respectively. At Jullundur, in the autumn crop, *Cyperus rotundus* dominated in the early stages while *Poa annua* was the dominant annual monocot in the later part of aurumn and in the spring crop. *Chenopodium album* was the most problematic dicot weed of the spring, followed by *Lepodium* sp., and *Spergula arvensis.* Dry weight of weeds at the end of the crop season, at Simla, was as high as 2,482 kg/ha resulting in the nutrient loss of 42.6 kg N, 8.24 kg P_2O_5 and 48.6 kg K_2O/ha, while dry weights of weeds ranged from 124-143 kg/ha for autumn and 424 to 1,066 kg/ha for spring at Jullundur. The weeds reduced the yield of potato to the extent of 48.8% in the summer crop at Simla and from 6.5 to 11.8% and from 19.5 to 48.4% in the autumn and spring crops respectively at Jullundur. The net returns obtained in cultural treatments over untreated controls amounted to Rs. 5,595, Rs. 916 and Rs. 3,814 per ha, in the respective seasons. The differences in the composition and intensity of weeds in different seasons as well as those in the hills and the plains may be ascribed to ecological factors such as temperature, humidity, day length and soil reaction.

INTRODUCTION

The short duration nature of the potato crop and its ability to give the highest production per unit area per unit time makes it particularly suitable for inclusion in the intensive multiple-cropping systems, specially in the plains of India, where about 90 per cent of this crop is raised. The adoption of such a system is beset with, the problem of weeds. In the hills also, the weed infestation in the potato crop is quite serious, resulting in severe reduction in yield (Mani *et al.,* 1968; Dutta *et al.,* 1969) though there is little multiple-cropping and the crop is largely grown under the rain-fed conditions.

Replicated field trials with a number of weed control treatments were carried out during 1973-74 and 1974-75, in summer at Simla (hills) and autumn and spring at Jullundur (plains), the two locations representing the hills and the plains of north-western part of India, respectively. The composition and intensity of weed flora in potato and their effect on crop yield, was assessed and economics of weed control worked out in different seasons of crop growth, at these locations.

MATERIAL AND METHODS

The climatic conditions, in crop seasons of the two locations, varied widely

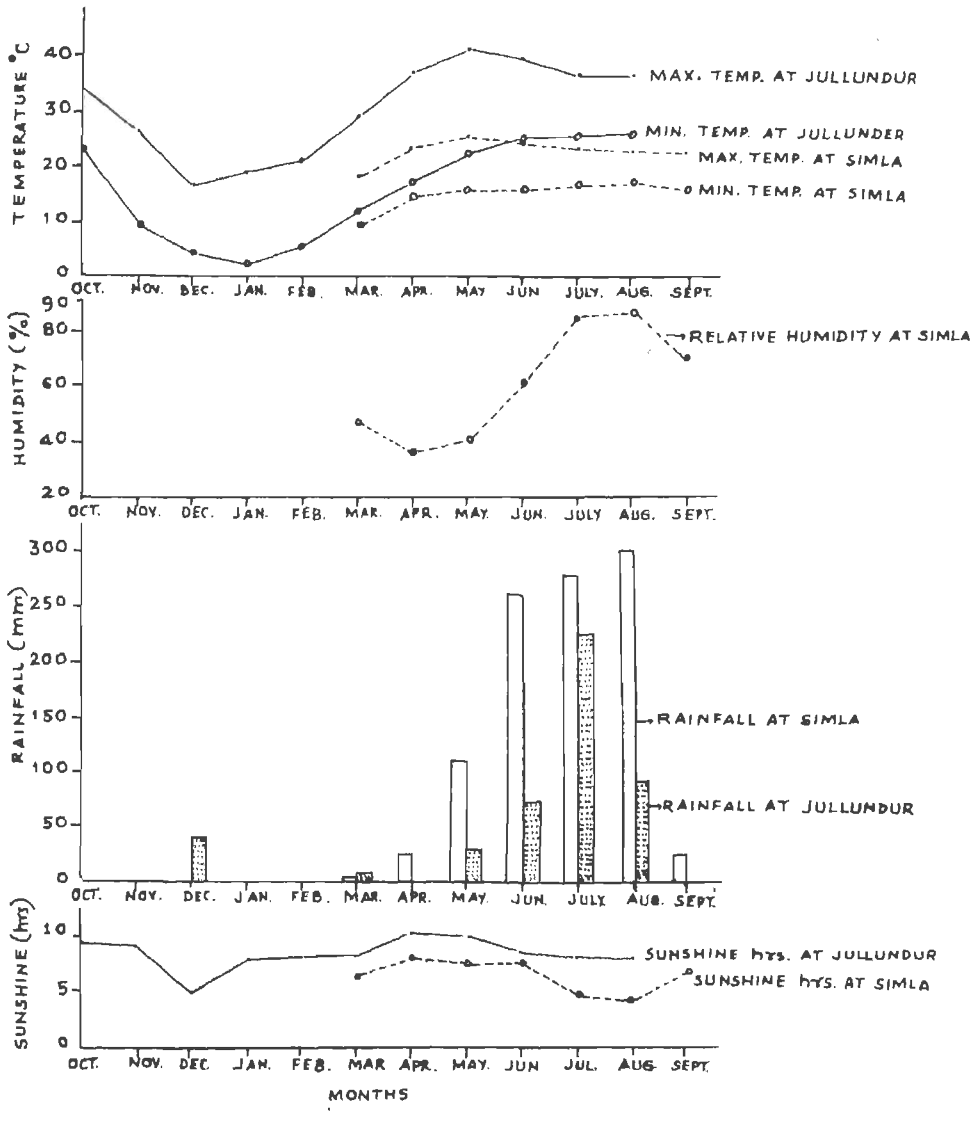

Fig. 1 : METEOROLOGICAL DATA AT SIMLA AND JULLUNDUR

(Fig. 1). Simla was comparatively cool and cloudy with frequent showers of rains. At Jullundur, the danger of frost in December-January necessitated the cultivation of potato in two distinct seasons. The main crop of potato, generally known as the autumn crop, was planted in October, which matured before the occurrence of severe frost, and the spring crop was planted in January so that it emerged after frost danger was over. The main crop started off when the temperatures were fairly high and grew under the condition of rapidly falling temperatures. The spring crop grew under progressively rising temperatures and the weather became very hot by the time the crop matured.

The two locations showed considerable variation in their soil properties. The soil at Simla was sandy loam in texture, high in organic matter and in available nitrogen, phosphorus and potassium and acidic in reaction while that at Jullundur was loamy sand, low in organic matter and in available nitrogen, medium in available phosphorus, high in available potassium and slightly alkaline in reaction.

RESULTS

The weed flora, in the potato crop at Simla (hills) was almost different from that at Jullundur in the plains (Table 1). Also, the weed flora in autumn and in spring seasons at Jullundur showed wide variations. At Simla, *Echinochloa colonum* and *Setaria glauca* were the principal monocot weeds and *Oxalis latifolia* and *Galinsnga parviflora,* were the dominant perennial and annual dicot weeds, respectively. At Jullundur, in the autumn crop, *Cyperus rotundus* dominated in the early stages while *Poa annua* was the dominant annual monocot in the later part of autumn and in the spring crop. *Chenopodium album* was the most problematic dicot weed of the spring, followed by *Lepidium* sp., and *Spergula arvensis.*

Dry weight of weeds at the end of the crop season, at Simla, was as high as 2,482 kg/ha resulting in the nutrient loss of 42.6 kg N, 8.24 kg P and 48.6 kg K/ha, while at Jullundur it was 143 kg/ha for autumn and ranged from 500 to 1,066 kg/ha for spring seasons (Table 2). The contribution of dicot weeds was considerable in summer and in spring seasons, while in autumn, monocots had an upper hand. The weeds reduced the yield of potatoes to the extent of 48.8 per cent in the summer crop at Simla and 13.4 and 48.4 per cent in the autumn and spring crops respectively, at Jullundur. The net returns obtained in cultural treatments over untreated controls amounted to Rs, 5,595, Rs. 916 and Rs. 3,814/ha, in the respective seasons.

DISCUSSION

The difference in weed flora in the hills and the plains may be ascribed to the ecological factors, Simla has a cold climate and the crop grows under conditions of long days and moderate temperatures in the summer and on soils, acidic in reaction. This probably accounts for the predominance of weeds, such as *Oxalis latifolia.* Jullundur, on the other hand, has sub-tropical climate and the crop grows under conditions of short days in winter, but the early part of the autumn crop and the late part of spring crop are subject to high temperatures. The soil is alkaline in reaction. These factors are mainly responsible for the predominance of *Chenopodium album,* a dominant dicot, and *Cyperus rotundus,* a perennial sedge.

As the potato required comparatively long time for emergence in the hills, many weeds emerged and competed with the potato crop and the weed problem

Table 1 : Weed flora in potato in hills and plains.

	Simla (hills) Summer	Autumn	Jullundur (plains) Spring
Sedges	–	Cyperus rotundus	–
Monocots	Echinochloa colonum	Poa annua	Poa annua
	Setaria glauca	Asphodelus tenuifolius	Panicum colonum
	Echinochloa crus-galli	–	Laphocloa puncilo
	Panicum psilopodium	–	Eragrostis tenella
Dicots	Oxalis latifolia	Chenopodium album	Chenopodium album
	Galinsnga parviflora	Lepidium sp.	Lepidium sp.
	Polygonum alatum	Portulaca oleracea	Spergula arvensis
	Trifolium sp.	Trianthema monogyna	Phyllanthus niruri
	Ipomea purpurea	Amaranthus viridis	Medicago denticulata
	Nicandra physaloides	Spergula arvensis	Fumaria parviflora
	Chenopodium album	–	Lathyrus aphaca
	Malva verticillata	–	Heliotropium supinum
	Amaranthus hybridus	–	Rumex sp.
	Datura stramonium	–	–

Table 2 : Final dry weight of weeds, nutrient removal, reduction in potato yields due to weeds, and economics of weed control.

Locations	Seasons	Treatments	Dry. wt. of weeds (kg/ha) Mono-cot	Dicot	Total	Nutrient removal by weeds (kg/ha) N	P	K	Yield of potatoes (q/ha)	Net returns (Rs/ha)
Simla	Summer 1974	Cultural*	163	228	391	7.1	1.47	8.8	235.5	11,625
		Control	496	1986	2482	42.6	8.24	48.6	120.6	6,030
		reduction in yield (%)	–	–	–	–	–	48.8		–
		increase in net returns	–	–	–	–	–	–	–	5,595
Jullundur	Autumn 1974	Cultural	14	7	21	0.4	0.08	0.4	261.4	8,868
		Control	95	48	143	2.5	0.51	3.0	230.5	7,952
		reduction in yield (%)	–	–	–	–	–	–	13.4	–
		increase in net returns	–	–	–	–	–	–	–	916
	Spring 1974	Cultural	39	123	162	2.8	0.61	3.2	197.2	9,932
		Control	69	997	1066	18.8	3.87	22.7	130.5	6,655
		reduction in yield (%)	–	–	–	–	–	–	33.9	–
		increase in net returns	–	–	–	–	–	–	–	3,277
	Spring 1975	Cultural	11	16	27	0.5	0.10	0.6	237.5	8,044
		Control	89	411	500	8.6	1.91	11.2	122.6	4,230
		reduction in yield (%)	–	–	–	–	–	–	48.4	–
		increase in net returns	–	–	–	–	–	–	–	3,814

* Cultural treatment consisted of weeding followed by second earthing-up, 50 days after planting at Simla; 30 days after planting in autumn and 42 days after planting in spring, at Jullundur.

became serious. In the North-western hills, the time for preparatory cultivation is rather short, the crop is rainfed and its growing season is long, and the period of active growth of the weeds almost synchronises with that of the potato crop. Hand weeding followed by second earthing-up, 50 days after planting, removed the existing weed population, and the subsequent emergence and growth of the weeds were much hampered due to shading effect of the vigorously growing potato crop. Thus the cultural treatment resulted in the increased yield to the extent of 114.9 q/ha and in increased net monetary returns (Rs. 5,595/ha) over control. The loss in yield was as high as 48.8 per cent. Dutta *et al.,* (1969) also reported 78.7 per cent loss in crop yield due to weeds at Simla.

At Jullundur, the problem of weeds was comparatively much more in the spring than in the autumn. The spring crop was grown under different agronomical and ecological conditions compared to the autumn crop. In spring, the use of freshly harvested tubers, treated with dormancy breaking chemicals, and prevailing low temperatures after planting, were responsible for delayed and slow sprout emergence but after subsequent shooting-up of temperatures, the plants became tall and lanky with diminitive leaflets favouring the growth of weeds, particularly of *Chenopodium album* which grew rapidly and luxuriantly and competed with the crop. The severe weed competition in this season resulted in loss of yield to the extent of 48.4 per cent. For the autumn crop, well-sprouted seed potatoes after cold storage were used for planting in October, resulting in quick emergence and rapid growth. Although weeds also emerged simultaneously, the rapid early growth of the crop together with progressively falling temperatures in November-December prevented the development of a severe crop-weed competition. The temperatures were favourable for the expansion of leaves, and the resulting bushy and spreading crop tended to smother the weeds giving marginal net returns of Rs. 9161 ha by weeding followed by second earthing up 30 days after planting, over untreated control.

CONCLUSION

The weed flora, in potato in the hills and the plains was almost different, and the same in autumn and spring seasons in the plains showed wide variation. The differences in the composition and intensity of weeds in different sessions as well as those in the hills and the plains may be ascribed to ecological factors such as temperature, humidity, day-length and soil reaction. The weeds reduced the yield of potato to an extent of 48.8 per cent in the summer crop at Simla and 13.4 and 48.4 per cent in the autumn and spring crops respectively, at Jullundur.

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INTEGRATED WEED MANAGEMENT IN SORGHUM

U. C. UPADHYAY, M. H. LOMTE and V. B. SHELKE
Marathwada Agricultural University,
Parbhani (Maharashtra) India.

ABSTRACT

The results of a field experiment conducted in 1980-81 revealed that the pre-emergence application of Atrazine at the rate of 1 kg a.i./ha (2-Chloro-4-(ethylamino) 6-(iso propylamino)-S-triazine) followed by one weeding and hœing at 6 weeks stage of the crop produced 16.07 q/ha yield which was significantly superior to the recommended practices of 2 weedings and 2 hœings at 3 and 6 weeks stage of the crop and control, producing 10.56 and 8.98 q/ha of the sorghum grain respectively. Keeping the field free from weeds for forty days, pre-emergence application of atrazine 1 kg a.i./ha followed by post-emergence application of 2,4-D (Na salts) at the rate of 1 kg a.i./ha at 6 weeks stage and pre-emergence application of 0.5 kg a.i./ha followed by one weeding and hœing at 6 weeks stage proved their efficacy at par, yielding 15.52, 14.08 and 13.74 q/ha of sorghum grain respectively, with the treatment of pre-emergence application of atrazine at the rate of 1 kg a.i./ha followed by one weeding and hœing at 6 weeks stage which had also given maximum additional net income of Rs. 686 per ha over the control. The weed index in this treatment was also seen to be minimum i.e., 17.97.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is a staple food crop of Maharashtra and is grown in both monsoon (*kharif*) and winter (*rabi*) seasons in some southern and central parts of India. In *kharif* it is grown as a rainfed crop. Weeds pose a serious problem under the favourable moist condition of the soil which is often too wet to permit mechanical methods of weed control. Both monocot and dicot types of weeds are commonly seen growing with the crop sorghum. Striga is a severe problem in sorghum which affects the grain yield even to the tune of 75 per cent. Beneficial effect of atrazine as preplanting followed by post-emergence application of 2,4-D (Na salts) or normal interculture was reported by many research workers (Upadhyay et al., 1977: Ali 1977 and Reddy et al., 1977). The present investigation was conducted to study the economics and effectiveness of atrazine and 2,4-D for the control of native weed flora in *kharif* sorghum in comparison with physical systems of weed control.

MATERIAL AND METHODS

The field investigation was carried out at Sorghum Research Station, Parbhani during *kharif* 1980 on clayey soil with medium status of NPK. The nine treatments (Table 1) comprising of pre- and post-emergence application of atrazine and 2,4-D (Na salts) respectively and other physical treatments were tested in Randomized Block Design with four replications. Atrazine was sprayed before sowing and incorporated well in the soil. Spraying of 2,4-D (Na salt) was done with boll and socket arrangement for the effective spray on weeds only. The sowing was undertaken on 7th July 1980 at 45 cm x 12 cm spacings. The basal appli-

Table 1 : Data on striga count, striga weight, weight of dry matter of weeds, weed index and weight of grain per ear.

Treatments	Striga count/ m^2	Dry wt. of striga/m^2 (g)	Weight of dry matter of weeds/net plot (g)	Weed index	Weight of grain/ear-(g)
T1 – Unweeded (control)	170.62	1.955	471	54.16	21
T2 – Complete weed free (9 weedings)	–	–	–	–	33
T3 – Recommended practice (2 hoeing + 2 weedings)	140.25	1.885	457	46.09	22
T4 – 20 days weed free after sowing	150.00	1.614	403	43.03	25
T5 – 40 days weed free + cultural practice (1 h + 1 w)	145.00	0.985	238	20.77	26
T6 – 20 day weed free + cultural practice (1 h + 1 w)	138.00	1.830	437	38.74	23
T7 – Atrazine at preplanting 1 kg a.i./ha + cultural practice at 6 weeks (1 h + 1 w)	126.00	0.910	227	17.97	27
T8 – Atrazine at preplanting 1 kg a.i./ha + 2,4-D (Na salts) 1 kg a.i./ha as post-emergence at 6 weeks stage of crop.	31.37	0.450	250	28.12	28
T9 – Atrazine at pre-planting 0.5 kg a.i./ha + cultural practice at 6 weeks (1 h + 1 w)	102.12	1.245	301	29.86	24

Weed index $= \frac{X - Y}{X} \times 100$, where X = Grain yield of complete weed free plot

Y = Grain yield of treatment for which weed index is to be calculated.

cation of 40 kg each of N, P_2O_5 and K_2O per ha was done at the time of sowing. Top dressing of 40 kg N/ha was done at 30 days after sowing through urea.

Data on striga count, dry weight of weeds, grain weight per earhead, plant population, grain yield and fodder yield were collected. Striga count was taken up at two random places in a plot each having 1 sq m area. Dry weight of weeds per net plot was recorded 30 days before the harvest of crop. Weed index was worked out by adopting the procedure laid down by Gill and Kumar (1969).

RESULTS AND DISCUSSION

Weed Flora :

i) *Monocot weeds:* The dominated monocot weeds were *Cynodon dactylon, Cyperus rotundus, Dinebra sp., Cana indica* and *Commelina benghalensis.*

ii) *Dicot weeds:* The common dicot weeds were *striga densiflora, Abutin indicum, Euphorbia spp., Achyranthus aspera, phyllanthus niruri, Corchorus acutangulus,* *Bidens pilosa, Convolvulus arvensis.*

Effect on weeds

The data on striga count and weight, dry matter of weeds, weed index and weight of grains per earhead under different treatments are given in Table 1. Data were not analysed statistically and hence inferences are drawn on the basis of mean values.

Data presented in Table 1 revealed that lowest striga count was recorded in the treatment of preplanting spray of atrazine 1 kg a.i./ha + post-emergence application of 2,4-D (Na salt) 1 kg a.i./ha at 6 weeks stage of crop. In the treatments of T3, T4, T5 and T6 where physical systems were adopted recorded more or less equal count and could not control the striga. This might be because of emergence of striga during boot stage i.e., 40 days after sowing when hœing was not possible and emergence of new striga plants took place. This specific observation clearly indicated that post emergence spray of 2,4-D at 6 weeks stage of crop effectively controlled the striga. The trend of dry weight per sq. m was just similar to that of striga count.

Highest dry matter accumulation in weeds was observed in the unweeded plot. There was no much deviation in the values of dry matter of weeds per net plot in T3, T6 and T4 treatments where cultural methods were adopted for the control of weeds. These values of dry matter were much higher than the values observed in the treatments of T7, T5, T8 and T9. The critical study of these treatments revealed that in T5 treatment, weed free condition was maintained for 40 days after sowing and this resulted in reducing the weed flora except striga. In T7, T8 and T9 treatments preplanting of atrazine controlled all types of weeds except *Cynodon dactylon* and *Cyperus rotundus* up to 40 days effectively and thus reducing the weed flora.

Maximum weed index of 34.16 was observed in unweeded control whereas it was minimum i.e. 17.97 was noticed in preplanting application of atrazine 1 kg a.i./ha + cultural practice (1 h + 1 W) at 6 weeks stage of the crop. It indicated the efficacy of this treatment over all other treatments.

Data on grain and fodder yield and economics of treatments are presented in Table 2. Data on grain yield presented in Table 2 revealed that preplanting application of atrazine 1 kg a.i./ha (2-Chloro-4-ethylamino)-6-(isopropylamino)-S-trazine) + one weeding and hœing at 6 weeks after sowing produced 16.07 a.i./ha grain yield which was significantly superior to the recommended practices i.e. 2 weedings and 2 hœings at 3 and 6 weeks stage of crop and the control. Keeping the field free from weeds up to 40 days, pre-emergence application of 2,4-D (Na salts) 1 kg a.i./ha at 6 weeks stage of crop, and pre-emergence application of atrazine 0.5 kg a.i./ha + 1 weeding and 1 hœing at 6 week stage proved their efficacy at par with the treatment of atrazine 1 kg a.i./ha + 1 weeding and 1 hœing at 6 weeks stage.

There were no significant differences in the fodder yield due to various treatments.

Economics of the treatments revealed that maximum additional income (Rs. 686/ha was obtained in the treatment of pre-planting application of atrazine 1 kg a.i./ha + 1 weeding and hœing at 6 weeks stage of crop followed by Rs. 656/ha in complete weed free treatment which is practically not feasible. Keeping the field weed free for 40 days was superior (Rs. 517/ha) to pre-emergence application of atrazine 1 kg a.i./ha + post-emergence application of 2,4-D at 6

Table 2: Data on plant population, grain and fodder yield of sorghum and economics of treatments.

Treatments	Plant population (000/ha)	Grain yield (q/ha)	Fodder Yield (q/ha)	Economics of treatments			
				Additional grain yield over control (q/ha)	Value of additional grain yield (Rs.)	Cost of treatments (Rs.)	Additional income (Rs.)
T1 - Unweeded (control)	108.3	8.98	33.73	–	–	–	–
T2 - Complete weed free (9 free (9 weedings)	126.2	19.59	54.56	10.61	1326	670	656
T3 - Recommended practice (2 hoeing + 2 weedings)	108.4	10.56	37.70	1.58	197	160	37
T4 - 20 days weed free after sowing	117.6	11.16	34.72	2.18	272	230	42
T5 - 40 days weed free after sowing	120.4	15.52	35.22	6.54	817	300	517
T6 - 20 days weed free + cultural practice weeks (1 h + 1 w)	118.3	12.00	37.70	3.02	377	150	227
T7 - Atrazine at preplanting 1 kg a.i./ha + cultural practice at 6 weeks (1 h + 1 w)	122.4	16.07	42.16	7.09	886	200	686
T8 - Atrazine at preplanting 1 kg a.i./ha + 2,4-D (Na salts) 1 kg a.i./ha as post-emergence at 6 weeks stage of crop.	123.2	14.08	35.22	5.10	637	175	462
T9 - Atrazine at preplanting 0.5 kg a.i./ha + cultural practice at 6 weeks (1 h + 1 w)	123.5	13.74	42.65	4.76	595	140	455
S.E.±		0.91	1.61				
C.D. at 5%		2.66	N.S.				

N.S.: Not significant.

weeks stage of crop (Rs. 462/ha) and pre-emergence application of atrazine 0.5 kg a.i./ha + 1 weeding and hoeing at 6 weeks stage (Rs. 455/ha).

Considering the feasibility and efficacy of treatments, the control of weeds in sorghum can be done effectively with pre-emergence application of atrazine 1 kg a.i./ha combined with 1 weeding and hoeing at 6 weeks stage of crop.

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WEED CONTROL THROUGH HERBICIDES IN DIFFERENT RICE CULTURES

M. P. SINGH and S. B. BISWAS
Department of Plant Breeding, Himachal Pradesh Krishi Vishva Vidyalaya
Palampur-176 062, H. P., India.

ABSTRACT

Weeds are one of the major causes of low rice yields in the Himachal Pradesh (India). Weed control in the three prevailing rice cultures is done manually. This is cumbersome and expensive operation. Field experiments were conducted in three *Kharif* (wet) seasons, ending 1980, at Palampur, Malan and Matiyari under mid-hill conditions of Himachal Pradesh to study the effectiveness of herbicides in controlling weeds, as well as their toxicity on crop plants in the transplanted, direct seeded puddled, and direct seeded unpuddled rice cultures. In these experiments 7 to 12 herbicides were compared with 'handweeding.'

C-288 (piperphos + dimethemetryn) gave effective control under different rice cultures at Palampur. The yield of rice from C-288 treated plots was comparable with handweeding. USB 3584 (dinitramine), USB 3153, and butachlor were toxic under Palampur conditions. However, at Malan dinitramine and butachlor were most effective under direct seeded unpuddled and puddled conditions. The toxic effect of butachlor and dinitramine at Palampur may be due to herbicide-agroclimate interaction.

Other promising herbicides under transplanted culture were Benthiocard/2, 4-D IPE and Sirmate at Palampur; Basalin at Malan; and Basalin and Propanil at malan controlled weeds effectively.

INTRODUCTION

Non-availability of labour at the critical crop weed competition stage results in delayed weeding and reduced yield. The present series of experiments were, therefore, planned to evaluate some new herbicides for effective weed control in transplanted, direct seeded puddled, and direct seeded upland rainfed rice cultures and their toxic effects on crop plants.

MATERIAL AND METHODS

Three field experiments, first on transplanted rice (puddled soil), second on direct seeded puddled rice (flooded), and third on direct seeded upland rainfed rice were conducted at three research stations (Palampur, Malan and Matiyari) of the Himachal Pradesh Krishi Vishva Vidyalaya (HPKVV), Palampur, India. The details of treatments, year and sites of experimentation are given in Tables 1 to 6. Palampur is situated at an altitude of 1300 metres above mean sea level in the North-Western Himalayan region of India (Himachal Pradesh). The annual rainfall is around 2,500 mm with major portion being received between July and September. The minimum and maximum temperatures during rice growth and development period vary from 13°C to 31°C. The soil of the area is deep clay loam in texture, low in available phosphorus, medium in available potash and has 1.03% organic matter with a soil pH of 5.8. Malan's (19 km from Palampur) elevation is 945 metres. The annual rainfall is around 2400 mm and the minimum and maximum temperature are 14°C and 33°C. The soil is loam having 1.02% organic matter and 5.85 pH. Matiyari (6 km from Malan) is situated at an altitude of

850 metres. The annual rainfall is around 2,000 mm and the minimum and maximum temperatures vary from 15°C to 36°C. Here during wet seasons the rice fields remain submerged. The soil is clay loam having 0.98% organic matter and 5.95 pH.

In Experiment I 25 days old seedlings (2 per hill) were transplanted on 10th July during both the years; in Experiment II the sprouted seeds were broadcasted (at 100 kg ha^{-1}) in puddled soils on 22nd, 29th and 27th June in 1974, 75 and 80, respectively; and in Experiment III seeds were drilled (at 70 kg ha^{-1}) on 30th, 12th and 24th June in 1975, 78 and 80 respectively. Data on weed control, herbicide toxicity and grain yield were recorded. The treatments were tried in a randomized complete block design with four replications each in all the experiments. Duncan's Multiple Range Test (DMRT) was used for comparing the treatment means.

RESULTS

Experiment I

In 1976 at C-288 (piperphos + dimethemetryn) gave significantly higher grain yield than all other treatments and at Matiyari yielded at par with hand weeding and 2, 4-D IPE treatments (Table 1). In 1980 at Malan fluchloralin (Basalin) (G) at 0.8 kg ha^{-1} resulted in maximum grain yield (Table 2). Unweeded checks at all the places and USB 3584 + 2, 4-D IPE at Palampur, butachlor at Matiyari and oxyfluorfen (G) 2% at 0.2 kg ha^{-1} at Malan produced lower yields. Dry weight of weeds from C-288 treated plots was lowest at Palampur. At Matiyari also amongst herbicides C-288 resulted in minimum dry weight of weeds, through more than handweeding. At Malan butachlor (G) treated plots resulted in lower dry weight of weeds. C-288 at Palampur and Matiyari, 2, 4-D IPE at Matiyari and butachlor (G) at Malan were least toxic to rice plants. USB 3584 + 2, 4-D IPE at Palampur, butachlor at Matiyari, and oxyfluorfen at Malan were most toxic.

Experiment II

In 1974 and 75, C-288 treatment yielded at par with handweeding (Table 3). In 1980 at Malan no herbicidal treatment could yield equal to weed free and handweeding checks (Table 4). Amongst herbicides oxadiazon followed by one mechanical weeding yielded maximum. During both the years of experimentation at Palampur C-288 treated plots resulted in lowest dry weight of weeds and least toxicity to the rice plants. In 1980 at Malan oxyfluorfen use resulted in most efficient control of weeds but it was highly toxic to rice crop.

Experiment III

In 1975 at Palampur rice grain yield from C-288 treatment was significantly higher than other treatments and in 1978 at Malan it was similar to USB 3584 and handweeding treatments (Table 5). At Malan USB 3584 treatment recorded highest grain yield while at Palampur it could out yield unweeded check only. In 1980 at Malan butachlor at 3 kg ha^{-1} yielded *at par* with weed free check and produced minimum number of weeds with least toxic effect (Table 6). In 1975, C-288 treated plots produced minimum number of weeds with least toxicity. In 1978 minimum number of weeds was recorded in USB 3584 treated plots having lowest toxicity rating.

C-288 gave wide spectrum weed control in all the rice cultures. It efficiently controlled *Echinochloa spp.*, *Cyperus spp.* and broad leaved weeds like *Monochoria vaginalis.* USB 3584 and butachlor effectively controlled *Echinochloa spp.*, other grassy weeds and were highly effective against sedges. 2, 4-D IPE controlled

Table 1 : Grain yield, dry weight of weeds, and visual toxicity rating as influenced by different herbicide treatments in transplanted rice, HPKVV, Palampur and Matiyari, 1976, wet seasons (Experiment 1).

Treatments*	Rate a.i. (kg ha⁻¹)	Grain yield** (kg ha⁻¹)		Dry weight of weeds (g/m²)		Visual toxicity rating (heading stage)	
		Palampur	Matiyari	Palampur	Matiyari	Palampur	Matiyari
MT-B-3015	1.0/0.7	4085 bc	4475 cde	84 d	78 e	3.25 d	2.75 bc
WL 29226	2.0	4100 bc	4500 cde	92 d	77 e	2.75 e	3.00 b
C-288	3.3	5368 a	5550 a	37 f	29 g	1.50 g	1.50 e
C-19490/2, 4-D IPE	4.0	3981 cd	4875 b	116 c	75 ef	2.00 f	2.50 c
NTN 5810/2079 a	6.0/2.0	3422 ef	4600 bc	169 b	126 b	3.75 c	3.00 ab
USB3584 + 2, 4-D IPE	2.0 + 3.2	3057 f	4450 cde	160 b	88 d	5.25 a	2.50 c
Butachlor	5.0	3248 e	4275 e	92 d	104 c	4.75 b	3.50 a
Butachlor 8 2, 4-D IPE	5.0 + 3.2	3756 cd	4650 bc	86 d	73 ef	5.00 ab	2.50 c
Nitrofen	8.0	3508 de	4350 d	130 c	101 c	3.00 d	2.50 c
2, 4-D IPE	3.2	4254 b	5525 a	80 d	68 f	2.50 e	1.50 e
Hand weeding Twice	20 & 40 DAT	4516 b	5600 a	63 a	14 h	0.00 h	0.00 f
Nonweeded	–	2238 g	2775 f	368 a	423 a	0.00 h	0.00 f
C. V. %	–	10.20	3.90	16.00	5.51	11.50	9.40

Any means followed by the similar letter in a column do not differ significantly at 5 per cent level by DPRT.
* Herbicides in granular form were applied at 6 DAT (Days after transplanting)
** Griain yield was adjusted at 14 per cent moisture.
+ O = No toxicity, 10 = complete kill.

Table 2 : Grain yield, dry weight of weeds and visual toxicity rating as influenced by different herbicides treatments in transplanted rice, HPKVV, Malan, 1980 wet season (Experiment 1).

Treatments*	Rate a.i. (kg ha⁻¹)	Grain yield** (kg ha⁻¹)	Dry weight of weeds (g/m²)	Visual toxicity rating* (Heading stage)
2, 4-D EE (G)	0.80	3633 abc	135 d	3.25 b
2, 4-D EE (G)	1.00	3850 abc	110 f	3.50 b
2, 4-D EE (L)	0.80	3650 abc	130 ef	3.00 c
Fluchloralin (G)	0.80	4033 a	101 g	3.00 c
Fluchloralin (G)	1.20	3600 abc	156 cd	3.25 b
Fluchloralin (L)	0.80	3800 abc	148 cde	3.00 c
BAS 3510 H (L)	1.20	3450 bcd	129 e	3.25 b
Nitrofen (G)	1.50	3417 cd	160 c	3.00 c
Oxyfluorfen (G) 2%	0.20	2717 e	210 b	4.50 a
Oxyfluorfen (G) 0.35%	0.10	3000 de	153 cd	4.50 a
Oxyfluorfen (G) 2%	0.750	3867 abc	153 cd	4.50 a
Oxyfluorfen (L) 1% EC	0.60	3767 abc	164 c	4.25 a
Butachlor (G)	0.50	4000 a	86 g	2.00 d
Handweeding Twice	20 & 40 DAT	3967 ab	95 g	0.00 e
Weed free	–	3700 abc	0.0 h	0.00 e
Nonweeded	–	2300 f	286 a	0.00 e
C. V. %	–	7.90	1.70	8.20

Any means followed by the similar letter in a column do not differ significantly at 5 per cent level by DMRT
* Herbicides were applied at 6 DAT
** Grain yield was adjusted at 14 per cent moisture
+ O = No toxicity, 10 = complete kill.

Table 3 : Grain yield, dry weight of weeds, and visual toxicity rating as influenced by different herbicide treatments in direct seeded puddled flooded rice, HPKVV, Palampur, 1974 and 75 wet season (Experiment 1).

Treatments*	Rate a.i. (kg ha⁻¹)	Grain yield** (kg ha⁻¹)	Dry weight of weeds (g/m²)	Visual toxicity rating* (Heading stage)
		1974		
Butachlor + 2, 4-D IPE	1.0 + 0.5	2769 abc	99 c	2.5 bc
C-288	1.0	3671 a	69 c	2.5 bc
C-19490/2, 4-D IPE	0.75	3513 a	115 c	2.7 bc
Oxadiazon + 2, 4-D IPE	0.5 + 0.5	2059 bc	186 b	2.5 bc
USB 3153+ 2,4-D IPE	2.0 + 5.5	2812 abc	79 c	5.0 a
Benthiocarb/2,4-D IPE	1.0/0.5	3754 a	91 c	2.5 bc
CNP/2, 4-D IPE	2.0/0.28	1632 c	101 c	3.7 b
Dustun/2, 4-D IPE	1.0/0.25	2899 ab	68 c	2.7 bc
USB 3584	2.0	2156 bc	96 c	7.5 a
Dichlormate	2.0	3596 a	126 bc	2.5 bc
Handweeding	as & when necessary	4001 a	0.0 d	0.0 d
Nonweeded	–	2099 bc	285 a	0.0 d
C. V. %	–	25.00	2.90	16.00
		1975		
MON 0358	0.5	2932 def	61 gh	4.2 d
MON 0358 + 2, 4-D IPE	0.25 + 0.5	2700 fg	64 fgh	3.1 f
C-288	0.5	4013 ab	42 i	2.6 g
C-19490/2,4-DIPE	0.75	3279 cde	156 b	4.3 d
Dustun/2, 4-D IPE	1.0 + 0.25	2547 fgh	110 d	3.7 e
USB3584	0.75	2378 gh	70 efg	6.2 a
USB3584 +2, 4-D IPE	0.5 + 0.5	2084 hi	55 h	3.5 e
Butachlor	1.5	2427 gh	67 fgh	5.2 b
Butachlor	2.0	2315 gh	66 fgh	6.2 a
Butachlor + 2, 4-D IPE	0.75 + 0.5	2658 fg	130 c	3.5 e
Dichlormate	2.0	3412 cd	81 e	2.5 g
Benthiocarb + 2, 4-D IPE	1.0 + 0.5	3607 bc	74 ef	4.7 c
Handweeding	As & when necessary	4167 a	0.0 j	0.0 h
Nonweeded	–	1801 i	172 a	0.0 h
C. V. %	–	19.00	8.70	3.90

Any means followed by the similar letter in a column do not differ significantly at 5 per cent level by DMRT.

* Herbicides in granular form were applied at 6 DAS (Days after sowing).

** Grain yield was adjusted at 14 per cent moisture.

\+ O = No toxicity, 10 = complete kill.

Table 4 : Grain yield, dry weight of weeds and visual toxicity rating as influenced by different herbicide treatments in direct seeded puddled flooded rice, HPKVV, Malan, 1980 wet season (Experiment II).

Treatments*	Rate a.i. (kg ha^{-1})	Grain yield** (kg ha^{-1})	Dry weight of weeds (g/m^2)	Visual toxicity rating+ (Heading stage)
2, 4-D EE	0.80	1731 g	129 b	4.75 bc
2, 4-D EE	1.00	1469 gh	118 bc	5.13 bc
2, 4-D EE fb	0.80	1719 g	96 cd	4.63 c
Fluchloralin	0.80	2981 e	119 b	3.13 d
Fluchloralin	1.20	3225 de	95 cd	3.25 d
Fluchloralin fb	0.80	3363 cd	77 d	3.13 d
Oxyfluorfen	0.10	1375 h	23 e	6.00 a
Oxyfluorfen fb	0.10	1438 h	14 e	5.62 ab
Oxadiazon	0.75	3156 d	95 cd	2.37 e
Oxadiazon	1.00	3281 c	88 cd	2.38 e
Oxadiazon fb	0.75	3519 c	81 cd	2.25 e
Handweeding	Twice 20 & 40 DARE	4313 b	73 d	0.00 f
Weed free	–	4675 a	0.0 f	0.00 f
Nonweeded	–	2344 f	205 a	0.00 f
C. V. %	–	7.30	11.60	10.80

Any means followed by the similar letter in a column do not differ significantly at 5 per cent level by DMRT.
* Herbicides in granular form were applied at 6 DAS.
** Grain yield was adjusted at 14 per cent moisture.
+ O = No toxicity, 10 = complete kill.
fb = followed by one mechanical weeding at 30 DAS.
DARE = Days after rice emergence.

Table 5 : Grain yield, weed stand and visual toxicity rating as influenced by different herbicide treatments in direct seeded upland rainfed rice, HPKVV, Palampur/Malan, 1975 and 78 wet season (Experiment III).

Treatments*	Rate a.i. (kg ha^{-1})	Grain yield** (kg ha^{-1})	Weed stand/m^2 (Heading stage)	Visual toxicity rating+ (Heading stage)
		1975 Palampur		
C-288	2.0	3537 a	80 c	0.0 b
Butachlor	2.0	2119 d	93 c	3.7 a
A-820	2.0	1728 e	105 bc	3.1 a
USB 3584	2.0	1437 ef	98 bc	3.1 a
Oxadiazon	1.0	2649 c	138 b	3.1 a
Handweeding	Twice 20 & 40 DARE	3185 b	85 c	3.1 a
Nonweeded	–	1377 f	344 a	0.0 b
C. V. %	–	9.38	9.76	14.8
		1978 Malan		
Antor	1.00	2121 ef	107 bcd	4.38 a
Butachlor	2.00	2955 bc	80 efg	3.88 a
Butralin	2.00	3114 b	96 cdef	1.88 c
C-288	2.00	4015 a	90 def	1.50 c
USB 3584	1.50	4268 a	72 fg	1.50 c
X-150	4.00	2096 ef	127 b	2.25 bc
Oxadiazon	1.00	2386 de	118 bc	2.25 bc
AC 92553	2.00	2588 cd	93 cdef	1.88 c
Oxyfluorfen	2.00	1755 f	103 bcde	3.63 ab
Propanil	3.00	3321 b	87 defg	1.63 c
Handweeding	Twice 20 & 40 DARE	4318 a	62 g	0.00 d
Nonweeded	–	1856 f	278 a	0.00 d
C. V. %	–	9.46	14.59	17.20

Any means followed by the similar letter in a column do not differ significantly at 5 per cent level by DMRT.
* Herbicides were applied through spray at 5 DAS.
** Grain yield was adjusted at 14 per cent moisture.
+ O = No toxicity, 10 = complete kill.

Table 6 : Grain yield, weed stand and visual toxicity rating as influenced by different herbicide treatments in direct seeded upland rainfed rice, HPKVV, Malan, 1980 Wet season (Experiment III).

Treatments*	Rate a.i. (kg ha^{-1})	Time of herbicide application	Grain yield** (kg ha^{-1})	Weed stand/ m^2 (Heading stage)	Visual toxicity rating+ (Heading stage)
Propanil	2.00	2 to 3 leaf stage of weeds	2275 d	47 b	3.5 c
Propanil	3.00	do.	2650 abc	43 bc	4.0 b
Propanil fb	2.00	do.	2675 abc	36 d	3.5 c
Butachlor	2.00	5 DAS	2538 bcd	21 e	3.0 c
Butachlor fb	3.00	do.	2913 ab	15 f	3.5 c
Butachlor fb	2.00	do.	2750 abc	18 ef	3.0 c
BAS 3510 H	1.00	do.	2030 ef	51 b	3.0 c
BAS 3510 H	1.50	do.	2313 cdef	38 c	3.5 c
BAS 3510 H fb	1.00	do.	2413 cde	30 d	3.0 c
BAS 3510 H fb	1.50	3 leaf stage of sedges	2363 cdef	25 e	3.0 c
Fluchloralin	0.80	5 DAS	1963 f	62 b	4.0 b
Fluchloralin	1.20	do.	2438 cde	49 b	4.0 b
Fluchloralin fb	0.80	do.	2300 cde	44 bc	4.0 b
Oxyfluorfen	0.40	do.	600 h	5 g	6.0 a
Weed free	–	–	3038 a	0.0 h	0.0 d
Nonweeded	–	–	1550 g	346 a	0.0 d
C. V. %	–	–	13.2	9.60	20.30

Any means followed by the similar letter in a column do not differ significantly at 5 per cent level by DMRT.

* Herbicides were applied through sprays.

** Grain yield was adjusted at 14 per cent moisture.

\+ O = No toxicity, 10 = complete kill.

fb = followed by one mechanical weeding at 30 DAS.

sedges and broad leaved weeds but failed to control *Cynodon dactylon* and was less effective against *Echinochloa spp.* Fluchloralin controlled grasses, broad leaved weeds but was less effective against *Scirpus articulatus.* Oxyfluoren though controlled wide-spectrum of weeds but was toxic to the rice crop also.

DISCUSSION

Higher yields in different rice cultures from C-288 treatment could be attributed to efficient weed control and least toxic effects to the rice crop. Similar beneficial effects were recorded by Green and Ebner (1972). Similarly because of good weed control and least toxicity to transplanted and direct seeded upland rainfed rice crop, butachlor resulted in higher yields. These findings are in conformity with those of Chang and De Datta (1972); Smith (1973); Hussain and Khan (1976); and Pillai (1977). The poor performance of USB 3584 and butachlor at Palampur in contrast to their good performance at Malan might be due to the herbicide agroclimate interaction. Similar interactional effects have also been reported by Harvey (1974) and Parochetti and Deck (1976). In the Philippines also differential response of various herbicides under multilocational testing has been observed (IRRI, 1978).

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NEW EXPERIENCES WITH BENTAZON AND BENTAZON COMBINATIONS FOR WEED CONTROL IN RICE

U. KIESSLING, B. H. MENCK, and W. UNGLAUB
Agricultural Research Station of BASF Aktiengesellschaft Limburgerhof
Federal Republic of Germany.

ABSTRACT

Bentazon [3-isopropyl-1 H-2, 1, 3-benzothiodiazin-(4) 3 H-one 2, 2-dioxide] is a highly selective herbicide for gramineous crops like rice. As rice is tolerant to Bentazon at all growth stages, this herbicide can be applied to the most sensitive stage of the weeds. Bentazon is normally used after a pretreatment of an early stage herbicide for grass control. Bentazon can be applied to rice fields adjacent to hormone-sensitive crops such as tobacco, soybeans, cotton, melons, vines and different kinds of vegetables.

In order to broaden the weeds spectrum of Bentazon and to fit nearly all weed situations, a range of ready-formulated combinations with other herbicides for paddy and upland rice conditions was developed. Combinations with MCPA, Propanil, Dicamba, 2, 4-D, Simetryn, Piperophos and Benthiocarb allow the farmer a high degree of flexibility to select combinations for his weed control programme according to the weed population in individual fields.

INTRODUCTION

Rice is the primary source of food for more than half of the world's population. Worldwide rice acreage in 1980 was 148,806,000 ha, of which 133,414,000 ha were in Asia (FAO monthly bulletin 10–1980. The rapid rate of population growth has necessitated an intensification of rice cultivation, which has meant the inevitable introduction of chemical weed control. Changed cultural conditions and the repeated use of grass herbicides, especially to control. *Echinochloa, crus-galli Beauv.* have resulted in more severe infestation with dicotyledonous weeds and *Cyperaceæ*. Some of these weeds are controlled only partially or not at all by the hormone-type herbicides, so that certain weeds are selected out and multiply all the more rapidly. Bentazon's broad spectrum of activity ensures control of many weeds and Cyperaceæ currently problematic in rice fields, making Bentazon a standard component of weed spraying programmes in leading rice growing countries today (Luib Weerd and Vande, 1974).

Crops sensitive to hormone-type herbicides such as cotton, soybeans and vines, tolerate Bentazon much better. This has taken the risk from applications in areas where rice is grown adjacent to these crops.

MATERIAL AND METHODS

Bentazon has an exceptionally broad spectrum of activity for rice weeds. Herbicidal activity concentrates especially on weeds from the families Compositæ, Cruciferæ, Karyophyllaceæ, Alismataceæ and Cyperaceæ. Bentazon is not effective against Gramineæ. Further to Bentazon at 3.0-4.0 l/ha of formulated product and a 10% granular at 30-40 kg/ha ready-formulated combinations of Bentazon and other active ingredients have been made to broaden the spectrum of activity even further and to stabilise the herbicidal performance.

Among these combinations are:

160g/l Bentazon + 340g/l Propanil(8-10 l/ha)
400g/l Bentazon + 60g/l MCPA (3-4 l/ha)
480g/l Bentazon + 48g/l Dicamba (1-1.5 l/ha)
7% Bentazon + 1.5% Simetryn + 1% MCPB (30 kg/ha; granular)
10% Bentazon + 4.4% Piperophos + 1.1% Dimethamethryn (30 kg/ha; granular)
7% Bentazon + 1% Simetryn + 7% Benthiocarb (30 kg/ha; granular)
10% Bentazon + 1.5% 2, 4-D (30-40 kg/ha; granular).

The results of trials with Bentazon alone and the most important combinations are summarised in the following section.

RESULTS AND DISCUSSION

Bentazon: Crop tolerance of Bentazon in rice was tested in numerous trials. It was found that the selectivity of Bentazon is excellent in both transplanted and direct-sown rice, whether applied to the foliage or to the soil (granular). And unlike the growth hormones, Bentazon can be used during all developmental stages of the rice. No damage was observed in either the Indica rice species or the Japonica rice species from triple overdoses of Bentazon.

Bentazon applied postemergence at a rate of 3.0-4.0 l/ha (480 g/l formulated product) control of important rice weeds like *Alisma plantago-aquatica, Ammania coccinea, Butomus umbellatus, Commelina communis, Cyperus spp., Eleocharis spp., Monochoria vaginalis, Rotala indica, Sagittaria spp., Scirpus, maritimus* and *Scirpus spp.* Granular Bentazon applications require a rate of 30.0 kg/ha (10% granular) for satisfactory control. The herbicidal activity of Bentazon against the major rice weeds is presented in Table 1.

Table 1: Percentage efficacy of bentazon against individual species in rice.

Weeds	Bentazon 3.0 l/ha*	Bentazon 4.0 l/ha*
Alisma Plantago-Aquatica	96 (25)	97 (71)
Ammania Coccinea	99 (27)	99 (39)
Butomus Umbellatus	93 (11)	95 (37)
Commelina cummunis	98 (16)	99 (19)
Eleocharis spp.	83 (19)	90 (20)
Fimbristylis spp.	93 (6)	98 (10)
Marsilea spp.	83 (3)	95 (5)
Monochoria Vaginalis	85 (18)	93 (23)
Rotala Indica	85 (9)	92 (10)
Sagittaria spp.	85 (11)	93 (12)
Scirpus spp.	95 (73)	95 (87)

( ) = Number of trials
Efficacy in %
The weeds were at 3-5 leaf stage of development at the time of treatment
* = Application rates were used as formulated product

Bentazon+Propanil: The combination of Bentazon + Propanil, ready-formulated with 160 G Bentazon and 340 G Propanil per litre of product, is a post-emergence herbicide for rice that optimally combines the advantages of both ingredients. Bentazon controls a range of dicotyledonous weeds and Cyperaceæ, while Propanil takes care of another side of the activity spectrum, namely the grasses and Leguminosæ *(Cassia, tora, Sesbania exaltata).*

Bentazon + Propanil has good selectivity in direct-sown rice and can be applied beginning at the 3 to 4 leaf stage of the rice. Occasionally tips of the leaves may turn slightly yellow following treatment, but this has no effect on subsequent development of the rice plants. Bentazon + Propanil at 8-10 l/ha product is very effective against *Alisma plantago-aquatica, Aneilema keisak, Cyperus difformis, Cyperus serotinus, Echinochloa crus-galli, Eleocharis spp., Monochoria vaginalis, Sagittaria Sagittifolia, Scirpus juncoides* and *Scirpus maritimus.* The efficacy of the Bentazon + Propanil combination against

Table 2 : Weed spectrum of Bentazon + Propanil in rice (Post-emergence).

Weeds	Bentazon + Propanil 8.0 l/ha*	10.0 l/ha*
Alisma plantago-aquatica	92 (1)	
Aneilema keisak	92 (2)	
Cyperus difformis	90 (3)	
Cyperus serotinus	98 (3)	
Echinochloa crus-galli	91 (3)	
Eleocharis spp.	98 (3)	
Limnocharis flava	91 (2)	
Linderia pyxidaria	98 (1)	
Marsilea crenata	90 (2)	
Monochoria vaginalis	88 (3)	92 (3)
Sagittaria sagittifolia	90 (3)	95 (2)
Scirpus juncoides	91 (3)	94 (2)
Scirpus lineolatus	85 (1)	87 (1)
Scirpus maritimus	94 (3)	98 (1)

( ) = Number of trials
Efficacy in %
* = Application rates were used as formulated product

Table 4 : Activity of Bentazon + MCPA in Comparison to Bentazon in rice (Post-emergence).

Weeds	N	Bentazon 4.0 l/ha*	Bentazon+MCPA 3.0 l/ha*	4.0 l/ha*
Alisma plantago-aquatica	8 (4)	98 (7)	97 (6)	97
Ammania coccinea	4	99 (3)	97 (7)	100 (0)
Cyperus difformis	16	86 (17)	98 (3)	99 (2)
Scirpus maritimus	16	91 (19)	92 (11)	96 (10)
Scirpus mucronatus	2	95 (5)	89 (5)	91 (4)

( ) = Standard Deviation 2nd Evaluation
N = Number of trials * Formulated product

Table 3 : Selectivity of Bentazon + MCPA in Comparison to Bentazon in rice (Post-emergence)

Variable	Evaluation †	N	Method of assessment ††	Bentazon 4.0 l/ha*	Bentazon + MCPA 3.0 l/ha*	4.0 l/ha*
Crop Injury	1.	30	U	0 (0)	0 (0)	0 (0)
	2.	28	U	0 (0)	0 (0)	0 (0)
	3.	28	U	0 (0)	0 (0)	0 (0)
Crop Injury	1.	6	P	0 (0)	0 (0)	0 (0)
	2.	6	P	0 (0)	0 (0)	0 (0)
	3.	6	P	0 (0)	0 (0)	0 (0)

( ) = Standard Deviation
† 1st Evaluation : 1-2 weeks after treatment
2nd Evaluation : 3-4 weeks after treatment
3rd Evaluation : 5-6 weeks after treatment

†† P = Percent/No crop injury
U = Scale 0-10/No crop injury
* Formulated product

individual weeds is listd in Table 2. This mixture is notable for its broad spectrum of activity in rice. As can be seen in Fig. 1, early elimination of weed competition is responsible for considerable increases in yield compared to untreated fields.

Bentazon+MCPA: The combination of Bentazon+MCPA is ready-formulated with 400 g Bentazon and 60 g MCPA per litre of product and is used postemergence at a rate of 3-4 l/ha product. The selectivity of the mixture is good in transplanted and direct-sown rice. The results are given in Table 3.

Compared to Bentazon alone, the combination Bentazon+MCPA has a somewhat broader spectrum of activity; efficacy especially against weeds in advanced stages of growth is distinctly improved. Particularly notable is the good control of *Cyperus difformis, Cyperus serotinus, Monochoria, vaginalis, Rotala indica, Sagittaria pygmaea* and *sagittaria sagittifolia.*

The herbicidal activity of Bentazon+MCPA compared to bentazon is given in Table 4.

The marked superiority of this combination to bentazon with respect to *Cyperus difformis* can be seen in Fig. 2 (cumulated frequencies of activities). This difference was especially great when the *Cyperus difformis* was more advanced at the time of the application and weather conditions were less favourable.

Bentazon+Dicamba – is ready-formulated with 480 g Bentazon and 48 g Dicamba per liter and is applied postemergence at a rate of 1.0-1.5 l/ha.

The mixture of Bentazon+Dicamba has good selectivity in direct-sown rice and may be applied beginning at the 3 to 4 leaf stage of the rice plants. The tips of the leaves may turn slightly yellow after treatment, but this has no adverse influence on the further development of the rice plants.

The advantage of Bentazon+Dicamba over Bentazon is that especially leguminous weeds like *Cassia tora, Sesbania exaltata, Desmodium tortuosum, Euphorbia, Ipomoea* and *Solanum* species are controlled. *Cyperaceæ* are satisfactorily controlled by this combination.

CONCLUSION

Bentazon has good selectivity in rice and at a rate of 3.0-4.0 l/ha gives good control of important rice weeds such as *Alisma plantago aquatica, Ammannia coccinea, Commelina cummunis, Cyperus spp., Monochoria vaginalis* and *Scirpus maritimus.*

Bentazon+Dicamba at a rate of 8.0-10.0 l/ha is effective against *Cyperus difformis, Monochoria vaginalis, Scirpus juncoides* and *Scirpus maritimus,* as well as against *Echinochloa crus-galli.*

Bentazon in combination with a small proportion of MCPA confirmed the good selectivity of Bentazon in rice at 3.0-4.0 l/ha. This combination is especially effective against *Cyperus serotinus, Sagittaria pygmæa, Sagittaria sagittifolia* and *cyperus difformis* in advanced stages of growth.

Bentazon+Dicamba at 1.0-1.5 l/ha offered good control of leguminous weeds like *Cassia tora, Desmodium tortuosum* and *Sesbania exaltata,* that are insufficiently controlled by bentazon alone.

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DIRECT CONTACT APPLICATION OF HERBICIDES: PRACTICALITY FOR SMALL FARM WEED CONTROL

A. E. DEUTSCH, L. C. BURRILL, F. FRASER and A. S. COOPER
International Plant Protection Center, Oregon State University, Corvallis
Oregon 97331, USA.

ABSTRACT

Development of an effective new, translocating, foliar-applied herbicide, and a genre of relatively simple, low-cost herbicide "wipers" has created interest in direct contact application (DCA) of herbicides. DCA, particularly with hand-held equipment, holds potential for improving food production through increased safe herbicide use and improved weed control on small plot farms, due to favourable economics.

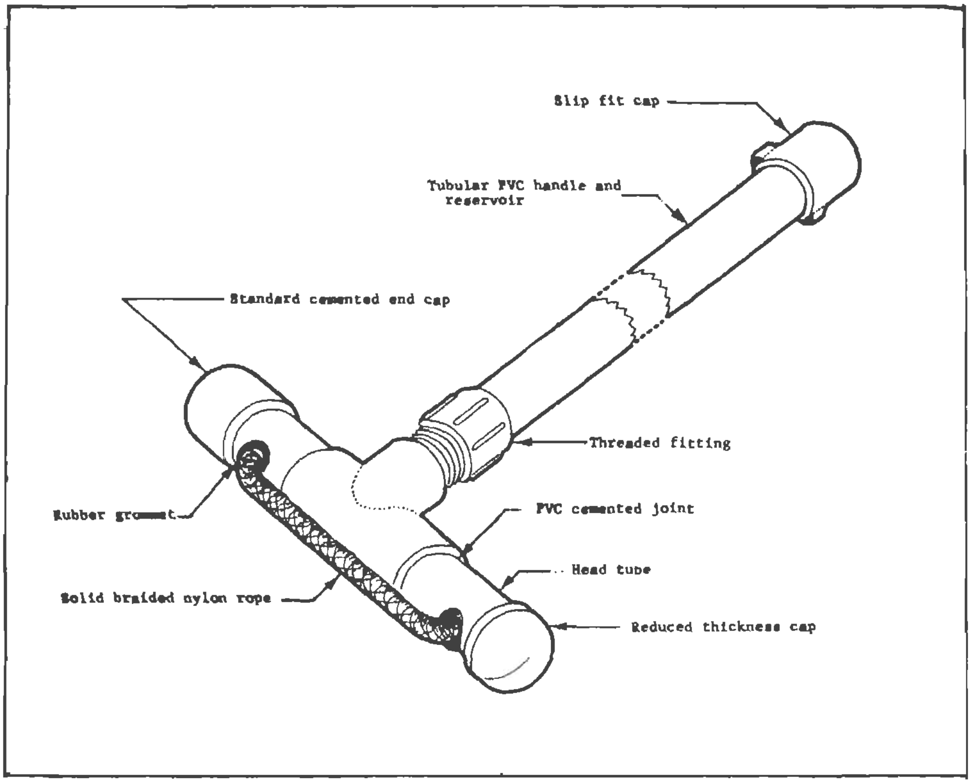
INTRODUCTION

Herbicides, for several basic reasons, enjoy a well entrenched position in advanced technology agriculture. Effectiveness, efficiency and economics broadly characterize the advantages of including chemical weed control methods, often in concert with cultural and physical methods, in crop protection programs.

The opposite case prevails in small plot, traditional technology agriculture. While weeds are no less a problem-frequently they are a devastatingly serious one-control procedures based on herbicides are rare. Attempts to encourage increased herbicide usage have encountered obstacles: (1) application equipment is too expensive, (2) chemicals are too expensive, (3) water may not be available at or nearby the application site, (4) spray equipment needs to be carefully calibrated, (5) risks develop for non-target plants, (6) over-, or under-application may occur, with negative results, (7) specific herbicides needed may not be available, and (8) spray application equipment, to be effective, requires maintenance and spares. However, development of both a new herbicide and an effective method of applying the same and other compounds, may address some of these problems and increase the advantageous usage of herbicides on small farms.

The concept of direct contact application (DCA), the act of wiping, rubbing, or smearing herbicide onto plant surfaces, has experienced a resurgence of interest spurred by the arrival of glyphosate, marketed as the isopropylamine salt of N-(Phosphonomethyl) glycine, an impressively effective translocating, foliar-applied herbicide, and the development of equipment specifically designed for DCA.

Dale (1979*a*, 1979*b*, 1980) at the U.S. Department of Agriculture's Southern Weed Science Laboratory, pioneered in this behalf in the 1970's by combining modern materials to create a DCA technique based on capillary action. A horizontal hollow boom, usually a section of plastic pipe capped at both ends though according to Dale other materials may serve equally well, receives short, horizontally strung, overlapping sections of braided rope. The rope ends pass through grommets, which secure them, and ter-



minate inside the boom, which also functions as a liquid storage reservoir. Capillary action saturates the rope segments. Bringing the saturated ropes, or wicks, into contact with an object causes transfer and application of herbicides.

Following development of the original "Stoneville Wiper" by Dale and publication of encouraging test results (Dale, 1979*a*), a trickle of devices swelled to a steady flow, all based on the DCA concept, but varying in design. Ropewicks, pressurized ropewicks, carpetwicks, bunched small diameter ropes (mops), pads, rolls, and numerous combinations have all appeared. Many firms offer models designed for vehicle mounting and wide swath or multi-row treatment. Additionally, 15 U.S. firms currently offer hand-held DCA units and four market wheel-mounted, operator-pushed machines (International Plant Protection Center, 1980).

Since the herbicide most often used in DCA is non-selective, there must be a space, or height differential, between crop plant and weed to avoid misapplication and injury to the crops. The space can be either horizontal or vertical to the ground surface, depending on specific crop, cropping pattern, and weed flora present. An equipment specialist for the manufacture of glyphosate recommends that weeds should be 15 cm higher than the crop to allow for a safety margin between applicator and crop (Agrichemical Age, 1981).

The DCA approach was quickly

adopted by growers in many regions of the U.S., and continues to gain acceptance in North America and Europe. Advantages have been cited as: (1) Eliminates spray drift hazard, (2) Applicators are relatively simple and easy to maintain, (3) Applicator costs are much lower than spray equipment, (4) DCA can take place when the ground is too wet to allow other weed control practices, (5) Calibration isn't needed, (6) Water requirements (to prepare solution) are dramatically reduced and (7) Energy requirements are lower compared to spraying.

The advantages of DCA prompted investigation of its applicability to small farm situations. Fullerton *et al.* (1981) found that "wiping on" a 2% solution of 2, 4-D [(2, 4-dichlorophenoxy) acetic acid] inhibited growth of *Ipomoea spp.*, and permitted more intensive hand-cutting of weeds in rows of soybeans on plots in Amazonian Peru. Glyphosate, while more expensive than 2, 4-D, was very effective also. "Wiped on " in narrow strips prior to soybean seeding, it reduced by more than half the number of man-days required for *Cyperus rotundus* control.

Potential for improved weed control also led another group to consider hand-held devices for DCA (Cooper *et al.* 1981). Prototype ropewick (Fig. 1) and carpet units were constructed and tested. Results revealed both advantages and problems.

Among benefits attributable to DCA, Cooper *et al.* (1981) noted that greater speed and ease of operation than hand-weeding, potential for farmer to be able to plant increased area (and avoid being constrained to solely the cropping area that could be handweeded), freedom from concern about walking speeds as contrasted to knapsack spraying operations, ability to treat areas inaccessible to other types of cultivation or herbicide application equipment, possibility of effectively controlling weeds that are difficult or impossible to handweed due to hard-to-reach propagating organs and/or a thorny, bristly, or barded nature, reduced volume of herbicide required due to treating only targeted plants, and potential for local fabrication of most parts, plus assembly.

DCA need not be limited to glyphosate. As mentioned, 2, 4-D has been used with favourable results (Fullerton, *et al.* 1981). Two recent papers (Peters and McKelvey, 1981; Lym and Messersmith, 1981) report that picloram (4-amino-3, 5, 6-trichloropicolinic acid), dicamba (3, 6-dichloro-o-anisic acid), and 2, 4-D, as well as glyphosate, when applied by rope-wick, demonstrated activity against certain perennial broadleaf weeds.

In the Philippines, investigators applied a 4 to 1 mixture of water and paraquat (di-chloride salt of 1, 1'-dimethyl-4, 4'-bipyridinium ion) to weeds growing between rows of 35-days old maize using a hand-held DCA device (carpetwick). While the experimental results were favourable in terms of control achieved, the practice could not be recommended due to the hazard associated with high concentrations of paraquat.

Utilizing DCA equipment based on a crop-weed height differential necessitates delaying application until weeds rise above the crop canopy. This may not be possible if a particularly heavy weed infestation inferferes with crop growth (Vincent, 1981). Tall weeds also have been competing with the crop for an extended period and may have suppressed crop yield by the time of DCA.

An informal survey of problems with DCA devices reported by others revealed several points: excess flow of herbicides, resulting in dripping; overly slow or insufficient flow, especially when treating dense weed stands; uneven flow, or wicking action, when operating on sloping ground (a condition predominantly associated with larger, multirow machines that utilize the boom as the only reservoir); awkward filling due to small diameter filling ports; contact element (rope, carpet and sponge) becoming caked with mud or plant debris thereby reducing herbicide transfer; and, difficulty in moving a handpushed unit over a rough seedbed.

Another problem developed when researchers applied glyphosate to low-growing weeds between rows of young beans using a DCA ropewick. Control levels achieved were satisfactory, but insufficient horizontal space caused herbicide to either be spattered onto crop plants, or transferred when weeds bent over during application straightened up and touched the crop plants. Injury resulted.

A continuous development process currently focuses on DCA devices, primarily-but not exclusively–the larger, tractor-mounted breed. The problem of uneven solution flow to the contact surface has been solved, in several cases, by applying air pressure to the solution reservoir to enhance wicking action. A more sophisticated ropewick machine introduces air pressure to the upper of a double horizontal tube pair and vacuum to the lower tube, recycling the evacuated solution and achieving steady, dripless flow (Farm Show, 1981).

Carpetwiper units are being improved by interposing layers of different material to gain better diffusion and more even saturation. Experience has shown that carpetwick units, whether powered roll or static surface, function most efficiently when front-mounted so as to make initial contact with weeds before the axle of the tractor bends them over. A powered roller unit developed in the U.K. employs two feed rolls to meter a gel of glyphosate mixed with a thickening agent on to a metal application roller.

The configuration of ropes in ropewick units varies including: the "traditional" horizontally strung and overlapping; a series of "V"s with slight overlap; horizontal rows angled against the direction of travel; and vertical, angled rows.

Rope technology, too, has advanced. Pioneering units constructed with either cotton or solid braided nylon rope (Dale, 1979*a*), or virtually any rope available that displayed wicking capability, have been replaced by rope specifically designed and manufactured for ropewicks. The latter uses a diamond braided polyester outer cover over an acrylic core.

As DCA methods and machinery develop in advanced technology agriculture, their potential advantages appear to increase in traditional technology agriculture. Though no panacea, DCA offers the advantages of low-cost devices that could be constructed locally; greatly reduce threat of harm to the environment or the operator; deliver the advantages of more effective weed control and associated benefits.

Cooper *et al.* (1981) observe that hand-held devices for DCA represent a potentially useful technique for small farm weed control in developing countries. The prospect warrants accelerated investigation and follow up.

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STUDIES ON ECONOMISING NITROGEN FERTILIZATION IN WHEAT THROUGH CHEMICAL WEED CONTROL

K. C. GAUTAM[1] and MAHATIM SINGH[2]

[1] Present Address: Division of Agronomy, Indian Agricultural Research Institute New Delhi.

[2] Department of Agronomy, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, India.

ABSTRACT

Field investigations were carried out for two seasons in *Rabi* 1977-78 and 1978-79 to ascertain the relationship between the use of fertilizer nitrogen and weed control measures in wheat *(Triticum vulgare)* for exploring the possibility of making an economy in nitrogen fertilization by controlling weed growth through the use of herbicides. The study involved the four levels of nitrogen (0, 40, 80 and 120 kg/ha) and pre- and post-emergence application of herbicides compared with manual weeding.

Comparable yields were obtained by controlling weeds from emergence and giving a very little nitrogen (40 kg/ha) or by delaying weed control for about a month and applying a bit higher dose of nitrogen (65 kg/ha) or allowing the weed growth amuck and adding a still higher dose of nitrogen (120 kg/ha). Pre-emergence application of methabenzthiazuron and penoxalin as well as post-emergence application of metoxuron proved economical over manual weeding. None of the herbicides applied either pre- or post-emergence in wheat crop left any toxic residues in the soil to affect adversely the succeeding crop of mung (green gram).

INTRODUCTION

The problem of weed control has assumed very serious nature with the introduction of high yielding dwarf varieties of wheat where application of high doses of fertilizers and frequent irrigations are considered to be essential for achieving high yields. These very factors which are indispensable for increasing yields also promote the rank growth of weeds. Besides causing a considerable reduction in yield, weeds deplete the soil of its fertility, more particularly nitrogen within 4 to 6 weeks of crop sowing. Gautam *et al.* (1974) have reported a loss of 40 kg nitrogen per hectare due to unchecked weed growth.

A great deal of attention has been directed recently towards the nitrogen fertilization of high yielding varieties of wheat as well as effective control of weeds, using newer broad spectrum herbicides for sustaining high production. Studies were initiated to elicit information that would help fill the gap in our present knowledge on the interaction of nitrogen fertilization and weed control to explore the possibility of economising nitrogen dose in wheat.

MATERIAL AND METHODS

Replicated field trials were conducted during winter seasons of 1977-78 and 1978-79 at the Research Farm of the Department of Agronomy, Banaras Hindu University, Varanasi, with wheat cultivar HD 1553 on a sandy loam soil with a pH of 7.1. The treatments comprised four

Table 1 : Dry matter accumulation in weeds (g/m^2), 105 days after sowing, as influenced by interaction of nitrogen levels and weed control treatments.

Weed control treatments	Nitrogen levels									
	N0	N40	N80	N120	Mean	N0	N40	N80	N120	Mean
	1977-78					1978-79				
Weedy check	45.6	54.2	126.1	216.3	110.6	50.3	64.6	133.2	226.6	118.7
Manual weedings	27.2	32.3	66.8	81.5	81.9	30.8	37.9	72.2	88.4	57.4
Methabenzthiazuron	24.6	31.6	61.1	72.2	47.4	25.2	32.5	64.5	78.9	50.3
Nitrofen	41.2	45.3	80.9	111.0	71.1	43.1	51.7	84.7	122.9	75.6
Penoxalin	24.8	31.7	61.7	73.3	47.9	25.9	31.5	65.2	79.2	50.5
Terbutryne	34.2	41.6	74.3	105.5	65.4	41.5	46.7	79.6	115.3	70.7
Metoxuron	36.9	34.1	64.2	75.0	50.1	28.2	34.2	66.8	81.4	52.6
2, 4-D	38.6	42.7	76.9	106.9	67.3	42.9	47.9	81.6	116.9	72.4
Mean	32.7	39.2	76.5	107.5	–	36.0	43.4	80.9	113.7	–
P = 0.05	0,9					1.3				

levels of nitrogen *viz.*, 0, 40, 80 and 120 kg/ha and eight weed control treatments: 1. Weedy check, 2. Manual weeding 3, 4 and 5. Pre-emergence application of methabenzthiazuron 1-(benzothiazol-2-yl)-1, 3-dimethylurea at 1.4 kg ai/ha, penoxalin (N-1-ethylpropyl-3, 4-dimethyl-2, 6-dinitrobenzamine) at 1.5 kg ai/ha and nitrofen (2,4-dichlorophenyl-4-nitrophenyl ether) at 1.0 kg ai/ha, respectively, 6, 7 and 8. Post-emergence application of terbutryne (2-*tert*-butylamino-4-ethylamino-6-methylthio-1,3,5-triazine) at 0.8 kg ai/ha, metoxuron [N'-(3-chloro-4-methoxyphenyl) N, N-dimethylurea] at 1.2 kg ai/ha and 2, 4-D (2, 4-dichlorophenoxy acetic acid) at 0.8 kg ai/ha, respectively. Nitrogen levels were kept in main plots while weed control treatments were placed in sub-plots in split plot design.

RESULTS

1. Effect on Weeds: However, the dry matter of weeds increased significantly with increasing levels of nitrogen (Table 1). The maximum dry matter accumulation in weeds was recorded under the highest dose of nitrogen (120 kg/ha). The increasing nitrogen levels proved instrumental for enhancing the dry matter of total weeds.

Pre-emergence application of methabenzthiazuron and penoxalin reduced significantly the weed population and dry matter accumulation in weeds over the other herbicidal treatments as well as manual weeding. No significant variation existed between methabenzthiazuron and penoxalin. Metoxuran post-emergence application recorded significantly lower dry matter of weeds than terbutryne and 2, 4-D. Nitrofen was the least effective herbicidal treatment. Methabenzthiazuron and penoxalin resulted in bringing about the greatest reduction in dry matter accumulation in weeds at all the four levels of nitrogen in both the years. The next best treatment was metoxuron which effected a significant decrease in dry matter of weeds as compared to manual weeding, nitrofen, terbutryne and 2, 4-D.

All the weed control treatments caused significant reduction in nitrogen removal by weeds as compared to weedy check (Table 2). Methabenzthiazuron was the most effective in arresting nitrogen depletion by weeds. The next best

Table 2 : Depletion of nitrogen by weeds (kg/ha), 105 days after sowing, as affected by interaction of nitrogen levels and weed control treatments.

Weed control treatments	Nitrogen levels									
	N0	N40	N80	N120	Mean	N0	N40	N80	N120	Mean
	1977-78					1978-79				
Weedy check	11.8	14.6	35.6	61.7	30.9	13.7	17.9	38.1	65.1	33.7
Manual weedings	8.8	10.5	18.3	23.8	14.0	8.2	10.2	10.6	24.3	15.5
Methabenzthiazuron	6.2	8.3	16.6	19.9	12.7	6.6	8.6	17.5	21.6	13.6
Nitrofen	10.5	12.1	22.5	32.9	19.5	11.7	14.2	24.3	34.5	21.2
Penoxalin	6.2	8.3	16.8	20.2	12.9	6.7	8.4	17.7	21.7	13.6
Terbutryne	8.6	11.9	20.4	21.1	17.8	11.3	12.6	21.8	31.9	19.4
Metoxuron	8.7	10.9	19.5	23.6	14.0	9.4	10.2	19.3	24.5	15.5
2, 4-D	9.3	11.3	21.2	31.6	18.4	11.5	12.8	22.4	32.3	19.7
Mean	8.3	10.4	21.1	30.1	–	9.6	11.7	22.5	31.7	–
P = 0.05	0.2					0.2				

Table 3 : Grain yield (q/ha) as affected by interaction between nitrogen levels and weed control treatments.

Weed control treatments	Nitrogen levels									
	N0	N40	N80	N120	Mean	N0	N40	N80	N120	Mean
	1977-78					1978-79				
Weedy check	26.2	32.8	45.1	47.2	37.8	19.9	26.6	34.3	35.7	29.2
Manual weedings	32.8	45.1	52.3	55.4	46.4	27.7	35.4	43.1	46.1	38.2
Methabenzthiazuron	33.3	45.6	52.3	55.8	46.7	28.2	35.8	43.6	46.6	38.6
Nitrofen	28.2	35.8	47.2	49.2	40.1	22.0	29.7	36.1	39.9	31.7
Penoxalin	33.3	45.6	52.8	55.1	46.6	28.2	35.8	43.6	46.6	38.6
Terbutryne	30.3	41.5	49.7	52.8	43.6	25.1	32.3	40.5	43.6	35.4
Metoxuron	30.9	43.5	49.3	53.4	45.5	26.6	34.3	42.1	45.1	37.2
2, 4-D	29.7	41.0	49.2	52.3	43.7	24.6	31.7	39.9	43.1	34.9
Mean	30.7	41.5	49.9	52.7	–	25.3	32.7	40.5	43.2	–
P = 0.05	2.0					0.9				

treatment was penoxalin which was significantly superior to rest of the treatments. Significant reduction in nitrogen removal by weeds was caused by methabenzthiazuron and penoxalin as compared to other herbicidal treatments and manual weeding under nitrogen application as well as in no nitrogen control.

2. *Effect on Crop:* All the weed control treatments resulted in a significant increase in grain yield over weedy check. Methabenzthiazuron and penoxalin yielded significantly more than other herbicidal treatments, but no significant variation existed among methabenzthiazuron, penoxalin and manual weeding in any of the years. Application of metoxuron registered significantly more grain yield over nitrofen, terbutryne and 2, 4-D.

Data in Table 3 reveals that under all the nitrogen levels, methabenzthiazuron, penoxalin, manual weeding and metoxuron produced more grain of a significant order over rest of the weed control treatments and weedy check.

DISCUSSION

Pre-emergence application of methabenzthiazuron and penoxalin had a wide spectrum of activity and were found to give an excellent control of weeds. The possible reasons for these results might be (i) the better absorption of these chemical by emerging weed seedlings, (ii) leaching to the greater depth in the soil and (iii) persistency in the soil for greater length of time. Aamisepp (1973) and Himme and Stryckers (1975) obtained similar results.

The dry matter of weeds increased significantly with nitrogen application and this might be due to the fact that weeds usurped greater quantities of soil applied nitrogen resulting in improved growth of weeds and higher dry matter production. Gruzdev and Satarov (1967) obtained similar results and opined that fertilizer enhanced the growth of weeds. McWhorter (1971) observed more vigorous growth of surviving weeds with increased nitrogen levels. Dry matter accumulation in weeds was significantly brought down in methabenzthiazuron and penoxalin treatment under nitrogen application. Depletion of nitrogen by weeds increased with the increasing levels of nitrogen. This might have been due to vigorous growth of weeds resulting in more dry matter production. Similar observations were made by Vengris *et al.* (1963).

The increase in grain yield may be attributed mainly to higher number of productive tillers which was favoured under high supply of nitrogen due to the ability of pre-emergence application of methabenzthiazuron and penoxalin as well as repeated manual weeding in securing weed free condition to the crop in early stage there by allowing the crop to grow uninterruptedly and ultimately leading to enhanced grain production. It is interesting to note that the grain production under post-emergence application of herbicides was significantly lower than pre-emergence application of methabenzthiazuron and penoxalin and repeated manual weedings. This suggest that for the first 28 days the weeds grew profusely and had a considerable competition with the crop for nutrients as a result of which the yields were reduced under these treatments.

CONCLUSION

For efficient utilization of applied nitrogen the weeds should be kept under check either by pre-emergence application of methabenzthiazuron/penoxalin or by manual weedings. There is considerable saving in nitrogen application by effective weed control. The drain of nitrogen through weeds can be considerably arrested by weed control measures. Pre-emergence application of either methabenzthiazuron or penoxalin and post emergence application of metoxuron were found economical over manual weeding.

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PRODUCTION AND NUTRIENT REMOVAL POTENTIALS OF *EICHHORNIA CRASSIPES* IN JAPAN

YOKO OKI, KYOJIRO NAKAGAWA and MARIKO NOGI
Division of Weed Science, Institute for Agricultural and
Biological Sciences, Okayama University, Kurashiki 710, Japan.

ABSTRACT

The purposes of this research were to determine the effect of sewage effluent on the growth of waterhyacinth and to determine how effective waterhyacinth were in removing nitrogen and phosphorus from water.

Waterhyacinth growth was investigated from August through January in three irrigations with different nutrient loading rates. The greatest production of waterhyacinth occurred in the lightly nutrient loaded irrigation where a maximum standing crop of 963 g/m^2 dry weight was obtained, but not in the irrigation with the highest nutrient loading rate due to an anaerobic condition. No significant difference in nitrogen content of the tops in the plants between three irrigations existed, whereas the nitrogen content of the roots varied significantly. Also, plants grown in the irrigation with higher concentration of phosphorus contained higher phosphorus content in both tops and roots. The maximum accumulation of nitrogen (29.23 g/m^2) and phosphorus (6.18 g/m^2) by waterhyacinths was observed in the lightly nutrient loaded irrigation. Therefore it appeared that the increase in accumulation of nitrogen and phosphorus by waterhyacinth was closely related to the increase in standing crop.

From these results it can be concluded that the treatment system employing waterhyacinth for nutrient removal will depend on the maximum biomass production.

INTRODUCTION

Eichhornia crassipes (Mart.) Solms, waterhyacinth, is widely recognized as one of the most troublesome aquatic weeds throughout world. Though most of the earlier studies of this plant were directed toward eradication, in recent years considerable study has indicated that this plant has many actual or potential uses as compost, feed for livestock, human food, energy and nutrient removal agent (Boyd, 1974). Especially the use of this plant as nutrient removal agent is not a new concept, Boyd (1976) and others (Rogers and Davis, 1972; Knipling *et al.* 1970) have reported nutrient removal potentials and the high growth rates.

In Japan since its introduction as ornamental in the 1890s, *E. crassipes* has spread rapidly and created a considerable problem today (Ueki *et al.* 1976). At present, extensive attention has been directed toward the development of practical utilization of this plant as well as control. However, little has yet appeared in the literature on its utilization.

The purposes of this research were to determine the effect of sewage effluent on the growth of *E. crassipes* and to determine absorption of nitrogen and phosphorus by *E. crassipes* population.

MATERIAL AND METHODS

Square timber was used to construct 1.5m by 1.5m frames which allowed to float in three irrigations (called location A, B and C) in Okayama prefecture. Two plants were placed in each enclosure in location B and C on August 13, in location A on September 6, and allowed to grow by January 29, 1980.

Surface water samples were collected during investigation and analyzed for ammonium nitrogen, inorganic phosphate, $KMnO_4$ consumption, electric conductivity, dissolved oxygen and water temperature. From water analyses it was found that the average nutrient loading rates was highest in location B due to the inflow of the thermal effluent, and that water quality in location A was similar to those in location C.

Space for continual growth was provided by removing one third of the plants from each enclosure every two to four weeks after enclosures were packed with plants. At harvest the plants were removed from the enclosure, counted and fresh weight determined. The sample was divided into tops and roots, dried at 80° C and weighed. Nitrogen content of plant material was determined by the salicylic acid modification of the micro-Kjeldahl technique. Also phosphorus content was determined by the molybdate method with ascorbic acid.

RESULTS

Full coverage of enclosures (2.25m^2) were attained in approximately 35 days in location B, 45 days in location C and 50 days in location A. The seasonal standing crop as dry weight of *E. crassipes* after the enclosures were packed with plants are shown in Fig. 1. The greatest production of *E. crassipes* appeared to be in location C where a maximum standing crop of 963.24 g dry wt./m^2 was attained on November 16. The second highest standing crop appeared to be in location B where *E. crassipes* population had a significantly larger percentage of tops than those of the other two locations ($P < 0.01$). This difference was reflected in the dry top-to-root ratio.

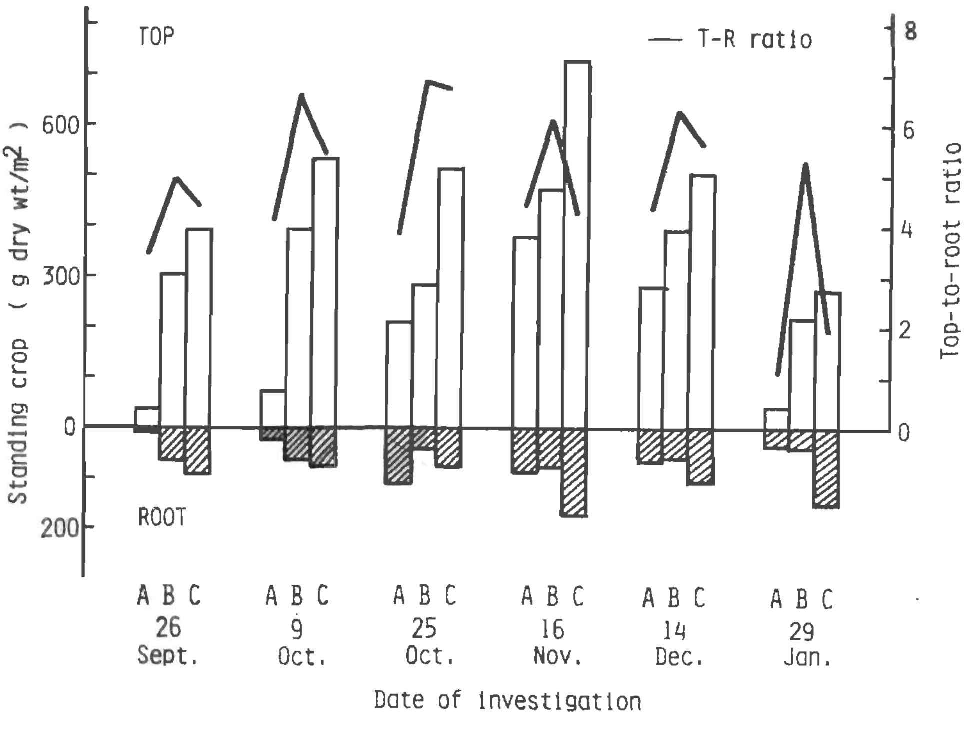

Table 1 : Content of nitrogen (% dry weight) in *E. crassipes* grown in three locations.

Part	Location	Date						Average
		Sept. 26	Oct. 9	Oct. 25	Nov. 16	Dec. 14	Jan. 29	
Top	A	4.00 a	4.84 a	4.91 a	4.05 a	3.95 a	2.22 a	4.00 ±0.97%a
	B	3.89 b	3.64 b	3.62 b	3.76 ab	3.67 a	4.22 b	3.80 ±0.23 a
	C	3.56 c	3.76 b	3.74 b	3.59 b	3.31 a	2.88 b	3.47 ±0.33 a
	Average	3.82 ±0.23	4.08 ±0.66	4.09 ±0.71	3.80 ±0.23	3.64 ±0.32	3.11 ±1.02	
Root	A	2.63 a	2.44 a	2.50 a	2.12 a	2.25 a	3.49 a	2.57 ±0.49 a
	B	3.74 b	3.79 b	3.11 a	2.68 a	3.12 a	4.38 a	3.47 ±0.61 a
	C	2.00 c	1.83 a	1.66 b	1.83 a	2.47 a	2.20 c	2.00 ±0.30 c
	Average	2.79 ±0.88	2.69 ±1.00	2.42 ±0.73	2.21 ±0.43	2.61 ±0.45	2.00 ±0.30	

Values having the same letter in each column are not significantly different at the 5% level by Duncan's Multiple Range Test.

The content of nitrogen of the dried *E. crassipes* samples are presented in Table 1. No significant difference in nitrogen content of the tops between three locations nor seasons existed, whereas the nitrogen content of the roots varied significantly by seasons ($P < 0.05$) and by locations ($P < 0.001$). Only tops of *E. crassipes* collected from location C were found to contain higher nitrogen significantly than roots.

Also the content of phosphorus in dried plants are shown in Table 2. Plants, grown in location B with higher concentration of phosphorus contained higher phosphorus content in both tops ($P < 0.05$) and roots ($P < 0.001$). Especially the phosphorus content in roots of plants

Table 2 : Content of phosphorus (% dry weight) in *E. crassipes* grown in three locations.

Date	Top			
	A	B	C	Average
Sept. 26	0.363 a	0.680 a	0.664 a	0.569 ±0.179 a(%)
Oct. 9	0.727 b	0.850 b	0.771 b	0.783 ±0.062 bc
25	0.768 b	0.916 bc	0.874 c	0.853 ±0.076 bc
Nov. 16	0.964 c	0.988 c	0.744 b	0.899 ±0.134 c
Dec. 14	0.822 b	0.919 bc	0.760 b	0.834 ±0.080 bc
Jan. 29	0.576 a	0.859 b	0.674 a	0.703 ±0.144 ab
Average	0.703 ±0.209	0.869 ±0.105	0.748 ±0.076	
	Root			
Sept. 26	0.216 a	0.559 a	0.308 a	0.361 ±0.178 a (%)
Oct. 9	0.330 b	0.849 b	0.418 b	0.532 ±0.278 ab
25	0.368 b	0.746 b	0.446 b	0.520 ±0.200 ab
Nov. 16	0.440 c	0.928 cd	0.452 b	0.607 ±0.278 b
Dec. 14	0.613 d	0.975 d	0.463 b	0.684 ±0.026 b
Jan. 29	1.076 e	1.085 e	0.754 c	0.973 ±0.189 c
Average	0.507 ±0.308	0.857 ±0.186	0.474 ±0.149	

Values having the same letter in each column are not significantly different at the 5% level by Duncan's Multiple Range Test.

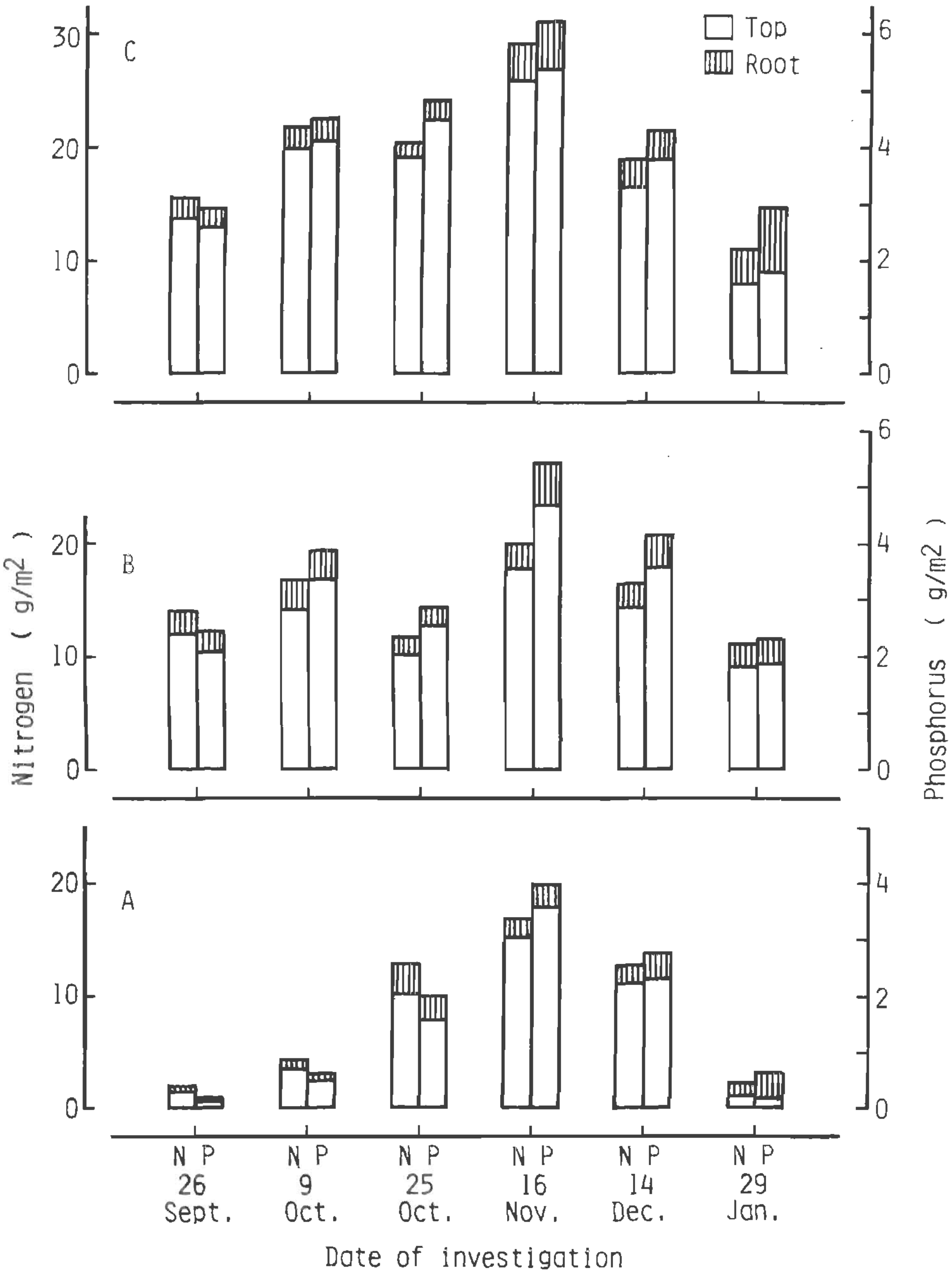
C
B
A
Top
Root
Nitrogen (g/m2)
Phosphorus (g/m2)
0
10
20
30
0
2
4
6
N P
26 Sept.
9 Oct.
25 Oct.
16 Nov.
14 Dec.
29 Jan.
Date of investigation

Table 3 : Correlation coefficients (r) between accumulation of nitrogen and phosphorus by *E. crassipes* populations and standing crop, content in dried plants, respectively.

		Accumulation by populations (g/m^2)					
		Nitrogen			Phosphorus		
		A	B	C	A	B	C
Standing crop	Top	0.918**	0.993**	0.953**	0.953**	0.955**	0.948**
(Dry weight g/m^2)	Root	0.924**	0.682	0.889**	0.780	0.703	0.871*
	Whole plant	0.896***	0.968***	0.962***	0.860***	0.969***	0.944***
Content in dried plants	Top	0.611	-0.542	0.838*	0.954**	0.697	0.707
	Root	-0.110	0.194	-0.015	0.595	0.614	0.859*
(%) plant	Whole 0.698	0.373	0.766*	0.898***	0.236	0.919***	

*, **, *** significant difference at 5%, 1% and 0.1% level, respectively.

collected from location B increased in winter ($P < 0.001$).

The nitrogen and phosphorus accumulated in *E. crassipes* populations are presented in Fig. 2. The maximum accumulation of nitrogen and phosphorus was 29.23 g/m^2 and 6.18 g/m^2, respectively, in location C on November 16. The second highest accumulation was recorded in location B on the same date. From these data it was obvious that the nitrogen and phosphorus accumulated in *E. crassipes* population indicated the same trends toward the increase and decrease of standing crop as dry matter.

Then it was attempted to correlate the accumulation of nitrogen and phosphorus by *E. crassipes* populations with the standing crop and the content in dried plants (Table 3). All correlation coefficients between the accumulation of nitrogen and the standing crop were highly significant, except those in roots of plant grown in location B. The accumulation of nitrogen was not much related to the content in dried plants. Correlation coefficients in phosphorus were similar to those in nitrogen. Therefore it appeared that the increase in accumulation of nitrogen and phosphorus by *E. crassipes* was closely related to the increase in standing crop.

DISCUSSION

In this study, the greatest production of *E. crassipes* occurred in the lightly nutrient loaded irrigation, but not in the irrigation with the highest nutrient loading rate due to an anærobic condition or growth inhibitors contained in sewage effluent. Boyd and Vickers (1971) also reported that no significant linear correlations between concentrations of macronutrients in the water and in *E. crassipes* biomass.

E. crassipes produces large standing crop in many tropical and subtropical areas. The maximum biomass value obtained in this study was 0.963 kg dry wt./m^2 in November. This value is lower than the value which was obtained by Penfound and Earle (1948) and Knipling *et al.* (1970). The low biomass in this study seems primarily due to too late start of the investigation. In Japan this plant starts to grow around May and ceases its growth in December by low temperature.

On the other hand, Parra and Hortenstine (1974) stated that nutrient content of *E. crassipes* varied with location, season of the year, and water quality. The present data revealed the same trends, especially in the phosphorus content in dried plants. Also it was obvious that the increase in accumulation of nitrogen and phosphorus by *E. crassipes* was more closely related to the increase in standing crop than those in tissue level.

From these results it can be concluded that the treatment system employing *E. crassipes* for nutrient removal will depend on the maximum biomass production. A more practical approach would be required to suggest a schedule of harvests that would take advantage of the maximum biomass production.

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STUDY ON ECONOMICAL WEED MANAGEMENT PROGRAMME IN YOUNG AND PRUNED TEA WITH OXYFLUORFEN

M. S. GHOSH and L. RAMAKRISHNAN
Indofil Chemicals Limited, Nirlon House, Bombay, India.

ABSTRACT

A detailed study has been undertaken to find out the weed management programme at economical level with the help of oxyfluorfen developed Rohm and Haas Company as "GOAL, E. C." in very young, young and pruned tea.

Oxyfluorfen was used at 0-0.125 kg ai/ha and 0.250 kg ai/ha as pre-emergence spray applied after cheeling during the month of May in 0 to 1 year and 1 to 3 years planted young tea and 3 to 5 years planted pruned tea at five different agro-climatic zones in North-East India at Terrai, Dooars, Tezpur, Jorhat and Dibrugarh – Doom Dooma regions. The first pre-emergence spray of oxyfluorfen was followed by a second spray of oxyfluorfen (0.060 kg ai/ha) in combination with paraquat (0.24 kg ai/ha) or 2, 4-D (0.80 kg ai/ha) when the regeneration of weeds attend 15-20% ground coverage kept, all the problematic weeds under control throughout the season.

The total cost of weed management and its percentage of control of weeds using oxyfluorfen along with later cocktail spray of it with paraquat or 2, 4-D were compared with the common garden practices. The results very clearly showed that using oxyfluorfen as the key chemical gave better weed management at a comparatively less cost in tea.

INTRODUCTION

Weeds are a serious problem in tea just as much as in other crops. Considerable reduction in yield would occur when the active growth of the weeds during the peak season (May to September) are left unchecked. Chemical weed control is being practised in tea plantations for more than a decade with obvious success. The choice of chemical in weed control is of particular significance in achieving adequate weed control at economical levels. Herbicide cocktails are in use today to combat different kinds of weeds. A good weed control programme in a plantation crop like tea should be able to provide a season-long adequate weed management at a reasonable cost without getting into soil erosion problems.

The following weeds have been found to be of considerable importance in Tea. Among the monocotyledons – *Imperata cylindrica* Beauv. *Paspalum conjugatum* Berg., *Arundinella bengalensis, Saccharum spontaneum* L. and *Setaria palmifolia* T. and among the broad-leaved weeds, *Borreria hispida* (K) Sch. and *Mikania macrantha* are considered as problematic. *I. cylindrica* or 'thatch' is considered to be a serious problem for young teas, particularly those planted in 'thatch-baris'.

MATERIAL AND METHODS

A detailed study was undertaken to find out an efficient weed management programme at economical cost with the help of the herbicide, oxyfluorfen-2-chloro-1-(3-ethoxy-4-nitrophenoxy) -4-(trifluor- methyl) benzene known as "GOAL" and with combinations of oxyfluorfen with paraquat or 2, 4-D in very young tea (zero to one year), young (one to three years) and pruned tea. The economics vs. efficacy of this practice was studied in comparison with the common tea garden weed control practices.

Different tea gardens were selected for conducting weed control experiments in different agro-climatic regions of North-east India.

Tea areas at different stages of growth (0-1 year, 1-3 years and pruned tea more than 3 years' old) were selected from various gardens selected for the trials. Individuals plot sizes were 10 m x 10 m^2. The treatments were replicated thrice in randomized block design. Aspee Bakpak sprayers were used with WFN 62 or WFN 40 nozzle as was necessary.

The plots were periodically visited for assessment of weed control/weed regeneration and the weed control results with oxyfluorfen are expressed as percentage weed control obtained over that of standard tea gardens weed control practices adopted in that particular tea estate.

RESULTS

The results presented in Tables 1-3 represent the percentage gain in the control of different species of weeds over the control (the standard tea garden practice) at different dates of observation. This also includes a cost analysis per hectare with reference to different weed control practices.

Oxyfluorfen at 0.125 to 0.25 kg ai/ha as pre-emergent soon after planting /cheeling, gave effective control of *Borreria hispida, I. cylindrica, Paspalum conjugatum, Ageratum conyzoides, Oxalis spp.*, etc., for at least 40 days after application in newly planted tea (0-1 year). When this was followed by oxy-fluorfen (0.06 kg ai/ha) plus paraquat (0.24 kg ai/ha) and one more application of paraquat alone 75 to 100%, better weed control performance than the standard weed control practices was obtained, for up to 150 days. The standard garden practices included, 8 rounds of paraquat (1.5 kg ai/ha) or 2 handweedings and 6 rounds of paraquat (1.5 kg ai/ha) or simazine (4.0 kg ai/ha) plus 2 handweedings plus 3 rounds of paraquat or 8 cheelings and 6 handweedings or 7 or 8 rounds of paraquat and 1 hœing, or simazine 4.0 kg ai/ha plus 2 rounds of paraquat plus 1 handweeding plus 2 rounds of paraquat.

It was also observed from these trials that weeds other than those listed above such as *Commelina bengalensis, Oplismenus compositus, Euphorbia hirta, Portulaca oleracea* and *Digitaria sanguinalis* were also controlled wherever these weeds were present.

The economics of weed control with different treatments is outlined in Table 1. Treatments using oxyfluorfen as the primary herbicide in different tea gardens under trial provided adequate weed control at cost/ha varying from Rs. 392/ha to Rs. 672/ha, compared to the standard garden practice weed control treatments varying from Rs. 1,078/ha to Rs. 2,500/ha.

Similar weed control experiments were conducted in young tea (1 year to 3 years). Oxyfluorfen applied at rates of 0.125 kg ai/ha to 0.25 kg ai/ha soon after cheeling and followed where necessary by sequential applications of oxyfluorfen 0.06 kg ai/ha or 0.125 kg ai/ha plus paraquat 0.24 kg ai/ha or spot application of paraquat alone, provided excellent control of weeds such as *Borreria hispida, Imperata cylindrica, Paspalum conjugatum, Ageratum conyzoides*, etc., for up to 150 days after the first treatment. Oxyfluorfen treatments showed 75% to 100% better weed control than standard garden practice treatments. The standard garden practice weed control treatments included simazine 3.5 kg ai/ha plus 6 hand weedings, or paraquat at 0.24 kg ai/ha in

Table 1: Effect of oxyfluorfen on the control of different weeds in newly planted tea (0-1 year).

Name of Tea Estate	Age of Tea	Treatments kg ai/ha and Cost/ha	Standard garden practice	Days of observation	% control over the standard garden practice					
					*B.H.	I.C.	P.C.	A.C.	Others	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Darrung T. E. (Tezpur)	7 mth.	1. Oxyfluorfen 0.125	8 rounds of Paraquat	40	73.9	73.9	90.8	100		84.1
				80	70.6	95	95	–		85.7
		2. Oxyfluorfen 0.06+ Paraquat 0.24 at 80 days		120	75	93.4	100	–		90.5
		Cost Rs. 393/ha	*Cost:* Rs. 1,088/ha							
Sessa T. E. (Tezpur)	7 mth.	1. Oxyfluorfen 0.125	2 hand weedings and six rounds of Paraquat	40	20.5	100	29	–	100 (E.H.)	40.7
				80	100	–	91.1	–	100 (E.H.) 100 (P.O.)	87.9
		2. Oxyfluorfen 0.06+Paraquat 0.24 at 40 days								
		3. Paraquat 0.24 at 80 days		120	100	–	88.1	–	100 (P.O.) 96 (E.O.)	83.9
		Cost: Rs. 492/ha	*Cost:* Rs. 1,600/ha							
Rupajuli T. E. (Tezpur)	8 mth.	1. Oxyfluorfen 0.125	2 hand weedings and six rounds of Paraquat	40	72.1	100	91.7	42.2	90 (E.H.) 100 (C.S.)	73.8
		2. Oxyfluorfen 0.06+Paraquat 0.24 at 40 days		80	91.2	100	92.7	88.2	–	83.4
				120	78.1	–	78.3	–	–	80.6
		Cost: Rs. 393/ha	*Cost:* Rs. 1,600/ha							
Addabarie T. E. (Tezpur)	5 days	1. Oxyfluorfen 0.125	Simazine 4.0 kg ai/ha + 2 handweedings + 3 rounds Paraquat	40	100	92.8	95.6	100	–	91.5
				80	100	76.7	77.8	–	100	85.5
		2. Oxyfluorfen 0.06+Paraquat 0.24 at 80 days		120	–	94.4	89.2	–	–	92.9
		Cost: Rs. 393/ha	*Cost:* Rs. 1,092/ha							
Kamala T. E. (Terrai)	3 mth.	1. Oxyfluorfen 0.25	8 cheelings and 6 handweedings	40	96.6	81.4	100	100	–	87.2
				80	41.7	50.0	83.3	–	–	58.5
		2. Oxyfluorfen 0.06+Paraquat 0.24 at 80 days		120	100	80.2	–	–	–	89.8
				150	89.9	70.9	–	100	–	82.1
		3. Paraquat 0.24 at 120 days								
		Cost: Rs. 672/ha	*Cost:* Rs. 2,500/ha							
Taipoo T. E. (Terrai)	8 mth	1. Oxyfluorfen 0.25	7 rounds of Paraquat and one hoeing	40	53.6	100.0	49.4	78.4	–	51.8
				80	67.4	100.0	58.2	100.0	–	75.0
		2. Paraquat 0.24 at 40 days		120	84.9	87.5	88.1.	100.0	–	86.0
		Cost: Rs. 500/ha	*Cost:* Rs. 1,350/ha							

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Addabarie T. E. (Tezpur)	7 mth.	1. Oxyfluorfen 0.25 2. One hand weeding at 40 days 3. Paraquat (Spot application) at 80 days) *Cost:* Rs. 552/ha	Simazine 4.0 kg ai/ha plus 2 rounds of Paraquat plus 1 handweeding plus 2 rounds of Paraquat *Cost:* Rs. 1,078/ha	40	54	93	–	–	–	72.8
				80	47	100	–	–	–	82.3
				120	90.6	100	100	–	–	98.2
Gangaram T. E. (Terrai)	9 mth.	1. Oxyfluorfen 0.25 2. Paraquat 0.24 at 80 days 3. Paraquat 0.24 at 120 days *Cost:* Rs. 500/ha	8 rounds of Paraquat and 1 hœing *Cost:* Rs. 1,350/ha	40	100	81.4	100	100	–	90.4
				80	15.6	71.4	100	100	–	61.3
				120	61	94.6	100	–	–	87.3
				150	86.8	90.2	–	–	–	92.2

BH – *Borreria hispida,* OX – *Oxalis spp.,* DS – *Digitaria sanguinalis,* IC – *Imperata cylindrica,* SP – *Setaria palmifolia,* PO – *Portulaca oleracea,* PC – *Paspalum conjugatum* CB – *Commelina bengalensis* EH – *Euphorbia hirta,* AC – *Ageratum Conyzoides gatum,* OC – *Oplismenus compositus.*

6 rounds and 1 application of glyphosate, or 4-13 rounds of paraquat (Table 2).

The economics of weed control treatments were again in favour of oxyfluorfen based treatments where the cost/ha varied from as low as Rs. 204/ha to Rs. 672/ha, while in the standard garden practice treatment, the costs were from Rs. 572/ha to Rs. 1,768/ha. (Table 2).

Table 3 illustrates that initial application of Oxyfluorfen at 0.125 kg ai/ha to 0.25 kg ai/ha in pruned tea (more than 3 years' old) as pre-emergence soon after cheeling and followed by sequential applications of oxyfluorfen + paraquat combination or spot application of paraquat can provide better weed control (80% – 100%), than the currently practised tea garden weed control practice. The standard garden practice in this case, included 6 – 8 rounds of Paraquat or 1 application of glyphosate + 1 application of paraquat +2, 4-D and one application of paraquat or 1 round of diuron (1 kg/ha) plus 4 rounds of paraquat plus one hœing.

While the cost of oxyfluorfen treatments varied from Rs. 303/ha to Rs. 672/ha, the costs incurred by the standard tea garden practices were between Rs. 600/ha to Rs. 1088/ha. (Table 3).

DISCUSSION

The results indicate that oxyfluorfen can be very effective as a pre-emergence herbicide and proves to be an effective tool for good weed control management for tea at economic cost. Particularly interesting is the use of this chemical in young tea management where weeding is critical and important to the healthy growth of the tea bushes. Application of oxyfluorfen even in newly planted tea did not produce any deleterious effect on its growth. The key to the success of using oxyfluorfen for tea weed control seems to be its excellent pre-emergent activity, particularly when applied to cheeled, clean surface. Its long residual activity is probably related to its persistence in soil;

Table 2: Effect of Oxyfluorfen on the control of different weeds in young tea (1-3 years).

Name of Tea Estate	Age of Tea	Treatments kg ai/ha and Cost/ha	Standard garden practice	Days of observation	% control over the standard garden practice					
					*B.H.	I.C.	P.C.	A.C.	Others	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Bagatpur T. E.	1 yr.	1. Oxyfluorfen	Simazine 3.5	40	95.8	100.0	93.9	100.0	–	96.7
(Dooars)	8 mth.	0.125	kg/ha plus 6	80	94.4	100.0	52.9	94.1	–	93.2
			handweedings	120	95.2	–	100.0	94.3	–	99.6
		Cost:	*Cost:*							
		Rs. 204/ha	Rs. 1,284/ha	150	90.0	–	78.3	100.0	100.0 (OX)	98.7
Mohanbarie T. E.	2 yrs.	1. Oxyfluorfen	1 application of	40	75.0	100.0	70.0	79.2	82.9 (CB)	69.4
(Upper Assam)	4 mth.	0.125	glyphosate and	80	94.8	100.0	100.0	75.5	100.0 (CB)	89.4
			6 application of						100 (EH)	
		2. Oxyfluorfen	Paraquat	120	80.0	100.0	97.1	93.1	–	83.2
		0.06 + Paraquat	Paraquat	150	72.0	100.00	–	100.0	–	79.7
		0.24 at 40 days								
		3. Paraquat 0.24								
		at 120 days								
		Cost:	*Cost:*							
		Rs. 492/ha	Rs. 1516/ha							
Sealkotte T. E.	2 yrs.	1. Oxyfluorfen	6 rounds of	40	85.5	100.0	–	84.0	100 (OX)	92.7
(Upper Assam)	4 mth	0.25	Paraquat	80	87.5	88.0	97.9	96.3	–	92.3
		2. Paraquat 0.24								
		at 80 days		120	93.3		91.9	97.7	89.1 OX)	90.3
		Cost:	*Cost:*							
		Rs. 402/ha	Rs. 816/ha							
Honwal T. E.	2 yrs.	1. Oxyfluorfen	4 rounds of	40	93.8	100.0	98.6	77.8	87.5 (DS)	96.2
(Jorhat)	5 mth.	0.25	Paraquat and	80	94.4	100.0	100.0	83.3	–	94.4
			1 spot application	120	92.5	100.0	89.8	100.0	–	91.7
			of Paraquat	150	93.0	–	100.0	–	71.8 (OK)	87.9
		Cost:	*Cost:*							
		Rs. 384 ha	Rs. 572/ha							
Melang T. E.	1 yr.	1. Oxyfluorfen	13 rounds of	40	78.2	87.8	95.3	–	–	81.9
(Jorhat)	5 mth.	0.125	Paraquat	80	77.1	100.0	89.0	–	–	78.6
		2. Oxyfluorfen		120	86.9	100.	43.3	80.5	–	63.2
		0.06+Paraquat		150	100.0	85.0	56.6	–	–	64.5
		0.24 at 40 days								
		3. Oxyfluorfen								
		0.125+Paraquat								
		0.24 at 120 days								
			Cost:							
			Rs. 1,768/ha							

*BH – *Borreria hispida*, OX – *Oxalis spp.*, DS – *Digitaria sanguinalis*,
IC – *Imperata cylindrica*, SP – *Setaria palmifolia*, PO – *Portulaca oleracea*,
PC – *Paspalum conjugatum*, CB – *Commellina bengalensis*, EH – *Eyphorbia hirta*,
AC: *Ageratnum foligars*, OC – *Oplismenus compositus*. T.E. – Tea Estate

Table 3 : Effect of oxyfluorfen on the control of different weeds in pruned tea (more than 3 years old).

Name of Tea Estate	Age of Tea	Treatments kg ai/ha and Cost/ha	Standard garden practice	Days of observation	% control over the standard garden practice					
					*B.H.	I.C.	P.C.	A.C.	Others	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dessoi T. E.	3 yrs.	1. Oxyfluorfen	8 rounds of							
(Jorhat)	6 mth	0.125	Paraquat	40	58.6	83.9	97.4	75.0	–	85.9
	pru-	2. Oxyfluorfen								
	ned	0.06 + Paraquat		80.0	77.9	80.1	100.0	93.3	–	91.4
	tea	0.24 at 40 days		120.0	86.0	88.0	100.0	93.0	–	93.6
		3. Paraquat 0.24								
		at 80 days		150.0	86.4	94.4	100.0	–	–	91.3
		Cost :	*Cost :*							
		Rs. 492/ha	Rs. 1089/ha							
Dessoi T. E.	3 yrs.	1. Oxyfluorfen	8 rounds of	40.0	28.5	98.3	100.0	88.3	–	85.0
(Jorhat)	6 mth.	0.25	Paraquat	80.0	90.1	96.2	100.0	100.0	–	97.4
	pru-	2. Oxyfluorfen		120.0	88.0	92.0	100.0	100.0	–	95.6
	ned	0.06+Paraquat		150.00	91.5	100.0	100.0	–	–	96.0
	tea	0.24 at 40 days								
		3. Paraquat								
		0.24 at 80 days								
		Cost :	*Cost :*							
		Rs. 672/ha	Rs. 1,088/ha							
Hansara T. E.	4 yrs.	1. Oxyfluorfen	1 appln. of gly-	80.0	79.5	100.0	100.0	–	100 (SP)	78.0
(Upper Assam)	6 mth	0.25	phosate +	120	58.9	84.0	94.7	–	–	73.3
	pru-	2. 2, 4-D 0.8	1 appl. of	150.0	100.0	57.1	100.0	–	44.1 (OX)	83.2
	tea	at 80 days	Paraquat							
		3. 2, 4-D 0.8	2, 4-D & 1							
		at 120 days	appln. of Paraquat							
		Cost :	*Cost :*							
		Rs. 512/ha	Rs. 864/ha							
Hansquo T. E.	4 yrs	1. Oxyfluorfen	Application	40.0	73.2	100.0	100.0	100.0	–	95.7
(Terrai)	7mth	0.125	of Paraquat	80.0	85.1	100.0	78.5	83.9	–	88.3
	pru-	2. Spot appln.	including 2	120.0	91.7	100.0	–	–	–	88.2
	ned	of Paraquat	spot applications	150.0	86.9	100.0	100.0	70.0	100 (OX)	95.3
	tea	at 80 days								
		Cost :	*Cost :*							
		Rs. 303/ha	Rs. 600/ha							
Nahartoli T. E.	5 yrs.	1. Oxyfluorfen	1 application of	40.0	100.0	100.0	98.6	–	100 (CB)	69.9
(Upper Assam)	4 mth	0.125	Diuron (1 kg/	80.0	80.8	–	70.0	–	40 (OC)	70.0
	pru-	2. Oxyfluorfen	ha) and 4 rounds	120.0	89.0	82.0	78.0	–	65 (SP)	81.5
	ned	0.06+Paraquat	of Paraquat							
	tea	0.24 at 40 days								
		3. Paraquat 0.24								
		at 80 days								
		Cost :	*Cost :*							
		Rs. 492/ha	Rs. 868/ha							

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IC – *Imperata cylindrica,* SP – *Setaria palmifolia,* CB – *Commelina bengalensis,*
PO – *Portulaca oleracea,* PC – *Paspelum conjugatum,* OC – *Oplismenus compositus.*
EH – *Euphorbia hirta,* AC – *Ageratum conyzoides,* T.E. – Tea Estate

and being less prone to leaching under high rainfall conditions due to its extremely low solubility in water. Weed control up to 150 days in newly planted tea, young tea and pruned tea, more than 3 years' old, has been obtained generally with 2 to 3 applications of oxyfluorfen/paraquat/2, 4-D combinations. This study reveals that oxyfluorfen based weed control programmes can cut down the application costs of herbicides for weed control in tea. Whereas the standard tea garden weed control practices demand 6 to 12 rounds of chemical application/hand weeding. The oxyfluorfen weed control programme seldom requires more than 3 applications for the period of weed control under study. In this study, no great difference between oxyfluorfen 0.125 kg ai/ha and 0.25 kg ai/ha was observed when the first pre-emergence application was made. While weeds such as *I. cylindrica, Paspalum conjugatum, Ageratum conyzoides* and *Borreria hispida* show suppression of growth/germination for a period of generally more than 40 days after application of chemical, weeds like *Cynodon dactylon, Mimosa pudica,* show tendency to regenerate/germinate earlier than 40 days after application of oxyfluorfen. The cost study for weed control under oxyfluorfen regime and the standard weed control practice followed by tea planters shows that oxyfluorfen based weed control programme can be more effective and economical.

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EFFECTS OF ATRAZINE AND ALACHLOR IN MAIZE-PULSES (PEAS, GRAM AND LENTIL) ROTATION

RAJ SINGH and V. S. MANI
Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110012.

ABSTRACT

Field trials were carried out for three seasons to study the herbicidal, selective and residual toxic effects of atrazine and alachlor in a rotation involving hybrid maize (Ganga-5) in *kharif* (rainy) and pulses (peas, gram and lentil in *rabi* (winter). A pre-emergence application of atrazine at 1, 2 and 4 kg/ha and alachlor at 1, 2 and 4 l/ha was made to maize in each season. After harvest of maize the three pulses were raised in the same herbicide treated plots.

Atrazine and alachlor were found more effective in suppressing dicot and monocot weed species respectively during *kharif* seasons. The highest dose of atrazine (4 kg/ha) resulted in the greatest decrease in the dry matter accumulation and nitrogen depletion by weed growth.

The grain production was stepped up under the two higher doses of alachlor (2 and 4 l/ha) and lowest dose of atrazine (1 kg/ha). The two higher doses of atrazine (2 and 4 kg/ha) left residues in the soil that suppressed the dicot weed population in the next *rabi*. The grain production in *rabi* pulses was unaffected by the herbicides applied to maize continuously for three years.

INTRODUCTION

In a land put to crop rotation, adoption of chemical weed control necessitates consideration of (i) persistency of the herbicides in the soil on account of which a long duration weed control is possible, (ii) the herbicides besides being selective in a particular crop should not leave residues to affect the subsequent crops. Keeping these considerations in mind investigations were carried out for assessing the comparative performance of atrazine and alachlor in terms of weed killing potency and productivity of maize (Hybrid Ganga-5) in *kharif* followed by pulses (peas-T 163; gram C-235 and lentil-L-12) in rabi.

RESULTS

Data on weed and crop attributes during kharif season are presented in Table 1.

Dry matter of Weeds: This was significantly reduced under the weed control treatments as compared to unweeded check. The atrazine 2 kg/ha as well as alachlor 2 l/ha brought down the dry weight of weeds to a level at par with hand-weeding (Hw) in 1975 while in 1976, atrazine 4 kg/ha was at par with hand-weeding and in 1977 both the doses of atrazine (medium and highest) equalled hand-weeding. Alachlor 2 and 4 l/ha were significantly inferior to hand-weeding in checking the dry weight of weeds in 1976 and 77.

Nitrogen depletion by Weeds: This was significantly reduced due to weed control treatments in all the three seasons. The atrazine 4 kg/ha checked the nitrogen depletion as effectively as that resulting from two hand-weedings given at four and eight weeks after planting of maize.

Dry matter of Crop: The dry matter production, which did not differ among all the weed control treatments in all the three years, was significantly superior to unweeded check.

Nitrogen uptake of Crop: In 1975 and 1976, nitrogen uptake at 60 days was significantly more in weed control treatments than unweeded check. In the last season (1977 kharif) nitrogen uptake did not differ statistically among unweeded check, hand-weeding and 2 and 4 kg/ha of atrazine. Atrazine 1 kg/ha and all the three doses of alachlor improved the uptake significantly over unweeded check. The treatments that were superior to hand-weeding were the atrazine 1 kg/ha and alachlor 2 l/ha.

Grain yield of Maize: In all the three seasons, the grain yield was significantly increased in weed control treatments over unweeded check. No statistical variation existed among the weed control treatments in 1975 and 1976 while in the last season (*kharif* 1977) the grain production under 2 and 4 l/ha of alachlor and all the levels of atrazine was significantly more than the lowest level of alachlor.

Succeeding Crops: Data on grain yield of pulses and dry matter of weeds in the *rabi* season, are presented in Table 2.

Grain yield of all the three pulses raised during *rabi* season after maize harvest did not differ significantly among the herbicide treatments applied continuously for three years.

With regard to dry matter of *rabi* weeds, atrazine 4 kg/ha checked significantly the dry matter accumulation in the dicot weed species in 1976 and 1977 as compared to the 2 and 4 l/ha of alachlor.

DISCUSSION

The performance of atrazine and alachlor was assessed in terms of their herbicidal efficacy and selectivity on maize in *kharif* and their residual toxicity on weed growth and pulse production in *rabi*.

Herbicidal efficacy

The dry matter of weeds was brought down by atrazine 2 kg/ha and alachlor 2 l/ha in 1975 to a level at par with hand-weeding; in 1976, atrazine 4 kg/ha was at par with hand weeding and in the last season (1977), atrazine 2 and 4 kg/ha equalled hand-weeding. In contrast to this, the dry matter accumulation in alachlor 2 and 4 l/ha was significantly more than hand-weeding (Table 1).

In the first year, the dry matter of weeds did not differ statistically among the weed control treatments. In the second year, the two herbicides did not differ statistically. But in the last season atrazine scored over alachlor at the different dosage levels. These results indicated that atrazine was more efficient than alachlor in paralysing the weed growth which was perhaps due to its persistence in soil for a greater length of time. Umesh Rai *et al.* (1978) reported that atrazine had a greater depressing effect than alachlor on dry matter in weeds.

Nitrogen depletion by weeds

The effect of herbicides was more or less similar to that of dry matter with the difference that even in the second year of the experiment (1976), atrazine 4 kg/ha had a relatively greater effect on curtailing nitrogen depletion by weeds than alachlor 4 l/ha. This observation suggests that atrazine exerted a greater depressing effect on nitrogen depletion as compared to dry matter.

Selectivity

Grain yield of Maize: The grain yield in atrazine 1 kg/ha was relatively higher in 1977 as compared to 1975, thereby pointing to some stimulatory effect of the low dose which was continuously used for three seasons. The beneficial effect of the low dose of atrazine was not related to its efficiency in paralysing the weed growth as the dry matter of weeds

Table 1 : Weed and crop attributes – *'kharif'*.

		*UWC	HW	Az1	Az2	Az4	AR1	AR2	AR4	CD 5%
DMW**	I	86.1	16.9	30.9	15.5	6.0	21.9	15.7	4.9	17.5
	II	127.5	10.5	61.2	38.2	13.8	58.4	43.0	29.8	17.5
	III	151.2	5.5	41.5	23.4	5.0	95.9	73.2	42.2	21.1
NDW	I	32.0	4.9	7.8	4.8	2.1	7.7	6.1	3.1	6.3
	II	34.4	3.6	15.8	11.8	4.4	18.5	15.0	9.5	5.0
	III	51.7	1.7	15.0	8.6	2.0	25.2	23.1	14.5	6.9
DMC	I	28.1	49.8	47.2	50.3	48.7	51.2	49.9	48.6	4.3
	II	28.3	49.2	45.8	47.4	46.9	48.1	48.3	44.0	6.4
	III	31.8	48.0	49.9	48.5	50.6	48.2	48.1	49.8	3.9
NUC	I	474.3	861.5	1018.5	833.8	886.8	894.0	986.3	820.5	165.8
	II	491.5	885.8	885.3	927.3	908.0	868.0	833.0	715.8	85.7
	III	495.0	618.8	786.3	645.3	654.3	766.0	783.8	753.3	161.5
GYM	I	15.6	24.4	20.4	22.9	21.7	23.6	23.1	25.3	4.5
	I	14.2	21.5	22.7	21.9	21.1	20.1	22.9	21.5	5.0
	III	15.5	24.0	24.0	24.4	24.3	20.2	24.7	23.3	2.7

*UWC : Unweeded check; HW : Hand weeding;
Azl, Az2, Az4 : Pre-em. atrazine 1, 2 and 4 kg/ha (Product Atrataf) respectively; AR1, AR2, AR4 : Alachlor 1, 2 and 4 l/ha (Product Lasso);
**DMW : Dry matter weeds g/0.5 m² at 60 days; NDW : Nitrogen depletion by weeds (kg/ha) at 60 days;
DMC : Dry matter crop (g/plant) at 60 days; NUC : Nitrogen uptake crop (mg/plant) at 60 days;
GYM : Grain yield of maize (q/ha); I, II, III : 1975, 75 and 77, respectively.

Table 2 : Pulse production and weed growth – *'Rabi'*.

		*UWC	HW	Az1	Az2	Az4	AR1	AR2	AR4	CD 5%
Gy. RP**	I P	21.6	21.8	23.4	21.1	22.3	22.0	21.1	22.7	NS
	G	19.5	19.6	21.2	19.6	18.8	18.9	20.2	20.9	NS
	L	17.0	18.6	19.4	18.0	18.9	20.4	18.6	18.2	NS
	II P	17.8	18.7	18.1	20.6	19.1	19.6	19.3	20.3	NS
	G	20.0	18.5	20.6	20.1	21.3	18.2	22.0	19.1	NS
	L	21.6	19.6	19.4	20.6	19.9	19.3	23.4	22.7	NS
	III P	20.0	20.9	20.9	20.6	20.3	19.2	19.8	19.6	NS
	G	17.9	18.8	18.4	19.1	18.1	19.1	19.3	18.7	NS
	L	17.8	17.8	18.6	18.9	18.6	18.4	18.7	18.4	NS
DMW	I P	51.2	31.6	31.7	29.6	6.5	46.0	37.9	27.9	12.6
	G	39.2	32.6	27.6	16.4	17.1	31.7	29.4	16.6	9.2
	L	31.8	31.5	33.5	20.9	13.3	31.5	29.1	23.1	13.0
	II P	39.6	35.4	28.9	16.2	4.2	35.0	30.7	27.3	10.6
	G	27.4	29.8	30.7	19.8	5.5	30.0	23.8	23.3	6.3
	L	28.2	23.0	24.8	18.7	3.6	22.7	21.4	23.4	8.6
	III P	27.6	26.7	28.9	22.1	9.3	25.3	27.8	26.0	5.6
	G	31.2	36.2	32.2	26.6	7.7	25.0	22.0	23.1	9.8
	L	26.4	21.5	19.7	21.9	11.6	24.1	27.8	26.4	5.6

* Treatments to maize (Abbreviations as in Table 1) ** Gy. RP : Grain yield q/ha of *'rabi'* pulses;
P = Peas G : Gram;
L : Lentil; DMW : Dry matter weeds (g/0.5 m²) 45 days after sowing;

I, II, III : 1975, 76 and 77, respectively.

did not differ much, on the other hand it was more in 1977 as compared to 1975. Low doses of herbicides have been reported to stimulate crop growth (Baumgartner and Mayers, 1972).

Phytotoxic effects: None of the herbicides manifested any phytotoxic effects on maize at any stage during all the three seasons. Mani *et al.* (1970) reported that atrazine (4 kg a.i./ha) was highly selective on maize while simazine beyond 1.5 kg a.i./ha depressed the growth of maize. Gita Kulshrestha *et al.* (1976) found negligible residues of simazine and atrazine (0.5, 1.0 and 2.0 kg a.i./ha) in soil at maize harvest.

Residual toxicity

Grain yield of pulses and dry matter of 'rabi' Weeds: The highest dose of atrazine (4 kg/ha) left residues in the soil that checked the dry matter of annual dicot weed species in the rabi season. Inspite of this, the grain yield of the pulses was not improved, thereby lending some credence to the view that continued application atrazine of 4 kg/ha to maize in the *kharif* had proved slightly inhibitory to grain production in *rabi* pulses. These results suggested that *rabi* weed species were sensitive to the residues of atrazine.

CONCLUSION

A pre-emergence application of either atrazine at 1 kg/ha or alachlor at 2 l/ha in maize effected selective control of weeds, stepped up grain production in maize and did not adversely affect any of the pulses raised in rotation.

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WEED MANAGEMENT AND NUTRIENT LOSSES IN UPLAND COTTON UNDER DIFFERENT ECOSYSTEMS OF MADHYA PRADESH

S. C. JAIN, B. G. IYER, H. C. JAIN and N. K. JAIN
All India Co-ordinated Cotton Improvement Project, JNKVV Campus
Indore-452 001, M. P., India.

ABSTRACT

Weed competition in cotton results in extremely poor yields besides inferior lint quality. Field studies carried out for five years under two different ecosystems existing in Malwa and Nimar regions of Madhya Pradesh revealed that effective weed management could be envisaged by herbicides or integrated methods as an alternative measure to the tedious and expensive traditional methods. Diuron 0.75 kg/ha as *pre-emergence coupled with two interculture at one month interval* gave as satisfactory weed control as was achieved by two hand weedings followed by two interculture operations.

Weeds remove 5 to 6 times of nitrogen, 5 to 12 times of phosphorus and 2 to 5 times of potash than the crop at early stages and thus reduce the raw cotton yields from 54 to 85 per cent. For every 30 kg of dry matter produced by weeds there was one kg reduction in *kapas* production.

INTRODUCTION

Cotton being heavily manured, often irrigated, coupled with slow growing habit at the initial stage and heavy weed population suffered immediately after emergence (Chaugule and Khare, 1961; Wankhede, 1963). The magnitude of problem assumed added dimension particularly with the prevalent practice of growing cotton after cotton; thus establishing a set of weed flora in the region (Gill and Brar, 1975). Yield losses to the tune of 30 to 85 per cent in cotton are reported due to weed competition (Singh and Katti, 1972; Singh *et al.* 1973; Robinson, 1976).

With a view to evaluate the most effective and economic weed management practice and computing the nutrient losses in upland cotton, series of experiments were carried out at Indore and Khandwa.

MATERIAL AND METHODS

Field experiments were carried out for a period of five years from 1974-75 to 78-79 at the Cotton Research Stations, Indore, and Khandwa. Treatments comprised mainly of chemical, conventional and integrated methods of weed control. Three treatments *viz.*, application of diuron at 0.75 kg a.i./ha as pre-emergence (PRE), post-emergence (PST) and a combination of pre plus post-emergence constituted the chemical methods. Superimposing two interculture (INTC) with *Kolpa* at monthly interval after pre-emergent diuron comprised of integrated method, while two handweedings (HW) superimposed by two interculture was adopted as the conventional method. These five treatments were compared with the unweeded control.

Biological composition and preponderance of weeds was recorded by visual

Table 1 : Biological composition and preponderance of weeds in two regions.

Name of weeds	Indore		Khandwa	
	75-77	77-79	75-77	77-79
Monocot weeds				
Cynodon dactylon (L.) Pers.	A	A	A	F
Cyperus rotundus L.	F	F	F	O
Commelina benghalensis L.	A	A	R	R
Dinebra arabica Jacq.	F	A	O	O
Echinochloa crus-galli (L.) Beauv.	R	R	–	–
Eleusine indica (L.) Gærtn.	F	O	R	R
Paspalum spp.	A	A	O	O
Saccharum spontaneum L.	R	O	–	–
Setaria glauca Beauv.	R	R	F	F
Panicum spp.	A	A	F	F
Dicot weeds				
Alysicarpus spp.	A	A	O	R
Boerhaavia diffusa L.	A	A	A	A
Celosia argentea L.	–	–	O	O
Cæsulia axillaris Roxb.	F	O	R	R
Convolvulus arvensis L.	R	R	R	R
Chorchoris spp.	F	F	R	R
Digira arvensis Frosk.	F	F	O	O
Euphorbia spp.	A	A	A	R
Lagasca mollis Cav.	A	A	R	R
Psoralea spp.	A	R	–	–
Phylanthrus niruri L.	R	R	A	A
Xanthium strumarium L.	O	O	–	–

(A) Abundant, (F) Frequent, (O) Occasional, (R) Rare, (–) Absent.

assessment. Dry weight of weeds was recorded at first picking. Composite sample obtained from the collected weed bulk in 1976-77 and 77-78 was utilised for analysing the N, P and K content by the standard methods. Simultaneously five random plants were uprooted, cleaned, dried and put to similar analysis. The crop was rainfed in both the locations. The soil was medium black cotton at Indore and shallow at Khandwa with poor nitrogen and phosphate content and adequate potash.

RESULTS AND DISCUSSION

Weed Spectrum: The biological composition and preponderance of weeds presented in Table 1 reveal that out of ten monocot and twelve dicot weeds, *Cyperus rotundus* L., *Cynodon dactylon* (L) Pers., *Paspalum spp.* and *Euphorbia spp.* were quite predominant. It is further observed that weed intensity in medium black cotton soils of Indore was relatively higher than that at Khandwa. Visual observations indicated that grassy weeds predominated at the earlier stage while broad leaf weeds were abundant at the latter stage of crop growth.

Effectivity of treatments: Data presented in Table 2 reveal that both at Indore and Khandwa pre- as well as post-emergence application of diuron 0.75 kg/ha individually or in combination, though inflicted considerable mortality to the growing weeds, maximum suppression in terms of dry weight was recorded in the

Table 2 : Dry matter production of weeds (q/ha) due to different weed management practices.

	Malwa (Indore) Region					Mean % decrease over weedy check	Nimar (Khandwa) region					Mean % decrease over weedy check
	74-75	75-76	76-77	77-78	78-79		74-75	75-76	76-77	77-78	78-79	
Diuron (PRE)	35.6	40.6	42.1	0.3	11.8	70	24.6	14.8	3.6	4.9	3.8	86
Diuron (PST)	42.0	52.2	60.6	25.5	15.4	55	15.0	5.0	13.7	3.9	14.4	86
Diuron (PRE + PST)	38.1	37.4	15.1	8.4	14.5	74	2.8	18.7	1.3	5.8	3.2	91
Diuron (PRE + INTC)	6.0	35.0	40.0	7.0	10.6	77	3.5	3.9	1.4	3.8	2.6	96
HW + INTC	4.9	34.3	1.3	0.2	0.3	90	3.0	1.6	1.2	0.9	1.9	98
Weedy check	98.4	119.7	76.1	102.0	34.3	-	49.3	65.8	86.0	66.8	99.5	-

conventional or integrated method of weed control. Exemplary effect of hand-weeding plus interculture, marked by 90 to 98 per cent reduction in weed weight was comparable with diuron (PRE) combined with interculture treatment (77 to 96 per cent) at Indore and Khandwa respectively. Efficacy of handweeding superimposed with interculture or diuron (PRE) followed by interculture has been reported by earlier workers (Singh and Katti, 1972; Shanmugam and Meenakshisundaram, 1977). Although solitary application of diuron as pre-emergence reduced the weed intensity substantially in the treated plots, its action as post-emergence remained low at Indore. Contrary to this, post-emergence spray of diuron at Khandwa performed comparatively better than pre-emergence in three out of five years of study. Different trend noted at two locations may be attributed to the difference in the time of weed emergence and density. Efficacy of pre-emergent herbicides over post-emergence has been reported by Sheriff *et al.* (1973) and Gidnavar *et al.* (1976).

Data further brought out that supplementing pre-emergence diuron with interculture was more promising than that with post-emergence at either locations. This is in conformity with the observation recorded by Hunsigi *et al.* (1969). Even though superimposing two interculture to prolong the longevity of diuron gave a satisfactory weed management in cotton its substitution with post-emergence spray of diuron appears to be vitally important under certain ecosystem. This view is well supported by similar effects observed in diuron + diuron (PRE + PST) and diuron + interculture for three years at Indore and four years at Khandwa. Present studies conform that diuron is a versatile herbicide in black cotton soils to knock down a broad spectrum of weeds in cotton.

Competition for nutrient : Data plotted in Table 3 clearly brought out the influence of weed persistence in various management practices and their consequent detrimental effects on nutrient utilization. As a result of negligible nutrient competition due to constant weed free condition observed in conventional management, cotton crop obtained maximum quantity of plant nutrients (NPK). Comparing this with other methods, it is clear that both chemical as well as integrated methods adequately curtailed the competition for nutrients. As against this, an intense growth of weeds in weedy check extended severe competition for N, P and K with the result that crop was

Table 3 : Nutrient competition between weeds and cotton plants at Indore during 1976-77 and 77-78.

Weed management practices		Nutrient uptake (kg/ha) N	P	K	N	P	K
		Plants			Weeds		
Chemical	: 1976-77	39.2	9.6	53.5	16.0	3.9	10.1
	1977-78	45.6	8.9	70.8	10.6	2.0	14.1
Integrated	: 1976-77	31.9	8.2	45.5	12.9	3.1	17.2
	1977-78	34.4	7.6	53.0	9.6	2.2	10.6
Conventional	: 1976-77	38.3	9.1	50.1	0.2	0.3	0.9
	1977-78	45.6	8.7	60.7	N.G.	N.G.	N.G.
Weedy check	: 1976-77	13.8	3.8	15.0	67.4	19.8	29.5
	1977-78	14.0	3.2	19.7	75.0	38.0	109.1

N G : Negligible number of weeds.

Table 4 : Seed cotton yield (kg/ha) as influenced by different weed management practices.

	Malwa (Indore) Region 74-75	75-76	76-77	77-78	78-79	Mean % Increase over weedy check	Nimar (Khandwa) region 74-75	75-76	76-77	77-78	78-79	Mean % Increase over weedy check
*Diuron (PRE)	606	129	222	282	190	70	407	1321	576	850	646	62
*Diuron (PST)	217	99	143	290	122	54	208	1408	610	833	414	58
*Diuron (PRE+PST)	531	236	421	340	233	77	367	1273	672	779	791	63
**Diuron (PRE + INTC)	1038	320	324	287	142	82	418	1448	702	883	707	65
***HW + INTC	1232	388	477	384	246	85	338	1573	745	941	746	67
Weedy check	48	24	101	119	106	–	35	949	176	191	96	–

*Chemical, **Integrated, ***Conventional methods of weed management.

deprived off by 5 to 6 times of nitrogen, 5 to 12 times of phosphorus and 2 to 5 times of potassium. Almost identical results have been reported by Rethinam and Sankaran (1979).

Yield response: *Kapas* yield had a direct bearing with the nutrient competition held by weeds in different management practices in two ecosystems. Mean yields of 545 kg/ha and 869 kg/ha, calculated on five years basis, obtained in handweeding + interculture (conventional method) exhibited the highest increase of 85% and 67% at Indore and Khandwa respectively over weedy check (Table 4). These increases, however, were at par with those recorded in diuron + interculture (integrated method) as 82 and 65 per cent. Consistently higher yields recorded both in conventional and integrated weed management practices was mainly due to long term weed control producing least dry weight of weeds and minimum competition for nutrients at critical stage. These results confirm the findings of Hunsigi *et al.* (1969) and Singh and Katti (1972).

Among the chemical methods, single spray of diuron as pre-emergence gave relatively higher yields than that observed in post-emergence. This may be due to the delay caused in controlling weeds and non-elimination of crop weed competition in the latter method which is seen by the higher dry weight of weeds at both the locations. Sequential spray of diuron as pre plus post-emergence inflicted greater mortality to fresh growth of weeds and gave a season long control. Knocking down a wider spectrum of weeds ultimately resulted in a satisfactory crop growth (Data not presented) and enhancement of yields in two ecosystems by 77% at Indore and 63% at Khandwa over the weedy check. High growth of weeds in weedy plots reduced the cotton yields significantly.

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EFFECT OF PLANTING DISTANCE AND INTER-CROPPING WITH COWPEA ON WEED GROWTH IN BANANA

ELIAS K. CHACKO and ARVIND REDDY
Indian Institute of Horticultural Research, 255, Upper Palace Orchards
Bangalore - 560 080, India.

ABSTRACT

Commercial banana plantings suffer severely from weed competition. Adopting high planting density (4440 to 6950/ha) and growing initially an intercrop of cowpea, weed growth could be drastically curtailed throughout the growth of the banana crop (cv. Robusta) and obtain higher yield. Commercial viability of the system of weed control by the agrotechnique developed at the Institute has been demonstrated in a number of field trials around Bangalore.

INTRODUCTION

Commercial banana plantings suffer to a great extent from competition from weeds for both nutrients and soil moisture (Feakin, 1972). Under the normal planting distances followed in India and elsewhere, rhizomatous and stoloniferous weeds (*Cynodon dactylon* and *Cyperus rotundus*) and many local broad leaved species flourish and compete severely with the banana plants especially during the early stages of crop growth. As the crop develops full canopy and shade the soil, weed growth decreases although not completely eliminated.

Weed control in banana using herbicides has been investigated in detail and the merits and demerits of contact and residual weedicides have been studied (Feakin, 1972). Since chemical weed control has yet to become popular among banana farmers in India, any major step towards other forms of weed management would be most appropriate.

Commercially, the semi-dwarf cv. Robusta belonging to the Cavendish banana (*Musa*, AAA group) is planted at distances ranging from 1.8 to 2.1 meters in square system giving an average yield of 30-50 t/ha (Randhawa *et al.* 1973). Since banana plants could tolerate shade to a great extent (Gietema-Groenendijk, 1970; Samson, 1980), the possibility of increasing the plant population/unit area was explored for higher yields, besides ensuring less weed growth.

MATERIAL AND METHODS

The experiments were carried out at the Experimental Station of Indian Institute of Horticultural Research, Hesarghatta, Bangalore, during 1979-80. Planting of suckers in the square system was done on 23rd June 1979, keeping four spacings viz., 1.2m x 1.2m (T_1, 6944 plants/ha), 1.5m x 1.2m (T_2, 4444 plants/ha) 1.8m x 1.8m (T_3, 3086 plants/ha) and 2.1m x 2.1m (T_4, 2227 plants/ha).

The corresponding net plants observed for yield were 36, 24, 20 and 16 respectively. The experiment was designed in a completely randomized block design with 5 replications.

A basal dose of one kg poultry manure and 250 g of dolomite/plant was given nearly one month after planting. Further, a uniform dose of 200 g N, 180 g P_2O_5 and 225 g K_2O/plant was applied in three split doses at 2, 4 and 6th month after planting the suckers.

An intercrop of cowpea (*Vigna ungiculata*) was sown 20 days after planting the suckers at the seed rate of 40 kg/ha. Before sowing, superphosphate at the rate of 100 kg/ha was broadcast all over the field. Two months after planting, when flowering started, the cowpea plants were pulled out and spread over the field taking care not to obstruct the irrigation arrangements. Two sprays of 'Navaras A', a commercial preparation containing nutrients and hormones, at 0.5% in water were applied to the cowpea during its growth period along with 0.2% malathion for the control of insects. The spray was also directed to the growing banana plants as a precaution against insect vectors of the bunchy top disease.

Observations on the biomass production of cowpea (top growth) were recorded from three plots measuring one m^2 and N, P, K content of vegetative parts were determined using standard procedures.

Since weed growth in wider spacings namely T_3 and T_4 was profuse after 7 months of sucker planting, paraquat at the rate of 5ml/l was sprayed to kill the weeds. Three rounds of sprays were found necessary for suppressing weed growth in the wider spacings, while the closer spacings did not require any paraquat sprays due to scarce weed growth.

To record the amount of weed growth in each treatment, four spots not sprayed with paraquat, each measuring one m^2 were selected. From these spots, weeds were collected periodically and their dry weight were recorded.

Observations on the light interception by the developing canopies of the rowing banana plants in various treatments were recorded with the help of a lux meter on bright and sunny days. Incident and reflected lights were measured both at ground level and at 1.5m above the ground level. The weight of bunches from each plant was recorded at the time of harvest and yield/ha in different treatments were calculated.

RESULTS AND DISCUSSION

Growing cowpea as an intercrop in banana resulted in the development of a dense canopy covering the entire ground area and suppressed weed growth completely for a period of 70 days (Fig. 1 & 2). Weed growth was checked for a further period of two months by mulching the soil with uprooted cowpea plants.

Besides the control of weed, the enormous biomass produced which later formed a mulch on the soil was advantageous in reducing the soil moisture eva-

Fig. 1 : One month cowpea planting intercropped with banana cv. Robusta.

Fig. 2 : Weed growth in banana fields and its control by cowpea intercropping.

Fig. 3 : Banana plants cv. Robusta 12 months after planting at 1.2 x 1.2 m distance showing complete absence of weed growth in the field.

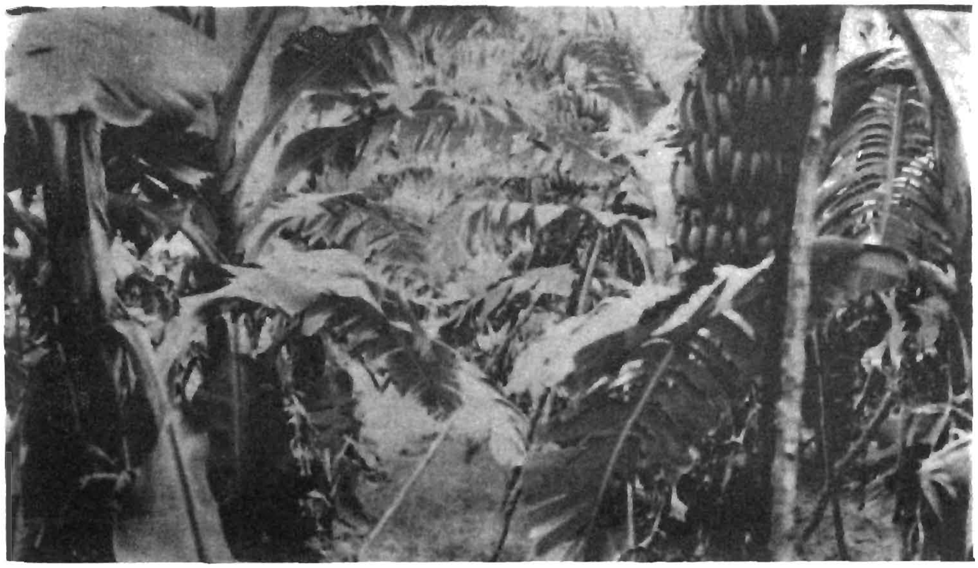

Fig. 4 : Banana cv. Robusta plants 12 months after planting at 2.1 x 2.1 m distance showing profuse weed growth in the inter spaces.

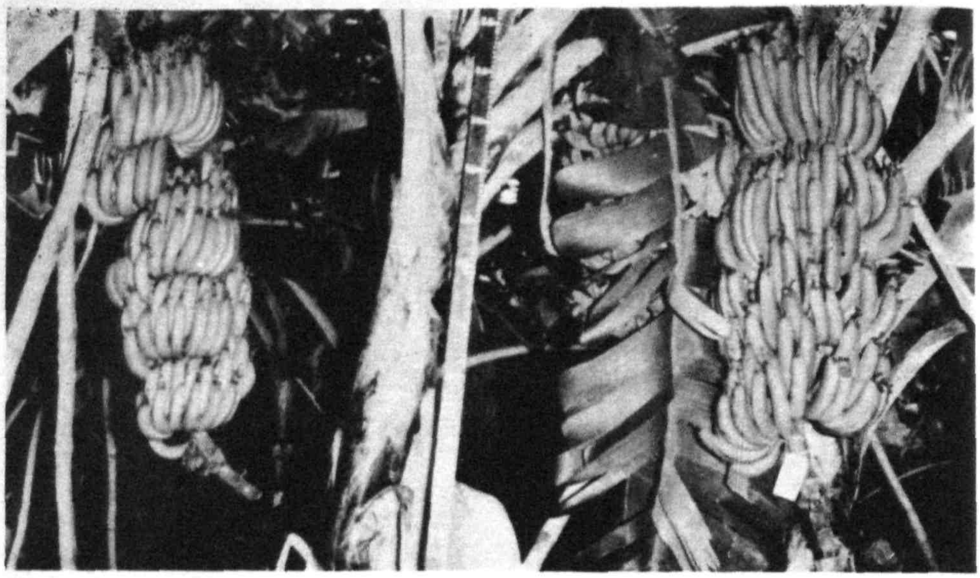

Fig. 5 : Large bunches obtained in banana cv. Robusta planted at 1.2 x 1.2 m.

Table 1 : Biomass production and NPK content in cowpea var. C152 intercropped with banana in kg/ha.

Fresh wt. of above ground organs	55,055.00
Dry weight	5,505.50
Nitrogen (N)	132.13
Phosphorous (P_2O_5)	13.76
Potash (K_2O)	47.34

Data based on average of 3 replicated samplings.

Table 2 : Effect of planting distance and intercropping cowpea on dry weight of weed growth (g/m^2) in Robusta banana plantations.

	Months after planting		
	7	9	12
T_1	42.58	14.00	0.57
T_2	106.31	61.33	3.00
T_3	181.19	119.00	10.23
T_4	211.11	175.99	23.78
CD at 5%	39.89	14.39	2.70

Table 3 : Light intensity in lux as affected by various planting distances in banana.

		Months after planting					
		9		11		14	
		Ground level	150 cm high	Ground level	150 cm high	Ground level	150 cm high
T_1	Direct	980	1590	1333	2006	347	452
	Reflected	320	590	366	873	13	33
T_2	Direct	2030	3690	3073	4019	777	1277
	Reflected	530	1150	886	1566	50	147
T_3	Direct	13170	21720	21319	35066	2438	5344
	Reflected	2100	3720	3712	5146	136	397
T_4	Direct	36100	49633	52133	56599	6612	11751
	Reflected	4316	6923	6566	8399	431	1042

Table 4 : Effect of planting distance and intercropping cowpea on % of flowering, economic yield and biomass production in Robusta banana.

Planting distance, m	Flowering %	Yield, t/ha	Biomass, t/ha
T_1 1.2 x 1.2	85.08	174.39	691.67
T_2 1.5 x 1.5	93.99	145.44	510.16
T_3 1.8 x 1.8	99.00	114.36	388.05
T_4 2.1 x 2.1	98.75	85.99	294.36
CD at 5%	5.77	17.64	50.00

portion, supply of humus and fairly large amounts of N, P and K for the growth of banana plants (Table 1). The amount of N added to the soil by cowpea biomass itself justified the cost of the initial cowpea seed material used for sowing.

The Records taken from 7th month onwards show that with increase in plant population, weed growth also decreased considerably (Table 2). The weed population was almost negligible in case of close planting like T_1 and T_2, while regular sprays of paraquat were required to suppress weed growth in T_3 and T_4 treatments (Fig. 3 & 4).

Decrease in growth of weeds was thus a direct consequence of reduced light intensities at ground level (Table 3). With increase in time, light intensity at ground level was further found to be considerably reduced both within and between treatments mainly due to increase in size of the plant canopy structure.

The high banana yield obtained from these experiments (Table 4 and Fig. 5) show the beneficial effect of controlling weeds by suitable agrotechniques like intercropping with leguminous cover crops contributing to improvement of soil structure and fertility.

Under the high density planting systems like T_1 and T_2, the increased number of plants per unit area also contributed largely to record yields, besides imparting natural control of weeds due to the development of high canopy structure and low light intensities prevailing at ground level.

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WEED COMPETITION IN UPLAND RICE

G. J. WELLS and NIDA CABRADILLA
Betinan Research Station, Zamboanga del Sur, Philippines.

ABSTRACT

The effect of the presence and absence of weeds for 0, 3, 6, 9, 12 and 16 weeks of the growing period of an upland rice crop was studied under rainfed conditions in the wet season of 1980. Weed growth increased exponentially to a maximum of 6.58 t dry matter/ha during the first nine weeks of the growing period and crop growth was increased as weeds were removed during this period. Continuing to remove weeds after nine weeks had little effect on grain yield. The critical period of weed competition was between two and nine weeks after sowing.

INTRODUCTION

Rice is one of the staple foods in the Philippines and there is an increasing number of upland farmers substituting rice for part of their traditional corn crop. However, because rice is grown at a much closer row spacing than corn, weeding is done by hand and represents a major production cost. In addition, labour is often not available and so crops become weedy with resultant low yields.

In developing a weed control program for a particular crop it is necessary first to establish the competitive relationship between the weeds and the crop. From this can be determined the critical period of competition where the growth of weeds results in an economically significant decrease in yield. It is then possible to either impose existing weed control practices or develop improved methods for the duration of this critical period.

In this paper, the effects of different durations of weed competition on the yield of an upland rice crop were studied under rainfed conditions at Betinan Research Station in the wet season of 1980.

MATERIAL AND METHODS

The rice cultivar, IR36, was sown on 28 May 1980 at the seeding rate of 70 kg/ ha together with fertilizer at the rate of 60 kg N and 60 kg P_2O_5 per ha. Plot size was 2 m x 5 m allowing eight rows of rice at 25 cm spacing. Upland rice has a 16 week growing period and so there were ten treatments: presence and absence of weeds for 0-3, 0-6, 0-9, 0-12 and 0-16 weeks of the growing period. A randomized block design with four replicates was used.

Plots were handweeded according to treatment and the dry matter production of weeds was measured 3, 6, 9, 12 and 16 weeks after planting. All plots were sprayed with benomyl and monocrotophos during the vegetative stage to control fungal pathogens and insect pests. Decamethrin was used during the reproductive stage to control insect pests.

The crop was harvested by hand on 17 September 1980 and both grain yield and plant height were measured.

RESULTS

The highest grain yield was obtained on the weed-free treatment (weeds absent 0-16 weeks) (Table 1). Weed competition commenced during the first three weeks of the crop and the longer weeds remained growing, the lower the grain yield. However weed growth in-

Table 1. Effect of weed competition on upland rice.

Treatment	Grain yield t/ha	Plant height[a] cm	Weed dry matter t/ha
Weeds absent			
0- 3 weeks	0.70	54.5	1.61
0- 6 weeks	1.23	57.0	1.63
0- 9 weeks	1.78[a]	56.3	0.48
0-12 weeks	1.57	56.8	1.33
0-16 weeks	1.99[a]	58.5	0.00[b]
Weeds present			
0- 3 weeks	1.58	54.0	0.17
0- 6 weeks	1.47	55.3	1.84
0- 9 weeks	1.28	52.3	6.58
0-12 weeks	0.51	52.0	4.99
0-16 weeks	0.12	48.3	5.05
L.S.D. (P = 0.05)	0.50	4.9	0.96

a = base to tip of plant b = not included in analysis

creased exponentially during the first nine weeks and reached 6.58 t dry matter per ha. The removal of weeds during this stage had the greatest effect on the grain yield on the rice crop and continuing to remove weeds after this resulted in little yield increase.

Plant height of the rice crop was significantly decreased by weed competition (Table 1).

DISCUSSION

Data in table 1 show that rice yields decreased from 1.99 to 0.12 t/ha when weeds were allowed to grow unchecked throughout the growing period. Plant height also decreased as a result of this competition. The competitive effect of weeds was evident at each stage of the growing period, commencing during the first three weeks (the third week, in fact, as there were no weeds present during the first two weeks) and still decreasing yield during the last four weeks. This is perhaps unusual because weed competition is normally more severe early in the life of the crop before it has become well enough established to exert competition against the weeds. Also, in the tropics, weeds continue to grow as the crop matures, unlike in drier climates, and so competition continues until harvest.

Almost maximum yield was obtained if weeds were controlled for the first 9 to 12 weeks of the growing period. This suggests that upland rice is not a very competitive crop and this might be due to the particular variety used in this case. Cultivar IR 36 has a shorter straw, a shorter growing period and is lightly lower yielding than the recommended cultivar, C 22, but it was chosen for this experiment because of the late time of planting.

The practical implications of this work are that upland rice crops should be kept weed-free for a much longer period than was previously realised. This in itself presents difficulties because of the high cost of hand weeding as well as a shortage of labour in many upland areas and new methods of weed control need to be developed for this crop.

INVASIVE CAPACITY OF *EUPATORIUM ADENOPHORUM*

B. A. AULD
Agricultural Research and Veterinary Centre, Forest Road, Orange, 2800 Australia.

ABSTRACT

Eupatorium adenophorum Spreng. (syn. *Ageratina adenophora* King and Robinson) is an important weed of northern India, south east Asia, eastern Australia, Pacific Islands and California.

A measure of the species' abilities to expand its range or increase in density could be assessed by its growth at a range of sites. Several vegetative and reproductive growth parameters were examined; cypsella weight and cypsella number per capitulum were chosen for detailed study.

These parameters provided a good indication of subsequent change in ground cover at three sites. They could have application in assessing the likely spread and increase in density of *E. adenophorum*.

INTRODUCTION

Eupatorium adenophorum Spreng. (syn. *Ageratina adenophora* King and Robinson; syn. *E. glandulosum* H. B. K. non Michx.) is an important weed of Northern India, Northern Thailand, South East Asia, Eastern Australia, Pacific Islands and California. Other species in this genus are weeds in Asia, Africa, America and Australia. *E. odoratum* is probably the other most important species in the genus.

E. adenophorum because of its high reproductive capacity and light windborne fruits (cypsellas) is particularly adapted to colonizing bare or intermittently bare areas (Auld and Martin, 1975). Auld (1969*b*) has described how in sub tropical eastern Australia the species occurs predominantly in high rainfall areas [> 1750 mm average annual rainfall (AAR)] with no tree cover. However, *E. adenophorum* does occur in areas of < 1250 mm (AAR) in the sub tropics and it extends to temperate areas in Australia (lat. 35°S).

The possibility of the species expanding its range or increasing in density in marginal areas was examined.

MATERIAL AND METHODS

Change in ground cover gives an indication of a species colonizing adaptability to site. It is an especially useful measure where species have clumped distribution and strong vegetative growth, making individuals difficult to determine. It is independent of quadrat size and overcomes problems associated with equating plants or stems of different ages in other methods.

The ability of *E. adenophorum* to expand its range or increase in density at a site would be greatly dependent on its reproductive output – the number and weight of cypsellas. (Although greatly increased cypsella weight might restrict mobility). Hence cypsella number per capitulum and mean cypsella weight were chosen as measures of performance at three sites. Other measures of performance including stems per plant, stems per unit area, capitula per unit area were considered but discarded.

The sites were located on the far north coast of New South Wales, two were in the eastern high rainfall area of

Table 1: Reproductive output year 1.

Site	Rose bank	Nim-bin	Richmond Range
Cypsella Weight ($g \times 10^{-3}$)	2.2	2.1	1.7
Cypsella number per capitulum	68	58	50

Means under a common line are not significantly different.

Table 2: Change in *E. adenophorum* cover.

Site	Rose bank	Nim-bin	Richmond Range
% Change in sward cover	+ 9.3	0	- 8.9
Change in isolated plant number	+ 7	0	- 1

the region where *E. adenophorum* was dominant "Rosebank" (AAR 2000 mm) and common "Nimbin" (AAR 1675 mm). A third site was in the west of the region where the species was rare, "Richmond range" (AAR 1250 mm).

Ground cover was measured in a 10 m x 10 m area at each site over a year. Individual isolated plants not in the contiguous sward of *E. adenophorum* were counted separately. Cypsella number per capitulum were counted from 20 capitula at each site and cypsella weight estimated from ten samples of 50 cypsellas at each site. Sample size was determined by calculating the running standard error against sample size.

RESULTS

There was significantly higher reproductive output at the two eastern sites, especially Rosebank (Table 1). This was reflected in the consequent increase in ground cover (Table 2).

DISCUSSION

Variation in reproductive capacity from site to site could provide a useful indication of the likely success of *E. adenophorum*. In the year following these observations the Richmond Range site received a higher rainfall than the eastern sites during cypsella initiation and filling. Subsequently heavier cypsellas were formed at Richmond Range. Hence observations on performance at an area should take into account any large variation in climate, especially rainfall for *E. adenophorum*, from the mean, if they are to be used to draw general conclusion.

Furthermore associated vegetation will play a large part in determining the success of an invading species (Auld *et al.*, 1979). This is particularly relevant for *E. adenophorum* as it requires light to germinate (Auld and Martin, 1975). However although it has a very small seedling, it is shade tolerant (Auld and Martin, 1975).

In Australia *E. adenophorum* is attacked by three organisms: the introduced gall fly, *Procecidochares utilis* Stone (trypetidæ), an exotic fungus *Cercospora eupatorii* Peck and a native crown boring Cerambycidæ, *Dihammus argentatus* Auriv.

Auld (1969*a*) reported on damage caused by these organisms to plants at six sites on the far north coast of New South Wales, including the three sites discussed in this paper. Damage was far greater at the Nimbin and Rosebank sites than the Richmond Range site (Cob O' Corn Creek) during the period of these observations. Yet *E. adenophorum* decreased where predator attack was least.

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EFFECT OF WHEAT DENSITY AND GEOMETRY ON *LOLIUM RIGIDUM* COMPETITION AND CONTROL

R. W. MEDD, B. A. AULD and D. R. KEMP
Agricultural Research and Veterinary Centre, Forest Road, Orange, N. S. W., Australia 2800,

ABSTRACT

Field experiments conducted over three years examined the effect of *Lolium rigidum* Gaud., annual ryegrass, competition on wheat grain yields for wheat crops sown in square and rectangular arrangements at 40, 74 and 200 plants m^{-2}.

These experiments showed an interaction between *L. rigidum* competition and wheat density with the depression of wheat grain yields by *L. rigidum* being greatest at low crop densities. Planting geometry of wheat had no effect on reducing competition from low densities of *L. rigidum*. However, populations of greater than 100 *L. rigidum* plants m^{-2} were less competitive in square planted crops sown at 200 plants m^{-2}, though the effect was small. We conclude that the competitive effects of residual populations of *L. rigidum* on wheat are best reduced by increasing crop density.

INTRODUCTION

L. rigidum is an important weed of winter cereals in southern Australia (Monaghan, 1980). Selective pre-emergence and post-emergence herbicides give effective control of the weed. However, residual populations usually remain and are composed of plants which either survive or escape treatment together with plants which emerge following treatment. Such populations may cause small but important grain yield losses. Their existence also ensures reproductive output which adds to the weed's seed bank and perpetuates the problem, as shown by Richardson (1980) for *Sinapis arvensis* L. in barley.

Various cultural alternatives could be used to combat residual weed populations. These include the use of aggressive crop genotypes, increased crop density, heavier applications of fertilizer and varying the geometry of the crop.

This report describes field experiments which investigated two of these alternatives – wheat density and crop geometry – for the control of residual *L. rigidum* populations.

MATERIAL AND METHODS

Four experiments were sown, over the years 1978 to 80, into well prepared, *L. rigidum* free, seedbeds on loam soils near Cudal in central N.S.W. (33°S, 148°E). All plots received a complete fertilizer including 18 kg P, 50 kg K and 40 kg N ha^{-1} at sowing. The sowing of experiments commenced on 22 June 1978, 2 July 1979 and for the two experiments in 1980 on 5 June and 15 July. Rainfall between sowing and harvesting totalled 390 mm in 1978, 128 mm in 1979 and 147 mm and 88 mm for the two times of sowing in 1980. In 1979 plots were watered for two weeks after sowing to ensure uniform establishment.

The crop treatments were square and rectangular planting geometry sown at

Table 1 : Wheat sowing geometry and rates used in the three years.

		Sowing rate (kg ha^{-1})	Wheat density (plants m^{-2})	Distance between rows (mm)	Distance within rows (mm)
Square	1980	12	40	159	159
(1 to 1)[1]	1978/9	22	74	116	116
	1978 to 80	60	200	71	71
Rectangular	1980	12	40	403	63
(1 to 6.4)	1979	22	74	295	45
	1978 to 80	60	200	180	28

[1] Ratio of distance between plants within rows to the distance between rows.

Table 2 : Relationships between wheat grain yield and *L. rigidum* density measured at establishment and maturity. (y = wheat grain yield as % of weed free crop, x = *L. rigidum* density). Results combined from four field experiments. All regressions were significant (p>0.05).

Wheat density (plants m^{-2})	Relationships between *L. rigidum* density and wheat yield	
	Establishment	Maturity
200	$Y = 97.98\ e^{-0.0015x}$ $r = -0.45$	$Y = 104.79\ e^{-0.004x}$ $r = -0.50$
40 and 74 Combined	$Y = 96.85\ e^{-0.0045x}$ $r = -0.94$	$y = 96.98\ e^{-0.004x}$ $r = -0.92$

12, 22 and 60 kg ha^{-1} using *Triticum æstivum* cv Condor (Table 1).

Graded seed was hand sown 50 mm deep through holes in marine ply boards precision drilled for each treatment. Any seed that failed to establish was replaced with plants grown in small pots. Wheat densities remained constant throughout the life of the crop. *L. rigidum* populations of from 0 to 300 plants m^{-2} were superimposed on the crop treatments. Measured quantitiesof seed were broadcast onto plots then raked in. Other weeds were removed by spraying with a proprietory mixture of bromoxynil plus MCPA at 1.4 l ha^{-1} and by regular hand weeding. Plant counts were taken during the life of the crop and yields measured at maturity.

RESULTS

Although mean wheat grain yield did vary between years from 1.3 to 6 tonnes ha^{-1} the proportional effects of *L. rigidum* competition were similar across experiments and hence the results from all four experiments have been combined by expressing grain yields as a percent of the weed free controls.

Sowing rate or geometry of wheat had little effect on changing the density of *L. rigidum* during the life of the crop. Consequently the relationship between weed density and wheat grain yield was similar for weed counts made at establishment and maturity (Table 2). The depression in wheat grain yield as a function of *L. rigidum* density (an exponential relationship) did not differ for crops with

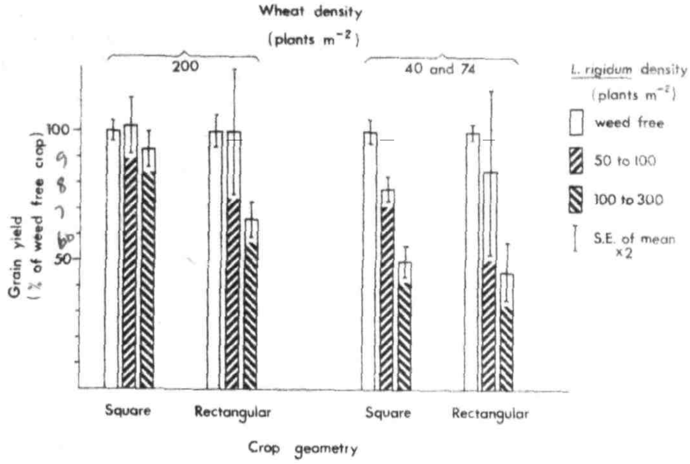

Fig. 1. Effect of crop geometry and density on *L. rigidum* competition. Results have been combined from four experiments by expressing grain yield as a percent of the weed free control.

a density of 40 and 74 plants m^{-2}. However, a significantly different ($p > 0.05$) relationship was found for crops sown at 200 plants m^{-2} (Table 2). The depression in wheat grain yield by increasing *L. rigidum* density was greatest in the low density crops. At low crop densities the depression of wheat grain yields by competition from *L. rigidum* was similar for square and rectangular geometries (Fig. 1). At high crop density *L. rigidum* densities less than 100 plants m^{-2} had no significant ($p<0.05$) effect on wheat yields for either geometry. However, *L. rigidum* populations greater than 100 plants m^{-2} significantly ($p > 0.05$) depressed grain yields in the rectangular but not the square planted crops. This effect was smaller than the depression found in the low density wheat crops.

DISCUSSION

Increasing the density of a crop is an established means of reducing the competitive effects of weeds (Cussans and Wilson, 1976; Zimdahl, 1980). Variation in crop geometry has also been shown to modify competition from dense populations of weeds in carrots (Bleasdale, 1960) and some summer crops (Zimdahl, 1980). However, studies with cereal crops have generally shown that variation in crop geometry has no pronounced effect on competition from grass weeds (Cussans and Wilson, 1975; Selman, 1975; Chancellor and Peters, 1976).

In our experiments a 3 to 5 fold increase in wheat sowing rate reduced the proportional decline in grain yield per unit increase in *L. rigidum* density by almost one third. A greater proportional reduction in the effects of *L. rigidum* competition was achieved by increasing wheat density than by varying geometry and in the latter case a reduction in weed effects was only achieved at the high crop density. Since grain yield of wheat is insensitive to sowing rate over a wide range, such as used here, it seems preferable to reduce the competitive effects of residual population of *L. rigidum* by increasing crop density rather than varying crop geometry.

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STUDIES ON THE USE OF *EICHHORNIA CRASSIPES* and *IPOMOEA CARNEA* WEEDS AS A SOURCE OF GREEN MANURE

S. M. KONDAP, Y. YOGESWARA RAO, WAJID ALI MIRZA, A. RAMACHANDRA RAO and K. SRIRAMA RAJU
Agricultural Research Institute, Andhra Pradesh
Agricultural University, Rajendranagar.

ABSTRACT

A field experiment was conducted during the rainy season of 1977-78 to find out the effect of inoculum spray of *Eichhornia crassipes* and green leaf incorporation of *Eichhornia crassipes* and *Ipomoea carnea* on the economy of fertilizers in rice. The grain yields obtained with 60 kg N/ha + *Eichhornia* or *Ipomoea* leaf incorporation at 10 t/ha were significantly higher than the grain yield obtained with 60 kg N/ha alone. Highest grain yield of 4.1 t/ha was obtained with 100 kg N/ha applied through urea and it was on par with the treatments receiving 60 kg N/ha + *Eichhornia* leaf incorporation (3.8 t/ha). 60 kg N/ha + *Ipomoea* leaf incorporation (3.9 t/ha). A saving of 40 kg N/ha was observed by incorporating the leaves of these weeds at 10 t/ha as green manure, with no adverse effect on the grain yield or spread of these species of weeds.

INTRODUCTION

The two most commonly found aquatic weeds growing in abundance in tanks, irrigation channels, drains etc., are *Eichhornia crassipes* (Mart.) Solms and *Ipomoea carnea* Jacq. These two weeds are lush green and may be useful as a cheap source of green manure. The dark green colour of *Eichhornia crassipes* plant may be due to its efficiency in fixing elemental nitrogen either through the association of microbes or through some other unknown process. The plants, especially the ones growing in deep waters, are exceptionally rich in potash and other nutrients including nitrogen and the chemical analysis has revealed that the dried plant contains 75.8% organic matter comprising of 1.5 % nitrogen and 24.2% ash, 28.7% potash and 7.0% phosphorus (Khandelwal, 1980). Sudhirendar Sharma (1980) reported that Hyacinth compost contains (on dry matter basis), nitrogen 2.05, phosphorus as P_2O_5 1.1 and potassium as K_2O 2.5 %. It is twice as rich as town compost and four times as rich as FYM in potash. These three nutrients are essential for plant growth and by the utilisation of these weeds efficiently by different methods, it is hoped that it will cut down the cost of fertilizers in paddy, and at the same time help in cleaning the tank beds, irrigation channels and drains from these weeds. Keeping this in view an experiment was conducted to find out the effect of inoculum spray of *Eichhornia* and green leaf incorporation of *Eichhornia crassipes* and *Ipomoea carnea* on the economy of fertilizers in rice.

MATERIAL AND METHODS

This experiment was conducted on the farm, College of Agriculture, Rajendranagar, Andhra Pradesh Agricultural University, Hyderabad during the rainy season of 1977-78 in a randomised block design with seven treatments replicated four times.

Table 1 : Grain yield and yield attributes of rice as influenced by *Eichhornia* inoculum spray and leaf incorporation of *Eichhornia* and *Ipomoea* with supplemental nitrogen application.

Treatment	Number of productive tillers/m²	1000 grain weight (g)	Grain Yield (q/ha)	Straw yield (q/ha)
T_1 60 kg N/ha	350.80	22.81	32.91	35.68
T_2 60 kg N/ha + 2% urea solution spray	342.00	22.55	38.03	37.61
T_3 60 kg N/ha + *Eichhornia* inoculum spray	337.80	22.67	36.92	34.61
T_4 60 kg N/ha + 2% urea spray + *Eichhornia* inoculum spray	408.50	23.09	35.21	39.10
T_5 100 kg N/ha	409.20	22.91	41.24	47.01
T_6 60 kg N/ha + *Eichhornia* leaf incorporation at 10 tonnes/ha	385.00	22.76	38.03	41.88
T_7 60 kg N/ha + *Ipomoea* leaf incorporation at 10 tonnes/ha	383.00	22.42	39.06	42.31
SEm ±	15.40	0.28	1.20	1.91
CD at 5%	45.75	–	3.59	3.97

T_1 – 60 kg N/ha; T_2 – 60 kg N/ha + 2% urea solution spray; T_3 – 60 kg N/ha + *Eichhornia* inoculum spray; T_4 – 60 kg N/ha + 2% urea solution spray + *Eichhornia* incoculum spray; T_5 – 100 kg N/ha; T_6 – 60 kg N/ha + *Eichhornia* leaf incorporation at 10 t/ha; T_7 – 60 kg N/ha + *Ipomoea* leaf incorporation at 10 t/ha.

Preparation of Eichhornia *inoculum spray*

The leaf and root samples of *Eichhornia crassipes* were collected from the drains. They were crushed and the extract along with small bits was shaken in sterile water. The suspension was plated with the usual Walksmen base medium (used for Azatobacter) and the colonies developed were isolated and purified. The isolate was multiplied in N – free liquid medium and used for the spray. One hundred ml of spray solution with a count of 2.3 x 10^9 ml was diluted 10 times and sprayed in each lot of 13.5m².

In treatment having 2% urea, spray 1000 ml of 2% urea solution was sprayed per plot. After the leaf incorporation of *Eichhornia crassipes* and *Ipomoea carnea*, one week time was allowed before transplanting for proper decomposition of the green material applied. The fertilizer 60 kg N and 100 kg N/ha was applied in 3 splits, i.e., 25% as basal, 50% at maximum tillering stage and 25% at flowering time of the crop.

RESULTS AND DISCUSSION

The results presented in Table 1 reveal that highest grain yield (4.1 t/ha) was obtained where 100 kg N/ha was applied through urea which was on par with the yield recorded in treatments receiving 60 kg N/ha + *Eichhornia* leaf incorporation (3.8 t); 60 kg N/ha + *Ipomoea* leaf incorporation (3.9 t) and 60 kg N/ha + 2% urea spray (3.8 t). However the grain yields obtained in treatments 60 kg N with either *Eichhornia* leaf incorporation or *Ipomoea* leaf incorporation at 10 t/ha were significantly higher than the grain yield obtained in treatment 60 kg N/ha. This may be due to the addition of essential nutrients to the soil by the leaf incorporation of either *Eichhornia* or *Ipomoea* weeds which finally helped the increasing of grain yield. Further, the difference in grain yield between the treatments T_3, T_6 and T_4 was not significant. A similar trend was observed in the number of productive tillers per m^2.

The straw yield was highest in treatment 100 kg N/ha followed by 60 kg N/ha + *Ipomoea* leaf incorporation at 10 t/ha and 60 kg N/ha + *Eichhornia* leaf incorporation at 10 t/ha which were significantly superior to 60 kg N/ha, 60 kg N/ha + *Eichhornia* inoculum spray and 60 kg N/ha + 2% urea solution spray.

The 1000 grain weight was not affected significantly by various treatments.

It can be inferred from the above results, that the *Eichhornia* inoculum spray was found to be equivalent to 2% urea spray. It was also observed that the use of green manure of either *Eichhornia crassipes* and *Ipomoea carnea* weeds was found to be more advantageous than using of *Eichhornia* inoculum spray. The green leaf incorporation of either *Eichhornia crassipes* or *Ipomoea carnea* weeds at 10 t/ha can save 40 kg N/ha with no adverse effect on the grain yield or spread of these species as weeds. In tropical countries like India where these aquatic weeds are prevalent, they can be utilised for farm lands for improving the soil fertility. It also helps for cleaning of the choking drains, canals, tanks etc., from these troublesome weeds.

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PHYTOPATHOGENS AS WEED CONTROL AGENTS

DESHPANDE KALIDAS
Post-Graduate Department of Botany, Science College
Nanded 431 602, Maharashtra, India.

ABSTRACT

Efficacy of a phytopathogen or its metabolites as weed control agent depends upon its receptivity by leaf epidermal cells (when used as foliar spray) or its absorption on soil particles (when used as preemergence weed killer or as wilt inducing agent). Toxins from Helminthosporium, *Phoma sp.* and Fusaria induced wilt in *Parthenium hysterophorus, Xanthium strumarium* and striga sp. seedlings. When used as foliar sprays the Ht-toxin was inactivated. A spore germination inhibitor in leaf surface wax of Parthenium could be located.

Attempts were made to modify antifungal activity of leaf surface waxes and exudates. A water soluble germination inhibitor co-extracted with wax from *Parthenium* supported germination of spores when supplemented with glucose. Selective activation of leaf or root-surface microflora may trigger the mechanism for initiation of successful infection.

Control of *Parthenium* through foliar sprays of phytotoxins/phytopathogens needs a careful study of leaf components and a lesion in structural integrity of leaf-epidermis.

INTRODUCTION

Toxic substances produced by fungi and bacteria affect morphogenetic responses in plants and thus form an untapped reservoir of substances for induction of wilt, defoliation, desiccation, etc. in test plants. Practical use of phytopathogens or their metabolites in weed control has not yet found wider acceptance (Daniel et al. 1973; Hasan, 1974). Selecting three noxious weeds, *Parthenium hysterophorus* L., *Xanthium strumarium* and *Striga jesneroides,* experiments were conducted to test efficacy of toxic metabolites of selected strains of four phytopathogens *Helminthosporium, Alternaria, Phoma* and *Fusarium* as weed killing agents.

Table 1: Wilt induction in weeds by phytopathogenic toxins. Time taken for wilting.

Source of toxin	*Parthenium hysterophorus*		*Xanthium strumarium*		*Striga jesneroides*	
	*BC	**SC	BC	SC	BC	SC
Helminthosporium tritici-repentis	+36	36	8	8	11	11
H. apatternæ	36	36	8	8	not tested	
H. ι.venæ	36	36	8	8	–do–	
H. proliferatum	36	36	8	8	–do–	
Alternaria solani	36	36	8	8	–do–	
Phoma exiqua	36	36	8	6	–do–	
Furarium moniliformæ	6	5	7	6	6	5

* BC = batch cultures; ** SC = shake cultures; + = time in hours.

Table 2 : Efficacy of toxin from *H. tritici repentis* as foliar spray against weeds.

Days after spray	Effect on *Xanthium*	Effect on *Parthenium*
1	No visible effect	No visible effect
2-3	Leaf margins black	– do –
4	Leaves show water soaked soft patches	– do –
5	Inward rolling of leaves	– do –
6	Desiccation/Necrosis	– do –
7-8	Wilt	– do –

Table 3 : Effect of extract from *Parthenium hysterophorus* on germination of spores of *H. tritici repentis*.

Treatment	Percentage germination
Extract flower	
flower	25
leaves	28
stem	25
roots	28
control (DW)	80

RESULTS

Typical wilt symptoms developed in seedlings of the test weeds following treatment with toxic metabolites of all the seven pathogens (Table 1). The period of appearance of symptoms however varied in each case. Wilt developed in *X. strumarium* in 6-8 hours and in *S. jesneroides* in 5-11 hrs. *P. hysterophorus* gave a slow response to all pathogens except *F. moniliforme*, where seedlings wilted in 5-6 hours. Toxic metabolites of *H. tritici repentis*, *Phoma exigua* and *F. moniliforme* induced early wilting and were used in further studies.

Foliar sprays: Partially purified toxin of *H. tritici repentis* was sprayed on young seedlings of *Parthenium* and *Xanthium* in field. Data presented in Table 2 indicate that *Xanthium* responded well to the treatment and desiccation of leaves and death of the plants was evident in 6-8 hours. Sprays, However, were inactive against *Parthenium*.

A study of germination of spores of *H. tritici repentis* in extracts from flowers, leaves, stem and root indicated strong inhibition of germination. In another experiment polysaccharidase and protease activity in the vicinity of root-zone of *Parthenium* was measured viscometrically. Keratinase and polygalaturonase activity decreased near roots, CM Case activity remained unchanged and protease activity increased considerably. (Table 3 & 4).

Table 4 : Enzyme activity in soil rhizosphere of *P. hysterophorus*.

Substrate	Percentage soil zone	Viscosity reduction zone
Keratin	*42.5	18.5
Gelatin	25	60
Pectin	75	28.5
CMCellulose	40	40

% viscosity reduction of 1% solution.

DISCUSSION

The results thus indicated inactivation of the toxin at the leaf surface. Assuming that the toxin was bound by surface components, detached leaves were dewaxed and sprayed with toxic metabolites. Water soaked black spots developed beneath the droplets of toxin. Binding of toxin by leaf surface wax from *Parthenium* was also observed in another experiment. Tomato leaves and safflower leaves when coated with wax from *Parthenium* were protected from toxic metabolites of *Alternaria solani* and *A. carthami* respectively (Pappu, personal communication, 1979). A spore germination inhibitor was co-extracted with leaf surface wax. Sprays, when supplemented with glucose allowed spore germination.

Soil enzyme activity owes its presence to its microbial content or to the plant cover. As such reduced polygalacturonase and keratinase activity indicated antimicrobial activity or presence of enzyme inhibitors in root zone. High proteolytic activity appears to be significant. Weeds are known to affect soil-enzymes (Galstyan, 1961). *Sinapsis arvensis* and *Gypsophila elegans* reduced soil amylase activity by 50%, organic matter added to the soil is important in determining the activity gradients of soil enzymes. It may be possible to modify soil enzyme activity temporarily through organic amendments and upset the establishment of weed species.

Available evidence suggests that insensitivity in plants to phytotoxins is based on lack of reactive sites. In susceptible cells, toxin is bound to the toxin receptors, in resistant cells either it is not bound or is rapidly inactivated (Scheffer, 1976). It appears thus that breakdown of resistance in *Parthenium* to Ho-toxin is possible. The answer seems to be changed nuritional status of the foliage, rendering it more suitable a habitat for the pathogen or a lesion in the structure of the leaf epidermis/surface wax to magnify activity of the toxin. It is hoped that selective activation of leaf/root surface microflora may trigger the whole process of infection.

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DISTRIBUTION OF SOME *CARDUUS, CIRSIUM, ONOPORDUM* AND *SILYBUM* SPECIES IN NEW SOUTH WALES, AUSTRALIA

R. W. MEDD
Agricultural Research and Veterinary Centre
Forest Road, Orange, N. S. W. Australia-2800.

ABSTRACT

Several species of thistles are foremost among weeds causing concern in pastoral, cropping and non-agricultural land in New South Wales, Australia. A mail survey of the State undertaken in 1978 provided initial estimates of the distribution and abundance of *Carduus nutans* L. *spp. nutans*, nodding thistle, *C. pycnocephalus* L. and *C. tenuiflorus* Curt., slender thistles, *Onopordum acanthium* L. and *O. illyricum* L. Scotch and Illyrian thistles, *Cirsium vulgare* (Savi) Ten., spear thistle, and *Silybum marianum* (L.) Gærtn., variegated thistle. Their current distribution, importance and likely future spread within the State are discussed.

INTRODUCTION

Information on the area and distribution of weeds is a pre-requisite for assessing their importance. Like most weeds in New South Wales the importance of thistles has not been documented because of the lack of such information.

This paper presents the results of a subjective survey of the distribution and abundance in N. S. W. of some thistle species, all of which are of European origin. None of the species surveyed have beneficial or marketable value despite the intentional introduction of some species by pioneers for ornamental and medicinal purposes.

SURVEY METHODS

During summer 1977–78, District Agronomists with the Department of Agriculture, N. S. W., were requested to map the distribution of thistles within their "district". Separate maps were requested for each of the following: *Carduus nutans, C. tenuiflorus/C. pycnocephalus* (regarded herein as one), *Onopordum acanthium/O. illyricum* (regarded herein as one), *Cirsium vulgare* and *Silybum marianum*. Officers were asked to map the abundance of each species according to the scale: Category 1 = does not occur; 2 = scattered isolated plants with small colonies up to one hectare; 3 = scattered plants with discontinuous colonies greater than one hectare but less than 50 hectares; 4 = continuous dense infestations greater than 50 hectares.

The Local Government areas defined in N. S. W. are divided among 49 agronomists such that each has a defined "district" in which he is responsible for extension of technical information pertaining to crop and pastoral agriculture. Because thistle problems tend to be seasonal and vary greatly with management, officers mapped the general problems based on their specialised knowledge. Thus the results reflect overall impressions rather than detailed distribution of species in the year surveyed although the survey was timed to coincide with a period of conspicuous thistle growth.

Table 1: Area of land in N. S. W. infested with *Curduus nutans ssp. nutans.*

Statistical Agricultural Area	Category of Abundance			
	1	2 (km²)	3	4
Northern Coastal	35975	–	–	–
Central Coastal	29026	1802	–	–
Sydney and Southern Coastal	26514	–	–	–
Northern Tableland	14500	19018	258	316
Central and Southern Tableland	39433	20510	664	104
Northern Slope	61876	6453	–	–
Central Slope	45234	–	–	–
Southern Slope	42717	377	–	–
Northern Plains	88943	–	–	–
Southern Plains	62844	–	–	–
Western Plains	300973	–	–	–
Total	748035	48250	922	420

Table 2: Area of land in N. S. W. infested with *Carduus tenuiflorus* and *C. pycnocephalus*

Statistical Agricultural Area	Category of Abundance			
	1	2 (km²)	3	4
Northern Coastal	20998	14977	–	–
Central Coastal	21105	9723	–	–
Sydney and Southern Coastal	15193	11321	–	–
Northern Tableland	13619	20563	–	–
Central and Southern Tableland	6150	54561	–	–
Northern Slope	47854	20475	–	–
Central Slope	29889	15347	–	–
Southern Slope	18670	24423	–	–
Northern Plains	87196	1746	–	–
Southern Plains	57062	5782	–	–
Western Plains	300838	135	–	–
Total	618574	179053	–	–

All officers replied and information for each species has been collated on a statewide basis. The area for each class of infestation by species was calculated by planimetry and collated for 11 subdivisions used by the Commonwealth Bureau of Census and Statistics.

RESULTS AND DISCUSSION

Carduus nutans ssp. nutans

Infestations of *C. nutans* were confined to the tablelands and slopes apart from an area in the Barrington Tops (Scone Shire, designated as Central Coastal) (Table 1).

C. nutans, being first identified in N. S. W., in the late 1940's, is now distributed over almost 50,000 km², approx. 3% of which is moderately to heavily infested. The weed, first recognised on the central, southern and northern tablelands has spread within and become one of the more important weeds of improved pastures in those areas. Efforts to control *C. nutans* have had limited success, evidenced by its spread into the northern and southern slopes (Table 1), although suitable techniques are available (Medd, 1979). Based on its climatic requirements for growth and reproduction Medd and Smith (1978) predicted that *C. nutans* could infest areas to the east and west of its present distribution.

Carduus tenuiflorus and *Carduus pycnocephalus*

Distribution of the closely related annual species *C. tenuiflorus* and *C. pycnocephalus*, differentiated by Parsons (1979), encompassed most of the eastern half of the State (Table 2). Although the survey showed only scattered plants with infestations < 1 ha (Category 2) heavier infestations of category 3 and probably 4 oc-

Table 3: Area of land in N. S. W. infested with *Onopordum acanthium* and *O. illyricum*.

Statistical Agricultural Area	Category of Abundance 1	2 (km²)	3	4
Northern Coastal	35975	–	–	–
Central Coastal	30829	–	–	–
Sydney and Southern Coastal	24424	1809	281	–
Northern Tableland	31226	2956	–	–
Central and Southern Tableland	22470	31389	6563	288
Northern Slope	35591	32739	–	–
Central Slope	29806	15428	–	–
Southern Slope	11685	24115	7293	–
Northern Plains	34421	54522	–	–
Southern Plains	40282	20367	2194	–
Western Plains	299716	1256	–	–
Total	596425	184581	16331	288

Table 4: Area of land in N. S. W. infested with *Silybum marianum*.

Statistical Agricultural Area	Category of Abundance 1	2 (km²)	3	4
Northern Coastal	20998	14977	–	–
Central Coastal	8398	12845	9586	–
Sydney and Southern Coastal	16896	9108	510	–
Northern Tableland	12185	21997	–	–
Central and Southern Tableland	4157	41920	14633	–
Northern Slope	3683	35720	28926	–
Central Slope	28563	11957	4714	–
Southern Slope	15066	21649	5976	402
Northern Plains	31100	48616	9226	–
Southern Plains	24302	38542	–	–
Western Plains	273152	27821	–	–
Total	438500	285152	73571	402

cur in parts of the central and southern tablelands in favourable years.

Onopordum acanthium and *Onopordum illyricum*

Both *O. acanthium* and *O. illyricum* were most probably intentionally introduced as ornamentals in the early/mid 1800's. *O. illyricum* differs from *O. acanthium* in its conspicuously broader bracts which taper gradually into a short spine. Their distribution was concentrated in south eastern N. S. W. (Table 3). In common with a group of species, *e.g., Echium plantagineum* L., Paterson's curse, *Nassella trichotoma* (Nees) Arech., serrated tussock and *Hypericum perforatum* L., St. John's wort, the *Onopordum* species were only sparsely distributed in the northern parts of the state.

The *Onopordum* species did not occur east of the Great Dividing Range, like *Carduus nutans*, and extended further westward than *C. tenuiflorus*/*C. pycnocephalus*.

Onopordum species, compared with the other thistles surveyed, appear to spread more slowly, due possibly to their heavy seed and short pappus hairs. Dispersal is effected by wind shaking mature seeds from heads and by livestock.

Silybum marianum

S. marianum occurred sporadically in coastal areas and in the eastern fringe of the western plains; denser infestations were only prevalent throughout the slopes and tablelands (Table 4).

S. marianum, like the *Onopordum* species was most probably intentionally introduced during early settlement and had become widespread by the 1900's. Its

Table 5: Area of land in N. S. W. infested with *Cirsium vulgare.*

Statistical Agricultural Area	Category of Abundance (km^2)			
	1	2	3	4
Northern Coastal	–	34660	1314	–
Central Coastal	3140	27688	–	–
Sydney and Southern Coastal	4950	21564	–	–
Northern Tableland	–	16779	16640	763
Central and Southern Tableland	114	46099	14110	387
Northern Slope	13079	50007	5242	–
Central Slope	15736	24808	4691	–
Southern Slope	–	38945	4148	–
Northern Plains	52646	35547	751	–
Southern Plains	19952	27046	15845	·
Western Plains	226117	74856	–	–
Total	335734	397999	62741	1150

Its dispersal has presumably occurred through contaminated fodder and movement of livestock since its large seed is not well adapted for wind dispersal.

Although the other thistles occur throughout the wheat/sheep belt, only *S. marianum* has importance as a competitor of crops. Reasons for this include its vigorous vegetative growth during spring, large rosette and annual life cycle.

In pastoral situations *S. marianum* particularly infests degraded pastures associated with fertile soils. Whilst reputedly having moderate feed value, it may cause nitrate poisoning in stock.

Cirsium vulgare

The seed of *C. vulgare,* with its compound pappus, is well adapted for wind dispersal and this has resulted in its widespread but sporadic abundance (category 2) in all regions of the State (Table 5). In contrast with the other species studied it occurred in the far north coastal area, was more abundant throughout the eastern coastal regions and extended further west into the plains but dense infestations were confined to the slopes and tablelands.

It was most probably accidentally introduced during early settlement and had become widespread by 1920, evidenced by its noxious proclamation in 48 municipalities and 8 shires.

Being the most widespread species it is potentially more important to the grazing industry where its greatest impact is probably as a contaminant of wool and as a pasture competitor.

CONCLUSIONS

With the exception of *Carduus nutans* the species studied have probably reached the limits of their potential distribution. Their early introduction, coupled with extensive movement of fodder and livestock "on hoof" as well as spread by natural agents would seemingly have ensured their dispersal to all areas of the state.

Agricultural practices have contributed to thistle abundance, particularly since the 1940's, coinciding with extensive use of clover and superphosphate. Whilst principles for the cultural control of thistles are well established (Michael 1968*a*, *b*; Medd 1979), failure to adopt long term control practices must inevitably result in an intensification of thistle abundance.

The ranges of species overlap, particularly throughout the tablelands and slopes. Whilst each species has climatic/edaphic requirements which influence their distribution, all but the far thistles. Using the growth index concept of Fitzpatrick and Nix (1970) the area bounded by their <0.2 isopleth[1] coincides closely with the western extremity of *Silybum marianum, Onopordum* species and *Cirsium vulgare* found in the survey. The western limit of the *Carduus* species lies approximately mid-way between 0.2 and 0.4 isopleths. Areas in which the thistles are presently most abundant coincide with the zone surrounding the 0.4 isopleth which encompasses the tablelands and near slopes. It is within this zone that an increase in the abundance of thistles is most probable. The eastern coastal zone with a favourable climatic index of>0.6 precludes, for reasons which are unclear, all but *Cirsium vulgare.* However, whilst areas may appear favourable for growth they may fail to induce reproduction and hence limit the range of a species. Thus specific requirements for reproductive initiation also need to be considered, as discussed by Medd and Smith (1978) for *Carduus nutans,* to define ecological range. Edaphic factors could similarly influence the ecological range of species but suitable techniques to analyse such have not yet been developed.

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ARTHROPODS AND NEMATODES HOSTED BY THE WORLD'S WORST PERENNIAL WEEDS

LEO E. BENDIXEN .
Department of Agronomy, Ohio State Univerisry, 1885 Neil Avenue
Columbus, Ohio 43210 USA.

ABSTRACT

Sixty families of plants were represented by the weeds reportedly serving as hosts of arthropods affecting crops as tabulated in our annotated bibliography on weeds as reservoirs for arthropods affecting crops. More than 70 families of arthropods affecting crops were reported as being hosted by weeds. More than 25 families of plants were represented by the weeds reportedly serving as hosts of nematodes affecting crops as tabulated in our annotated bibliography on weeds as reservoirs for nematodes affecting crops. More than 20 genera of nematodes affecting crops were reported as being hosted by weeds. Seven of the world's worst weeds identified by Holm *et al.* are perennials. *Cyperus rotundus* has been reported to host 7 species of arthropods and 19 species of nematodes affecting crops; *Cynodon dactylon*, 11 and 12 species, respectively; *Sorghum halepense*, 7 and 10 species, respectively; *Imperata cylindrica*, 5 and zero species, respectively; *Convolvulus arvensis*, 7 and 5 species, respectively; *Cyperus-esculentus*, 4 and 6 species, respectively; and *Paspalum conjugatum*, 1 species of nematode. The role of these weeds as hosts of other destructive organisms, in addition to their role as competitors with crops, increase the urgency of weed control.

INTRODUCTION

The world's worst weeds were identified by Holm *et al.* (1977) on the basis of their prevalence and seriousness as competitors with crops, which is rightfully a matter of much concern. Weeds may play an equally significant though indirect and, therefore, inconspicuous role in hosting such destructive organisms as arthropods, nematodes, pathogens, and vertebrates. In their role as hosts, weeds serve as reservoirs and maintain a population of these organisms in the absence of crop hosts, available to invade susceptible crops when planted.

Annotated Bibliographies

Annotated bibliographies have been published on weeds as reservoirs for arthropodes (Bendixen *et al.* 1981) and for nematodes (Bendixen *et al.* 1979) affecting crops. Sixty families of plants were represented by the weeds reportedly serving as hosts of arthropods affecting crops. Weed species classified in the Gramineæ family were reported far oftener than any other; next was Compositæ; then Leguminosæ, Solanaceæ, Malvaceæ, Chenopodiaceæ, Cruciferæ, Amaranthaceæ, Cyperaceæ and Polygonaceae.

More than 70 families of arthropods affecting crops were reported as being hosted by weeds. Those reported most frequently were Aphididæ, Noctuidæ, Curculionidæ and Chrysomelidæ; less frequently were Pentatomidæ, Thripidæ, Cicadellidæ and Tetranychidæ.

More than 25 families of plants were represented by the weed reportedly serving as hosts of nematodes affecting crops. Weed species classified among the Compositæ and Gramineæ families were most numerous. Next most numerous were weed species classified among the Cruciferæ, Cyperaceæ, Scrophulariaceæ, Leguminosæ, Polygonaceæ, Chenopodiaceæ and Amaranthaceæ families.

Of the more than 200 genera of plant

parasitic nematodes, 50 of which affect crops, more than 20 genera were reported as being hosted by weeds. This list includes the most destructive of the nematode genera. For example: *Meloidogyne*, the root-knot nematode, which reportedly causes the most damage to crops worldwide, is hosted by *Cyperus spp., Sorghum halepense,* and *Amaranthus spp., Pratylenchus,* the root lesion nematode, is hosted by *Sorghum halepense, Echinochloa crus-galli,* and *Digitaria spp.*, and *Heterodera,* the cyst nematode, is hosted by *Chenopodium alba, Polygonum spp.* and *Brassica spp.*

Using this annotated bibliography on nematodes as a base, (Manuel *et al.* 1980) have published a report of weed hosts of *Pratylenchus* and are preparing a report on weed hosts of *Heterodera.*

Perennial weed hosts

Seven of the world's worst weeds are perennial. They reportedly host 25 species of arthropods and 27 species of nematodes affecting crops. *Cyperus rotundus,* the world's worst weed, reportedly hosts 7 species of arthropods: *Ferrisia virgata, Macrosiphum avenae, Rhopalosiphum padi, Spathosternum prasiniferum, Spodoptera (Cirphis) compta, Truxalis grandis grandis* and unidentified leafhoppers.

Cyperus rotundus also reportedly hosts the cyst nematode *Heterodera marioni;* the root-knot nematode *Meloidogyne incognita;* and the root lesion nematodes *Pratylenchus branchyrus, P. coffeae,* and *P. pratensis;* plus 14 other species of nematodes: *Anguillulina spp., Anguina spp., Aphelenchus avenae, Belonolaimus longicaudatus, Criconemoides onoensis, Ditylenchus spp., Rotylenchus multicinctus, Trichodorus christiei, Tylenchus spp.* and other unidentified species of *Pratylenchus, Rotylenchus,* and *Trichodorus.*

Cynodon dactylon, the world's second most serious weed, reportedly hosts 11 species of arthropods affecting crops: *Ferrisia virgata, Haplaxius crudus, Hydrellia philippina, Petrobia latens, Pyrgomorpha conica, Schizaphis graminum, Schizotetranychus andropogoni, Spathosternum prasiniferum, Spodoptera (Cirphis) compta, Tetranychus yusti,* and *Truxalis grandis grandis.*

Additionally, *Cynodon dactylon* is reported to host the cyst nematode *Heterodera marioni;* the rot-knot nematode*Meloidogyne incognita;* and the root lesion nematodes *Pratylenchus brachyurus, P. coffeae, P. hexincisus, P. neglectus, P. penetrans, P. thornei,* and *P. zeae;* plus 3 other species: *Belonolaimus gracilis, Hoplolaimus columbus,* and *Trichodorus christiei.*

The third most serious perennial weed is *Sorghum halepense* and ranks sixth amongst the world's worst weeds. It is reported to host 7 species of arthropods affecting crops: *Anthonomus grandis, Contarinia sorghicola, Oligonychus indicus, Schizaphis graminum, Schizotetranychus andropogoni, Spathosternum prasiniferum* and *Atherigona soccata.*

Sorghum halepense also reportedly hosts the 3 most destructive nematode genera, as did the 2 previously described weed species: the cyst nematode, *Heterodera marioni;* the root-knot nematode *Meloidogyne incognita;* and the root lesion nematodes *Pratylenchus brachyurus, P. hexincisus, P. neglectus, P. thornei,* and *P. zeae.* Additionally, it is reported to host *Hopolaimus columbus, Trichodorus sp.* and *Tylenchorhynchus martini.*

One might suppose that *Imperata cylindrica* had not been studied extensively as a host since no nematode and only 5 arthropod species affecting crops were reported as being hosted by this weed. The arthropods report to be hosted are: *Aphanisticus peninsula, Leonondra vittata, Melanitis leda, Pyrgomorpha conica* and *Schizotetranychus andropogoni.*

The world's most serious perennial dicotyledonous weed is *Convolvulus arvensis.* It is reported to host 7 arthropod and 5 nematode species. The species of arthropods include: *Aphis gossypii, Cassida* spp., *Chaetocnema basalis, Euxoa ochrogaster, Petrobia latens, Spodoptera littoralis,* and *Tetranychus urticae.* The nematodes include: *Anguillulina dipsaci, Aphelenchoides ritzemabosi,* and *Ditylenchus dipsaci,* plus the root-knot nematode *Meloidogyne hapla* and the root lesion nematode *Pratylenchus penetrans.*

Cyperus esculentus reportedly hosts but one-half as many species of arthropods and one-third as many species of nematodes as hosted by *Cyperus rotundus.* The arthropods are: *Haplaxius crudus, Macrosiphum avenæ, Rhopalosiphum padi,* and *Tetranychus yusti.* The nematodes are: *Criconemoides onoensis, Hoplolaimus columbus, Trichodorus sp.,* the cyst nematode *Heterodera mothi,* the root-knot nematode *Meloidogyne incognita,* and the root lesion nematode *Pratylenchus brachyurus.*

Apparently *Paspalum conjugatum* is either repulsive or has not been studied extensively as a host since no arthropod and but one nematode species was reported. The species was *Pratylenchus coffeæ.*

A word of caution is warranted regarding reports on weeds as hosts of other organisms. There is non-uniformity in identifying hosts, ranging from observation of an organism in the vicinity of a plant, which is then identified as a host, to the completion of the life cycle in isolation on a host plant. We relied on the judgement of the authors reporting their research in identifying hosts. One would appropriately conduct ones own screening tests for verification in pursuing research of this nature.

Notwithstanding this uncertainty of specific credibility, the world's worst perennial weeds have the potential of perpetuating enormous unwanted problems in hosting arthropods, nematodes, and other organisms affecting crops. Rotations to non-host crops are of limited value in reducing populations of hosted organisms if host weeds are permitted to persist. Following is also of limited value if host weeds persist. Effort and resources expended in weed control, are rewarded in reduced competition with the crop and in reduced impact from hosted organisms. Weed science and weed control research would appropriately move beyond the bounds of vertically integrated, monodisciplinary activities. Horizontally integrated, multidisciplinary activities in crop protection are awaiting the involvement of weed scientists. It is now our turn to act.

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TAXONOMY OF *CARDUUS NUTANS* IN NORTH EASTERN NEW SOUTH WALES, AUSTRALIA

R. W. MEDD
Agricultural Research & Veterinary Centre, Forest Road
Orange, New South Wales, Australia 2800.

ABSTRACT

Carduus nutans is a complex taxonomic group of European origin. Two taxa of the group have previously been recorded to occur in northern New South Wales. A survey and quantitative study of specimens collected throughout the region revealed only one taxon of the group, *Carduus nutans* L. *ssp. nutans*, nodding thistle, was present.

INTRODUCTION

In the most recent comprehensive study of the genus *Carduus*, Kazmi (1964) distinguished seven species generally referred to as *C. nutans* L. s. lat. Doing *et al.* (1969) reported two taxa of the group, *C. nutans* L. *ssp. nutans* and *C. thoermeri* Weinm. *ssp. thoermeri* occurred in north eastern New South Wales but cited no specimens from the area of the latter taxon. Both weeds are exotic to Australia (Kleinschmidt and Johnson, 1977; Medd, 1981).

The study reported here was undertaken to clarify whether both entities ocurred within the region because there were no recorded collections of *C. thoermeri* and only a few of *C. nutans* from the area.

METHODS

All farms in the region reported in local government inspection records as having infestations of *C. nutans* were surveyed in 1973. Flowering specimens were collected from 65 farms in the Severn, Dumaresq, Uralla, Guyra and Walcha Shires. On another 33 farms suitable specimens could not be obtained because control had been effective.

Measurements were made of flower head diameter, involucral bract dimensions and shape (Fig. 1), floret dimensions, pappus length and the degree of leaf dissection (pinnatified ratio, Fig. 2).

The descriptions given by Kazmi (1964) were followed to identify the specimens collected throughout the region.

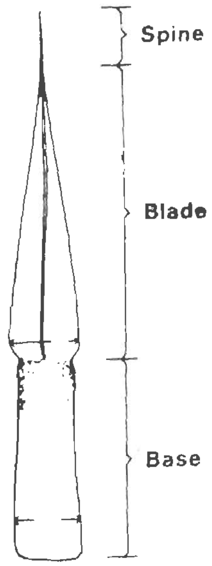

Fig. 1. Illustration of measurements taken on involucral bracts.

Table 1 : Measurements of characters on 65 mature thistle specimens.

	Mean and 99% C.L.	Range	Kazmi (1964)
Flower head diameter (cm)	2.2 ±0.16	1.2 - 4.0	2.0 - 4.0
Intermediate bract:			
- length (mm)	16.9 ± 1.0	13.0 - 26.0	7 - 25
- blade width (mm)	2.6 ±0.2	1.0 - 4.0	1.5 - 2.5
- blade length/length	0.59±0.02	0.40 - 0.70	≃0.5
- spine length (mm)	2.7 ±0.2	1.0 - 5.0	-
- base width/blade width	1.2 ±0.1	0.6 - 2.0	≃ 1.0
Corolla:			
- length (mm)	19.1 ±0.8	12.0 - 23.0	18.0 - 22.0
- narrow tube length (mm)	8.8 ±0.6	3.0 - 12.0	9.0 - 11.0
Pappus length (mm)	15.3 ±0.9	6.0 - 19.0	15.0 - 20.0
Leaf pinnatifid ratio	0.75±0.04	0.4 - 1.0	≃ 0.83

dimensions, pappus length and the degree of leaf dissection (pinnatified ratio, Fig. 2).

The descriptions given by Kazmi (1964) were followed to identify the specimens collected throughout the region.

RESULTS AND DISCUSSION

Features distinguishing the two taxa in question, summarized by Doing *et al.* (1969), include head diameter and the shape and dimensions of the intermediate involucral bracts. *C. thoermeri spp. thoermeri* has flower heads 3 to 8 mm dia. with bracts to 10 mm wide at the base, the base being narrower and shorter than the blade which tapers abruptly to a rigid spine. *C. nutans spp. nutans* has heads 2 to 4 cm dia. and the bases of the bracts are broader than the blades which taper gradually to a rigid spine.

Fig. 2. Magnitude of dissection in lower to middle cauline leaves expressed as in pinnatified ratio

In the specimens studied the flower head was 2.2±0.16 cm dia. and the base of the brackts was broader than the blade (Table 1). Based on these two characters, all the specimens studied were identified as *C. nutans ssp. nutans.* The means of the other characters measured generally accord with those given by Kazmi *loc. cit.* for the taxon (Table 1).

The range in some characters exceeded those nominated in Kazmi's description viz., both limits for bract blade width and corolla length, lower limits for head diameter and pappus length and lower limit for bract length. These departures may describe variation due to environmental factors and stage of maturity, since samples were not grown in a uniform environment.

The identity of 12 specimens covering the phenotypic range has been substantiated with determinations by Kazmi (personal communication) and these along with a selection of other specimens used in the study are housed in the National Herbarium of N. S. W., Sydney.

CONCLUSION

Analysis of thistle specimens collected throughout north eastern N. S. W. revealed that only one taxon of the *C. nutans* group was present namely *C. nutans* L. *spp. nutans*. A previous report – seemingly unsupported – of the occurrence in the region of *C. thoermeri ssp. thoermeri* was not verified and it appears that distribution of this taxon is confined in Australia to south eastern Queensland.

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GROWTH AND DEVELOPMENT OF *PHALARIS MINOR* RETZ., *CHENOPODIUM ALBUM* AND *MELILOTUS INDICA* ALL. IN WHEAT CROP ECOSYSTEM

H. S. GILL and SAT PAUL MEHRA
Punjab Agricultural University, Ludhiana (Punjab), India.

ABSTRACT

In field studies conducted during 1978-79, 1979-80 and 1980-81, the influence of wheat genotypes of different stature i.e. tall, medium and dwarf on the growth and development of *Phalaris minor* Retz., *Chenopodium album* and *Melilotus indica* was studied. The tall wheat genotype (plant height about 115 cm) exerted a strong suppressing effect on the weed intensity (population & dry matter) and height of these weeds. The three gene dwarf wheat genotypes proved very favourable for the growth and development of these weed species. The desirability of an effective weed control programme is discussed.

INTRODUCTION

Under natural field conditions, seeds of *Phalaris minor* Retz. (Canary grass), *Chenopodium album* L. (Lamb's quarter) and *Melilotus indica* All. (yellow sweet clover) which are typical winter season weeds, do not germinate in summer and stay dormant till temperature conditions become favourable for their germination from end of October onwards. *Phalaris* is a major weed in irrigated wheat in Punjab and has been reported to reduce the wheat yield by 51.0 per cent (Gill & Walia, 1979). All the weed control methods - chemical, mechanical/cultural are directed towards shifting the growth margin in favour of the crop plants so as to exert a strong smothering effect on weeds. By advancing the date of sowing wheat to mid October or so when *Phalaris* seeds are still under temperature induced seed dormancy, wheat can assume a meaningful growth superiority over later emerging *Phalaris* plants and thus, the crop may be in a better position to suppress the growth and development of *Phalaris* and other weeds. Further, 2-gene and 3-gene dwarf wheat cultivars have become increasingly popular due to their higher yield potential compared with single gene indigenous tall cultivars. A study of the infuence of height of wheat genotypes of different stature on the growth of *Phalaris* may generate some information on the increasing density of this weed, particularly in three gene dwarf wheat in irrigated North-Western Plain Zone comprising Punjab, Haryana and Uttar Pradesh.

In view of this, field experiment on permanent plot basis was planned to study the influence of wheat cultivars of different stature sown on different dates on the growth and development of *P. minor*, *C. album* and *M. indica*.

MATERIAL AND METHODS

These field studies were conducted in the Punjab Agricultural University, Ludhiana (India) during 1978-79, 1979-80 and 1980-81. The soil was a loamy sand with the following physical and chemical characteristics:

Soil depth (cm)	Percent			pH	Organic carbon (%)
	Sand	Silt	Clay		
0 – 15	90	7	3	8.3	0.2

The field had natural infestation of all the three weed species under study. The experiment was laid out in split-plot design with five dates of sowing (details given in Table 1-2) in the main plots and wheat cultivars (C 306, W.711, W. 903/W. 1562) in the sub-plots and all the treatments were replicated four times. The growth habit of wheat cultivars was as under:

Wheat cultivars	Growth habit
C 306	One gene, tall
W. 711	Two gene, semi-dwarf
W. 903/WL 1562	Three gene dwarf

The recommended dose of fertilizers was given i.e. for dwarf/ semi-dwarf cultivars 125 kg N, 62.5 kg P_2O_5 and 30 kg K_2O/ha and for tall cultivar (C 306) it was 50% less than that of dwarf/semi-dwarf genotypes. Full dose of phosphorus, potash and half dose of nitrogen was applied at the time of sowing and remaining half of nitrogen was applied with first irrigation (3-4 weeks after sowing). The crop was sown by *kera* method (dropping the seed behind the plough in the furrow) and a seed rate of 80 kg/ha was used, keeping seed rate per row constant. The gross plot size was 3.0 m x 8.0 m.

Phalaris intensity and height was recorded at the maturity stage of crop. In addition to this, data on *C. album* and *M. indica* were also recorded using a quadrat of 30 cm x 30 cm. The height of crop plants and *Phalaris* plants was recorded from ground level upto the base of ear head (peduncle) but in case of *C. album* and *M. indica* it was recorded up to the tip of apex of the main shoot.

RESULTS AND DISCUSSION

Effect on the growth and intensity of weeds

(a) Phalaris minor Retz. (Canary grass) The height of *P. minor* plants was significantly influenced by the type of wheat genotype. The height of *P. minor* growing in association with the single gene tall wheat genotype (C 306) was significantly less as compared to *Phalaris* plants growing in three gene dwarf wheat genotype (WL. 903) during 1978-79 (Table 1) and WL. 1562 during 1979-80 and 1980-81 (Table 2). The tall genotype reduced the height of *P. minor* plants by 15.3%. Similar findings have been reported by Paul and Gill (1979). In our present studies, the difference in height of *P. minor* when growing in association with 2 gene and 3 gene dwarf genotypes was not materially different. However, due to a distinct difference of 22.5 cm (Table 1) in the plant height of 2 gene and 3 gene wheat genotypes (in favour of the 2 gene semi dwarf) the *Phalaris* plants grow out well above the crop line and get enough space and light for its growth and development. Likewise the number of tillers/plant of *Phalaris* was also favourably influenced by the semi-dwarf/dwarf wheat genotypes.

The dry weight of *Phalaris* per plant was significantly lower when growing in tall wheat genotype than in 2 gene and 3 gene dwarf wheat cultivars (Table 1 & 2). The value of this parameter was significantly higher in the medium dwarf than the tall genotype. These data thus indicate that the dwarfness of the wheat genotypes favourably influences the growth of this weed.

The number of panicles/m^2 of *Phalaris* was lowest in case of first sowing of

Table 1 : Effect of dates of sowing and wheat genotypes on the growth of weeds and crop at maturity stage of the crop (1978-79).

Treatments	No of *P. minor* panicles m^{-2}	Plant height of *phalaris*	Dry wt. per plant of *phalaris*	Population of *C.album* m^{-2}	Population of *M.Indica* per sqm	Dry wt./ plant of Melilotus (g)	Crop plant height (cm)
Dates of sowing 1978							
October 24, 1978	16	82.1	2.39	22	18	4.09	83.7
November 11	26	86.6	2.22	21	19	2.16	87.4
November 23	19	76.4	1.90	19	19	2.65	81.7
December 8	26	76.8	1.95	19	23	2.29	72.2
December 23	21	75.0	2.71	29	25	5.02	55.6
L.S.D. at 0.05	N.S	6.0	N.S.	N.S.	N.S.	N.S.	7.6
Weed cultivars							
C 306	13	69.8	1.37	17	13	2.22	94.4
WL 711	16	84.8	1.84	19	18	2.28	79.1
WL 903	36	82.4	3.48	31	31	5.23	56.6
L.S.D at 0.05	5.0	7.0	0.36	6	10	1.34	4.1

Table 2 : Effect of dates of sowing and wheat genotypes on the growth of *Phalaris minor* and crop at maturity (1979-80 and 1980-81).

Treatments	No. of *Phalaris* panicles (m^{-2})			Plant height of *phalaris* (cm)			No. of tillers per plant of *phalaris* (including main shoot			Dry wt. per plant of *phalaris* (g)			Crop plant height (cm)		
	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean
Dates of sowing															
October 15	8	9	8.5	79.4	68.9	74.1	2.0	2.1	2.05	4.10	4.25	4.17	86.8	85.8	86.3
October 30	9	55	32.0	80.5	95.4	87.9	1.8	2.0	1.90	5.66	4.01	4.83	89.9	88.2	89.0
November 14	9	53	31.0	85.6	105.2	95.4	1.9	2.0	1.95	9.24	5.04	7.14	86.2	89.3	87.8
November 29	8	44	26.0	82.7	88.4	85.5	1.7	3.0	2.35	8.89	3.45	6.17	84.7	86.9	85.8
December 14	9	33	21.0	73.5	66.6	70.0	1.9	2.7	2.30	7.03	2.17	4.60	84.8	82.5	83.6
L.S.D. at 0.05	N.S.	N.S.	–	N.S.	15.9	–	N.S.	0.7	–	1.19	N.S.	–	N.S.	5.1	–
Wheat cultivars															
C 306	5	2	3.5	66.3	65.3	65.8	1.3	1.8	1.55	4.09	2.75	3.82	114.9	111.5	113.2
WL 711	8	8	8.0	82.9	88.9	85.8	1.7	2.4	2.05	6.85	3.31	5.08	83.7	87.3	85.5
WL 1562	13	29	21.0	91.8	100.6	96.2	1.9	2.8	2.35	10.02	5.30	7.66	60.9	60.9	60.9
L.S.D. at 0.05	2	6	–	8.5	12.8	–	N.S	0.4	–	1.02	1.57	–	4.6	3.8	–

Table 3: **Effect of dates of sowing and wheat genotypes on the growth of** *C. album* **and** *Melilotus* (1979-80 and 1980-81).

Treatments	Chenopodium album: Population/m² at harvest			Plant height (cm)			Dry wt/plant (g)			Melilotus sp.: Population/m²			Plant height (cm)			Dry wt/plant		
	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean	79-80	80-81	Mean
Dates of sowing																		
October 15	20	53	36.5	77.9	96.5	87.2	6.08	24.13	15.10	10	8	9.0	59.8	66.5	63.1	5.73	4.42	5.08
October 30	15	22	18.5	87.8	78.6	83.2	8.33	8.95	8.64	13	14	13.5	69.8	85.2	77.5	7.83	4.63	6.23
November 14	13	12	12.5	74.1	64.7	69.4	8.5	5.98	7.24	10	3	6.5	58.8	64.8	61.8	8.11	1.90	5.00
November 29	12	13	12.5	74.3	58.9	66.6	8.19	7.44	7.81	9	1	5.0	59.4	44.8	52.1	7.23	1.86	4.54
December 14	12	1	6.5	81.9	37.5	59.7	7.43	2.25	4.84	8	1	4.5	56.0	35.1	45.5	5.08	1.69	3.38
L.S.D. at 0.05	5	32	–	N.S.	14.4	–	N.S.	8.42	–	N.S.	14	–	N.S.	25.3	–	2.18	2.52	–
Wheat cultivars																		
C 306	11	11	11.0	72.1	52.0	62.0	54.4	7.73	6.58	8	4	6.0	51.6	54.1	52.8	5.01	2.30	3.65
WL 711	13	18	15.5	81.8	62.0	71.9	7.68	10.14	8.91	8	2	5.0	64.8	57.8	61.3	5.40	2.99	4.19
WL 1562	19	32	25.5	83.6	74.0	78.8	10.01	11.94	10.97	15	9	12.0	65.8	65.8	65.8	9.98	3.46	6.72
L.S.D. at 0.05	2	9	–	6.6	10.0	–	2.30	3.14	–	3	N.S.	–	N.S.	N.S.	–	2.35	N.S.	–

wheat on October 24 (Table 1). The differences in the number of panicles of *P. minor*/m^2 at maturity were rather inconsistent; however, first date of sowing i.e. mid October had the lowest number of *P. minor* panicles/m^2 (Table 2). It appears that early development of foliar mass of wheat under first sowing asserts an inhibitory effect on the emergence/development of *Phalaris* plants. The differences in the height of *Phalaris* were in favour of early sowing and the *Phalaris* plants had lowest plant height in case of December sowing.

(b) *C. album* L. (Lamb's quarter) and *M. Indica* All. (Yellow sweet clover)

The population of these weeds was also greatly influenced by the type of wheat genotype, their number being significantly higher when growing in association with 3 gene dwarf wheat genotypes (WL. 903 & WL. 1562). The dry weight per plant of these weed species was also significantly higher when growing in the three gene dwarf wheat genotype (Table 3). These data thus convincingly show that crop genotypes with reduced plant height favourably influenced the growth of *C. album* plants growing in different crop genotypes were significant; it being significantly higher when growing in three gene dwarf wheat genotypes compared to its height in the tall genotype (C 306). The height of *Melilotus* was also favourably infuenced by the 3 gene dwarf wheat genotypes.

These data on the growth and development of *P. minor, C. album* and *M. indica* growing in association with wheat genotypes of different stature show that the 3 gene dwarf wheat genotypes are mot conducive for rank weed growth. Due to their better yield potential, the wheat breeder has shown keen interest in developing three gene dwarf wheat cultivars since they are reponsive to higher levels of fertilizers and irrigations and are resistant to lodging as well. However, it may be pointed out that in the absence of an effective weed control programme in dwarf/semi-dwarf wheat cultivars, the maximum yield potential of these cultivars may not be possible to attain. Based on our present investigations, three gene dwarf wheat genotypes have proved most conducive for the growth and development of *Phalaris, C. album* and *M. indica* which are dominant weeds of this crop. It may be advisable to go in for medium dwarf varieties which combine a reasonably good level of yield and also adequately smoother the weeds. The tall genotypes though have good smothering potential, are comparatively low yielder.

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PREVALENCE OF *CHROMOLÆNA ODORATA* (L). R. M. KING AND ROBINSON UNDER DIFFERENT GRAZING INTENSITIES AND METHODS OF WEED CONTROL

A. C. CASTILLO, E. M. SENA, F. A. MOOG and
N. S. MENDOZA
Bureau of Animal Industry Research Division and Dow Chemical Pacific Ltd.,
Metromanila.

ABSTRACT

A 3 x 3 factorial experiment to determine the effects of three intensities of grazing (0.25, 0.5 and 1.0 animal unit/ha) and three methods of controlling *Chromolæna odorata*, "hagonoy" (control or no weeding, brushing and spraying with TORDON* 101) was done in Santos Ranch, San Jose, Mindoro Occidental. Changes in biomass of hagonoy and other species from different treatment were measured in one year period.

Intensity of grazing had no significant effects (P∠.05) on *C. odorata* and other component species of the pasture sward while methods of control had highly (P∠.01) significant effects. No significant interaction between intensity of grazing and methods of weed control was observed.

C. odorata components of the pasture sward was significantly (P∠.01) reduced both by brushing and spraying TORDON* 101. With reduced stand of *C. odorata* in the pasture sward, the grass component significantly increased. There was no change in the legume (particularly *Calopogonium mucuniodes Aesv.)* composition in the different treatments. After one year, *C. odorata* biomass on the brushed and TORDON* 101 treated swards was two and eight times lower than that of the control plots, respectively.

INTRODUCTION

Chromolæna odorata (L.) King and Robinson (Eupatorium), is one of the most obnoxious weed species present in pasture land. Continuous invasion of this weed in natural grazing grounds results to subsequent decrease in carrying capacity of native pastures. This prompted authorities to devise an effective grazing management system for recommendation to livestock raisers in affected areas from phasing out. Authorities feel that for the recommendation to become effective, it must take into consideration all factors which affect *C. odorata's* prevalence. It was noted, however, that almost all studies undertaken on *C. odorata,*none so far had included the effect of grazing animals. This study, therefore, conducted from July 1979 to June 1980 at Santos Ranch, San Jose Mindoro Occidental, aim to determine the effects of different grazing intensities on the prevalence of *C. odorata* and what method can effectively control the invasion of this weed.

Van Poolen and Lacey (1979) reviewed pertinent literature and concluded that grazing systems and grazing intensities both influence herbage production on western ranges. However, they noted that adjustment in livestock numbers has a greater effect on herbage production than grazing systems. Local studies on the long term effect of grazing on composition of native grasslands are virtually non-existent. Nevertheless, Javier

(1974) stated his general observations that "overstocking" could lead into the replacement of *Imperata cylindrica* Beauv. and *Themeda triandra Forsk.* dominated pasture with *Chrysopogon aciculatus*, Trin., Cynodon sp. and *Paspalum sp.*

He further observed that *Themeda australis* (Kangaroo grass), a predominant species in tropical and sub-humid areas of Australia, gave way to other species upon the introduction of livestock. This observation was similar to the findings of Moore (1970) that due to heavy grazing, *Themeda australis* gave way to *Stipa sp.* and *Danthonia sp.*

Herbicides containing picloram (4-amino-3,5,6 trichloropicolinic acid) can be used to control selectively brushes and other broadleaved plants without destroying the grass (Getzendaner *et al.* 1969). Thus, large areas of rangeland may be improved for increased livestock production. Picloram has a low order of toxicity to wildlife and fish (Lynn, 1965). Acute toxicity (LD_{50}) is 750 mg/kg for cattle and 1,000 mg/kg for sheep (Bovey and Scifres, 1971). Likewise, treatments of rangeland or of small grain field with effective dosage of picloram would not result in levels of residue in food or feed toxic to human or livestock.

MATERIAL AND METHODS

Eighteen paddocks each measuring 100 by 33 m were established on native pastures dominated by *C. odorata*. The established paddocks were then alloted at random into the following treatments with two replications:

LC	Lenient	Control
LH	Lenient	Brushing
LP	Lenient	Picloram 101 Mixture
MC	Medium	Control
MH	Medium	Brushing
MP	Medium	Picloram 101 Mixture
HC	High	Control
HH	High	Brushing
HP	High	Picloram 101 Mixture

Each paddock was separated by three strands of barb wire to restrain the movement of grazing animals.

The biomass or the quadrat method of sampling was used to determine the pasture's botanical composition. Three one sq meter quadrat samples were taken from each paddock at monthly interval for 12-month period. Samples taken were then separated according to species and or classified into four components, i.e. (a) *C. odorata*, (b) grasses, (c) legumes and (d) other broadleaved sp. After classification, samples were air-dried and weighed to approximate the dry matter production of each pasture component. The total air-dry matter produced by *C. odorata* for 12 months period was used as indicator of its prevalence.

The three grazing intensities applied in this study were simulated by allowing cattle to graze the alloted area for 24 hr at monthly intervals. Three, six and twelve heads of mature cattle were turned into their respective paddocks leniently (0.25 a.u./ha) mediumly (0.5 a.u/ha), and heavily (1.0 a.u./ha) grazed areas. Quadrat sampling was always done before allowing the animals to graze their respective paddocks.

Picloram 101 (10.2% of Picloram + 39.6% 2,4-D w/w) was applied at the rate of 0.5% active concentration of the product mixture. Spot application of herbicide solution using ordinary knapsack sprayer was done in the months of June and July 1979 at an average of 111 l of solution/ha. Spray solution was directed to thoroughly wet foliage and stems of *C. odorata* growth and re-growth from seeds and cut-stamps, respectively. Hand weeding of the respective paddocks was done simultaneously with herbicide application.

RESULTS AND DISCUSSION

A total of twenty eight pasture species were identified i.e., eleven, eight and nine species for grasses, legumes and broadleaved weeds, respectively. The scientific names of these species and their classification are shown in Appendix I.

The effect of grazing intensity on prevalence of *C. odorata* as indicated by its total air-dry matter yields was found to be insignificant. The results imply that regardless of grazing intensity applied, the prevalence of *C. odorata* will be more or less equal. Note, however, that *C. odorata* yield on the leniently grazed paddocks was slightly higher (1.25 kg/3 sq m) than the mediumly and heavily grazed areas. This may be due to the higher trampling effects on *C. odorata* caused by the larger number of cattle grazing on the latter areas. Grazing intensity also did not affect significantly (P = 05) grass, legume and other broadleaved weed components of the pastures. The trend, however, imply that grasses tend to decrease while the broadleaved species tend to increase (Table 1).

Except for legumes, the effect of the different methods of weed control on total air-dry matter yield of each pasture component was found to be significant (P = 0.5). For *C. odorata,* its yield of 0.22 kg/3 m^2 on paddocks sprayed which Picloram 101 was 88 and 76 percent lower than the unweeded and the brushed paddocks, respectively. *C. odorata* yield of

Table 1. Average total air-dry matter yield (kg/3 m^2) of the different pasture components (July 1979 – June 1980).

Treatment	PASTURE			COMPONENTS	
	Hagonoy	Grass	Legume	Broadleaved	Total
LC	2.38	3.52	1.05	2.10	9.05
LH	1.15	2.98	1.47	1.18	6.78
LP	0.22	4.35	1.01	0.90	6.48
MC	1.40	2.82	1.10	1.77	7.09
MH	0.73	3.00	0.96	1.67	6.36
MP	0.34	4.78	0.80	1.11	7.03
HC	1.71	2.63	1.28	1.73	7.35
HH	0.83	2.97	1.67	1.69	7.16
HP	0.09	4.39	1.19	1.06	6.73
MEAN	0.98	3.49	1.17	1.47	7.11

MEAN EFFECT :

Grazing	Eupatorium	Grass	Legume	Broadleaved
L	1.25	3.61	1.18	1.39
M	0.82	3.53	0.95	1.52
H	0.88	3.33^{a}	1.38	1.49
Weed Control	**Eupatorium**	**Grass**	**Legume**	**Broadleaved**
C	1.83^{a}	2.99^{a}	1.14^{a}	1.86^{a}
H	0.90^{b}	2.98^{a}	1.36^{a}	1.51^{ab}
P	0.22^{c}	4.51^{b}	1.00^{a}	1.02^{a}

Means in column with similar letter superscript are not significantly different at (P = .05) using DMRT.

Table 2: Average total air dry matter yield (kg/3 m^2) of the pasture and components.

Treatment	Pasture components			Weed component		
Weed Control	Grass	Legume	Total	Eupatorium	BL Weeds	Total
C	2.99	1.14	4.13	1.83	1.86	3.69
H	2.98	1.36	4.34	0.90	1.51	2.41
P	4.51	1.00	5.51	0.22	1.02	1.24

0.90 kg/3 m^2 on the weeded areas was only 51% lower than control plots (Table 1). This indicates that *C. odorata* biomass can be significantly decreased either by brushing or by application of Picloram 101 mixture. In the brushing method, only the above ground parts were affected while the root system remain intact. Sprouts from stumps were observed on the brushed paddocks whereas regrowths were completely absent in Picloram 101 treated areas.

Air dry matter yield of grasses significantly increases in Picloram 101 treated areas while no significant differences were obtained between control and brushed areas. Significant reduction of broadleaved weeds was noted also in herbicide treated paddocks.

The yield of legumes components was not affected by methods of weed control. The highest air dry matter yield of leguminous species were obtained in the brushed areas while the lowest was noted in the herbicide treated paddocks.

The lower air dry matter yield on the sprayed areas, although not significant can be attributed to the inherent characteristics of leguminous species to herbicides. Nevertheless, the results indicated that the nutritive value of pasture component increased with Picloram 101 application. Pasture species increased by 33% while weed species were reduced by 66% (Table 2). In the long run, this balance is expected to get better due to decrease of weeds species like *C. odorata* and other broadleaf plants. Likewise, seed proliferations will be eliminated as Picloram 101 application will kill *C. odorata* before they reach the reproductive stage.

The interaction effect of the two factors on the total air dry matter yield of the different pasture component was found to be insignificant. This indicate that regardless of grazing intensity employed, the response of the different pasture components on the method of weed control will be more or less equal. This result indicated that lowering of stocking rate alone will not control the invasion of *C. odorata* in the pasture. Biomass of *C. odorata* will more or less remain equal whether you leniently grazed or heavily stocked the pasture. This may be due to the following: a) *C. odorata* is not normally eaten by livestock giving it unhampered growth and development. b) The degree of competition provided by native species in the pasture was greatly lowered due to the inherent characteristics of *C. odorata*. Its profuse lateral branching habit inhibit the growth of competitor species through shading. In Chromolæna infested pasture, therefore, grazing management must always be coupled with weed control measures to effectively check the dominance of this noxious weeds. Brushing will help but spraying with Picloram 101 has been found more effective.

CONCLUSION

No significant effect (P = .05) of grazing intensity on *C. odorata* and other pasture components was observed while the effect of weed control measures was found to be highly significant (P = .01). The interaction effect of the two factors was insignificant (P = .05). It was concluded that regulated stocking alone will not control the invasion of *C. odorata* in the pasture. Grazing management must always be coupled with weed preventive measures for the effective control of this weed. In this study a picloram/2, 4-D mixture proved the most effective measure. The final choice depends on economic considerations.

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Appendix 1. Species Present in Mayor Santos Ranch, San Jose, Mindoro Occidental.

Classification	Scientific name	Local name
A. Broadleaved	*Chromolæna odorata*[1/] L. K. & R.	Eupatorium
	Cassia tora L.	Acacia-acasiahan
	Borreria lævis Griseb.	
	Synedrella nodiflora Gaertn.	Tuhod-manok
	Euphorbia geniculata Orteg.	
	Tridax procumbens L.	
	Hyptis suaveolens Poit.	Suag kabayo
	Sida acuta Burm.	Sida/walis-walisan
	Euphorbia hirta L.	
B. Grasses	*Heteropogon contortus* Beauv.	Spear grass
	Pennisetum polystachyum Schult.	Foxtail
	Echinocloa colona Link.	Gutad
	Setaria pallide-fusca Stapf & Hubb	
	Brachiaria distachya Stapf.	
	Digitaria macrobæne Link.	Kanrawraw
	Dactyloctenium ægyptium Beauv.	Damong-kabit
	Eragrostis zeylanica Nees & Mey	Yabok
	Cypoerus iria L.	Mutha
	Imperata cylindrica Beauv.	Cogon

Classification	Scientific name	Local name
C. Legumes	*Stylosanthes humilis* H.B. & K.	Townsville Stylo
	Aeschynomena indica L.	Damong byuro
	Calopogonium mucuniodes Desv.	Calopo
	Alysicarpus bupleurifolius DC	
	Urania lagopodioides	Basing karan
	Mimosa invisa Mart.	Giant mimosa
	Alysicarpus vaginalis DC	Mani-manian
	Indigofera hirsuta L.	Tina-tinaan

1/Treated as a separate pasture component in the analysis of data.

CERTAIN WEEDS OF CENTRAL INDIA AND THEIR ANTIMICROBIAL PROPERTIES

S. M. KAZMI, V. B. TRIVEDI and S. N. KAZMI
Department of Botany, University of Saugar, Sagar, 470 003, India.

ABSTRACT

A large number of angiosperms and certain pteridophytes exist in the form of weeds, in nature. It is a well known fact that their abundant growth proves hazardous to mankind. With the idea, that how they can be rendered useful to man the present study was taken up. A number of weeds were picked up to determine the antimicrobial properties. Out of several listed weeds, *Withania somnifera, Euphorbia spp., Lantana camara, Orthrosiphon pallidus,* and two pteridophyte aquatic weeds are discussed here. The well method was followed to measure the inhibition zone on agar plates. *Vibrio choleræ,* a severe human pathogen was inhibited by a large number of extracts obtained from various organs of above weeds e.g., root bark of *W. somnifera,* stems of *L. camara* and *O. pallidus,* and whole plant of *salvinia sp.* Another human pathogen *Salmonella paratyphi* was strongly inhibited by the stem extract of *O. pallidus.* In some of the tests pathogen the growth got stimulated e.g., *Bacillus anthracis* against leaf and flower extracts of *L. camara, O. pallidus* and *W. somnifera.* Whereas *Helminthosporium sp.* was significantly inhibited by the leaf extracts of *Euphorbia hirta.* Here sporulation was severely inhibited. Other test fungi were found to be less sensitive to the extracts.

INTRODUCTION

A number of weeds appear in the fields of central India in different seasons. Out of these, a number of them were picked up to determine the antimicrobial properties. Data based on the findings with different species of *Euphorbia, Orthrosiphon pallidus, Azolla sp. and Salvinia sp.* were published from time to time (Kowdikar *et al.* 1977; Trivedi *et al.* 1980a; Trivedi *et al.* 1980b). From the above studies it becomes clear that bacteria are more sensitive to the extracts from different organs of weeds than fungi. Out of several fungal species, tested against extract of different weeds, only *Helminthosporium sp.* was significantly inhibited by the leaf extracts of *Euphorbia hirta.* Even its sporulation was also inhibited (Kowdikar *et al.* 1977). Stem extract of *Orthrosiphon pallidus* was reported highly inhibitory against two human pathogenic bacteria *Vibrio choleræ* and *Salmonella paratyphi* (Trivedi *et al.* 1980a). *V. choleræ* is also reported to be inhibited by extracts of whole plants of *Salvinia sp.* (Trivedi *et al.* 1980b). Further continuing the study the following two weeds were further selected. The findings of the same are discussed here in this paper.

MATERIAL AND METHODS

Withania somnifera Dunal. (Solanaceæ) is commonly known as Asgand. It is said that the root and root bark are quite poisonous or toxic to microbes. Authors tried to get growth inhibition of some pathogenic bacteria from the extracts of different organs of the plant.

Lantana camara Linn. (Verbenaceæ) commonly known as Kuri, is a struggling aromatic shrub. It was an ornamental plant in British time but now has become a troublesome weed of the forest. It is already known that decoction of *L. Camara* is given in tentanous and rheu-

Table 1 : Growth inhibition of bacteria in different extracts of *W. somnifera.*

Organisms	Zone of inhibition in mm* in the extracts** (average of three values)						Control
	1	2	3	4	5	6	
Baccilus anthracis (+)	12	22	14	00	00	00	30
B. pumilis (+)	28	20	16	18	00	24	38
B. subtilis (–)	28	36	29	36	20	20	22
Salmonella paratyphii (–)	28	22	14	14	22	12	28
Staphylococcus albus (+)	00	20	22	18	22	16	22
Vibrio choleræ (+)	28	24	24	20	24	20	22
Xanthomonas compestris (–)	22	22	00	00	18	16	26
X. malvacearum (+)	00	20	16	00	20	12	28

* Diameter of well 10 mm is included.
** 1. Root bark, 2. Root, 3. Stem, 4. Leaves, 5. Flower, 6. Fruit.
+ is gram positive bacteria. – is gram negative bacteria.

Table 2 : Growth inhibition of bacteria in different extracts of *L. camara.*

Organisms	Zone of inhibition in mm* in the extracts** (average of three values)			Control
	1	2	3	
Baccilus anthracis (+)	16	00	00	30
B. pumilis (+)	28	24	30	38
B. subtilis (–)	16	00	00	22
Salmonella paratyphii (–)	24	20	20	28
Staphylococcus albus (+)	16	22	18	22
Vibrio choleræ (+)	24	12	18	22
Xanthomonas compestris (–)	22	22	24	26
X. malvacearum (+)	24	12	14	28

* Diameter of well 10 mm is included. ** *Lantana camara.*
1. Stem extract, 2. Leaf extract, 3. Flower extract, + is gram positive, – is gram negative.

matism. Antimicrobial property of the essential oil of *L. camara* is already reported by Avdhoot and Varma (1978).

Different plant parts i.e., root, root-bark (the peripheral portion) leaves, flowers and fruits of *E. crassipes* and stem, leaves and flowers of *L. camara* were collected from three individuals. Methanol extracts weed made as described by Kowdikar *et al.* (1977) and antibacterial assay was done as described by Kazmi *et al.* (1978). After 12 hr of incubation inhibition zones were measured and recorded in Table 1.

RESULTS

Antimicrobial properties of *Withanic somnifera* : It was found that out of eight test bacteria, five were strongly inhibited by the root-bark extract. Root bark extract caused a good inhibition against two Bacilli i.e., *B. pumilis* and *B. subtilis.* This extract also caused a satisfactory inhibition against human pathogen i.e., *Salmonella paratyphii* and *Vibrio choleræ.* While *X. malvacearum, Staphylococcus albus* and *B. anthracis* were not inhibited by root bark extract, *V. choleræ* was severely inhibited by all the extracts, even the inhibition was found more than control.

V. choleræ and *B. subtilis* were found susceptible to all the extracts while *B. anthracis* was found highly resistant against extracts of leaves, flowers and fruits. Extracts of leaves and stem failed to inhibit the bacterial growth. Similar results were recorded with fruit extract except against *B. pumilis* where comparatively a mild inhibition was observed.

Antimicrobial properties of L. camara : Aromatic shrub showed inhibition against all the test organisms, except *B. subtilis* and *B. anthracis* where the inhibition was almost nil. In case of *S. albus*, leaf-extract showed an equal inhibition as that of the control. Though all three extracts showed prominent inhibition against *B. pumilis*, none of them reached upto that of the control. Though *S. paratyphii* was not inhibited up to the extent of control, the results were promising. Specially in case of stem extract it was found comparatively more inhibitory against *V. choleræ*. Results of *X. campestris*, against three extracts, were more satisfactory than those of *X. malvacearum*.

DISCUSSION

Amongst tested Baccilli, *B. anthracis* was found to show similar response to extracts of stem, leaves and flowers as were reported by Trivedi *et al.* (1980a) for the extracts of *O. pallidus*. Out of two *Xanthomonas*, *X. malvacearum* was found resistant against leaf extracts of both weeds, their results are also in conformity with those of *O. pallidus* (Trivedi *et al.* 1980a).

As far as *Vibrio choleræ* – a severe human pathogen is concerned, stem extracts of both weeds are found strong inhibiting agent. Similar results were observed with extracts of whole plants of *Azolla sp.* and *Salvinia sp.* (*Trivedi et al.* 1980b) and stem extract of *O. pallidus* (Trivedi *et al.* 1980a). *S. paratyphii*, another human pathogen is found highly resistant to the stem extract of *W. somnifera*, while a slight susceptibility observed against stem extract of *L. camara*. Contrary to those results, a very strong inhibition was reported by stem extract of *O. pallidus* (Trivedi *et al.* 1980a).

CONCLUSION

In a nutshell it can be said that nearly all extracts from *W. somnifera* are controlling the growth of *V. choleræ*. *B. pumilis* is succeptible to extracts of *L. camara*, specially to flower extract while *B. anthracis* is quite resistant to all the extracts from both weeds.

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THE WEEDS OF RABI VEGETABLES

J. P. TIWARI and C. R. BISEN
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur-4, Madhya Pradesh, India.

ABSTRACT

Dominance and ecological success of occurrence of weeds under rabi vegetable fields were determined on the basis of "importance value index" (IVI) at JNKVV., Jabalpur, M. P. The most commonly occurring dominant weeds having higher IVI in peas sweet potato, onion, tomato and brinjal fields are listed. The study revealed that the occurrence of wet season *(kharif)* weeds are also common in winter season *(rabi)* vegetable fields.

INTRODUCTION

The problems of weed management in vegetable cropping systems are serious and several due to high inputs, frequent irrigation, and multiple cropping sequences. The losses caused by weeds depend upon their density, dominance and ecological success. Therefore, the knowledge about their occurrence, relative density, dominance and frequency in different vegetable crops is essential to take appropriate control measures at suitable time. These studies are totally lacking particularly at Jabalpur.

MATERIAL AND METHODS

The floristic survey of rabi vegetable fields was carried out at Vegetable Research Farms, Maharajpur and Imaliya, JNKVV, Jabalpur, during 1978-79. The fields of peas (*Pisum sativum* L.), sweet potato (*Ipomoea batatas* Lamk.), onion (*Allium cepa* L.), tomato (*Lycopersicon esculentum* Mill.) and brinjal (*Solanum melongena* L.) were surveyed. Under each crop ten list count quadrats were taken randomly. The size of quadrat used in sampling was 0.5 m^2. The quantitative parameters *viz.*, abundance, density, percentage frequency, relative dominance, relative density, relative frequency and importance value index (IVI) were computed for each species under each crop as per methodology described by Ashby (1948) and Misra (1973) and they are:

$$\text{Abundance} = \frac{\text{Total Number of individuals of the species}}{\text{Number of the quadrats of occurrence}}$$

$$\text{Density} = \frac{\text{Total Number of individuals of the species}}{\text{Total Number of the quadrats studied}}$$

$$\text{\% Frequency} = \frac{\text{Total Number of quadrats of occurrence}}{\text{Total Number of quadrats studied}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

$$\text{Relative density} = \frac{\text{Total No. of individuals of the species}}{\text{Number of occurrence of all the species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all the species}} \times 100$$

Importance Value Index = Relative dominance + Relative density + Relative frequency.

Table 1: Weed flora in pea fields.

Weed species	Abundance	Density	Frequency %	Relative dominance	Relative density	Relative frequency	IVI
Abutilon indicum Sweet	1.1	0.2	25	2.35	0.91	3.33	6.59
Ageratum conyzoides L.	4.0	2.0	50	7.15	7.84	6.89	21.88
Anagallis arvensis L.	3.0	2.2	75	3.90	8.91	10.71	23.52
Chenopodium album L.	3.0	0.75	25	5.97	2.80	3.33	12.10
Cyperus rotundus L.	2.0	0.5	25	1.26	1.85	3.33	6.44
Cynodon dactylon Pers.	2.0	0.5	25	0.84	1.85	3.33	6.02
Digitaria adscendens Henr.	9.6	7.2	75	13.77	35.80	10.71	60.28
Eclipta alba Hassk.	2.0	1.0	50	3.45	3.77	6.89	14.11
Euphorbia geniculata Orteg	1.0	0.2	25	1.05	0.91	3.33	5.29
Lathyrus aphaca L.	2.5	1.2	50	3.13	4.76	6.89	14.78
Melilotus alba Desr.	1.5	0.75	50	1.91	2.80	6.89	11.60
Eragrostis spp.	5.5	2.7	50	4.81	11.11	6.89	22.81
Physalis minima L.	5.7	4.2	50	55.01	18.28	10.71	84.00
Portulaca oleracea L.	2.5	1.2	50	4.35	4.76	6.89	16.00
Sida carpinifolia L.	1.0	0.2	25	0.84	0.91	3.33	5.08
Sonchus arvensis L.	2.0	1.5	75	15.98	5.76	10.71	32.45
Vicia sativa L.	1	0.2	25	0.21	0.91	3.33	4.45

RESULTS AND DISCUSSION

Weed flora in pea fields

The vegetable pea fields which were under survey had sandy loam soil. The fields were tube-well irrigated. The highest frequency in these fields was noted in case of *Anagallis arvensis, Sonchus arvensis, Digitaria adscendens* (75%). 50% frequency was noted in case of *Physalis minima, Eragrostis spp., Melilotus alba, Lathyrus aphaca, Eclipta alba* and *Ageratum, conyzoides* (Table 1). Other species had 25% frequency. However, the most dominant weed species were *P. minima, Sonchus arvensis, D. adscendens* and *A. conyzoides.* The ecological success of weeds in peas determined on the basis of IVI, was the highest in case of *P. minima* followed by *D. adscendens, S. arvensis, A. arvensis, Eragrostis spp., A. conyzoides, P. oleracea* and *L. aphaca.*

It was interesting to note the occurrence of various weed species in the peas fields during winter, which generally do occur during the *kharif* season and they become important weeds of *rabi* season. *P. minima, D. adscendens, Eragrostis spp.* and *A. conyzoides* normally grow during the *kharif* season but they were noted during the *rabi* season and were dominant also. This obviously indicated that these *kharif* weeds had no ormancy and climatic influence on their growth and development. One should be very cautious about the occurrence of these *kharif* weeds under irrigated conditions during *rabi* season also.

Weed flora in sweet potato fields

The soil of the sweet potato fields was heavy black to clayey loam. The fields were irrigated with the tube well. In these fields *Chenopodium* had 100 per cent frequency whereas *D. adscendens, E. alba* and *Indigofera spp.* had 75% frequency. 50% frequency was noted in case of *Cyperus rotundus, Cynodon dactylon, M. alba, P. oleracea* and *S. arvensis.* The relative dominance was higher in case of *S. arvensis* (21.93), *Ch. album* (14.87) and *C.*

Table 2: Weed flora in sweet potato fields.

Weed species	Abundance	Density	Frequency %	Relative dominance	Relative density	Relative frequency	IVI
Anagallis arvensis L.	1.0	0.2	25	0.36	1.26	3.44	5.06
Chenopodium album L.	1.0	1.0	100	14.87	5.26	15.38	35.51
Cyperus rotundus L.	5.5	2.7	50	13.46	15.94	7.14	36.54
Cynodon dactylon L.	5.0	2.5	50	7.75	14.28	7.14	29.17
Digitaria adscendens Henr.	2.6	2.0	75	9.14	11.11	11.11	31.36
Eclipta alba Hassk.	2.0	1.5	75	9.44	8.10	11.11	28.65
Indigofera spp.	4.0	3.0	75	9.44	17.64	11.11	38.19
Eragrostis spp.	7.0	1.7	35	5.40	9.58	3.44	18.42
Euphorbia geniculata Orteg	1.0	0.2	25	1.83	1.26	3.44	6.53
Melilotus alba L.	1.0	0.5	50	2.20	2.56	7.14	11.90
Phyllanthus simplex Retz.	1.0	0.2	25	1.72	1.26	3.44	6.42
Portulaca oleracea L.	1.5	0.7	50	3.34	3.89	7.14	14.37
Rumex dentatus L.	1.0	0.2	25	2.20	1.26	3.44	6.90
Saccharum spontaneum L.	1.0	0.2	25	1.09	1.26	3.44	5.79
Sonchus arvensis L.	2.5	1.2	50	21.93	6.66	7.14	35.73
Commelina benghalensis L.	7.0	1.7	25	8.17	9.58	3.44	21.19

rotundus (13.46). The IVI has higher in *Indigofera* sp. (38.19) followed by *C. rotundus* (36.54), *S. arvensis* (35.73). *Ch. album, D. adscendens* (31.36), *C. dactylon* (29.17) and *E. alba* (28.65). In these fields the weeds of *kharif* season were also noted and some of them had higher IVI as mentioned above. The other kharif weed species which had comparatively lower IVI were *Commelina benghalensis, Phyllanthus simplex, Eragrostis spp.* and *Euphorbia geniculata* (Table 2). The patches of *Saccharum spontaneum* were also noted.

Weed flora in onion fields

The soils of the fields where onion was grown varied from sandy to sandy loam. The fields were tube-well irrigated. In these fields the weeds were comparatively more than *rabi* weeds as out of total 22 weed species only 6 were of rabi weeds (Table 3). *Cyn. dactylon, C. rotundus* and *Iseilima laxum* were perennial. Where others were kharif seasons weeds, *Eragrostis spp., C. rotundus, Vicia sativa* and *Ch. album* were the most frequent and dominant weed species. The frequency varied from 60 to 100%. The relative frequency of *D. adscendens* was maximum followed by *Vicia sativa, Eragrostis spp.* and *C. rotundus*. The relatively more dominant weeds were *Eragrostis spp., C. rotundus, Ch. album, D. adscendens* and *V. sativa*. On the basis IVI *Eragrostis spp.* again occupied the highest position followed by *C. rotundus, D. adscendens, V. sativa, Ch. album* and *I. laxum*. The dicot weed species of *kharif* which were noted in onion fields included *Ag. conyzoides, Lagasca mollis, Phyllanthus niruri, Ph. minima, Solanum nigrum, Sida cordifolia, E. alba, Corchorus trilocularis* and *Eu. hirta*. The IVI were 12.55, 10.16, 10.63, 8.75, 8.29, 7.68, 2.92, 3.31 and 4.57 respectively.

Weed flora in tomato fields

The soils of the tomato fields which were under survey included sandy loam, sandy and clayey-loam. The sources of irrigation were tube-well and Pariat river at Maharajpur Research Farm and Imalia Farm respectively.

Table 3: Weed flora in onion fields.

Weed species	Abundance	Density	Frequency %	Relative dominance	Relative density	Relative frequency	IVI
Ageratum conyzoides L.	2.0	1.2	60	3.60	3.39	5.56	12.55
Chenopodium album L.	2.0	0.3	60	10.21	3.39	5.56	19.16
Chloris barbata Sw.	2.0	1.2	60	3.60	3.39	5.56	12.55
Artemissia spp.	1.5	0.6	40	2.37	1.67	3.65	7.69
Cynodon dactylon Pers.	2.0	1.2	60	2.37	3.39	5.56	11.32
Cyperus rotundus L.	5.2	4.2	80	13.84	12.96	7.55	34.35
Corchorus trilocularis L.	1.0	0.2	20	0.97	0.55	1.79	3.31
Digitaria adscendens Henr.	4.0	2.4	60	7.02	5.56	17.43	30.01
Eclipta alba Hassk.	1.0	0.2	20	0.58	0.55	1.79	2.92
Eragrostis spp.	14.0	11.2	80	27.58	44.09	7.55	79.22
Euphorbia hirta L.	0.5	0.2	40	0.38	0.55	3.64	4.57
Iseilima laxum Hack.	5.0	3.0	60	2.98	8.93	5.56	17.47
Lagasca mollis Cav.	1.5	0.6	40	4.85	1.67	3.64	10.16
Melilotus alba Desr.	2.0	1.2	60	3.60	3.38	5.56	12.54
Physalis minima L.	1.0	0.4	40	4.01	1.10	3.64	8.75
Phyllanthus niruri Hook. f.	3.0	1.2	40	3.60	3.39	3.64	10.63
Portulaca oleracea L.	2.0	1.2	60	3.60	3.39	5.56	12.55
Rumex dentatus L.	1.2	0.6	40	3.60	1.67	3.64	8.91
Sida cordifolia L.	1.5	0.6	40	2.37	1.67	3.64	7.68
Solanum nigrum L.	1.5	0.6	40	2.98	1.67	3.64	8.29
Sonchus arvensis L.	0.5	0.2	40	2.17	0.55	3.64	6.36
Vicia sativa L.	3.2	3.2	100	6.58	9.58	9.62	25.78
Gnaphallium indicum L.	2.0	1.2	60	3.60	3.39	5.56	12.55

Table 4: Weed flora in tomato fields.

Weed species	Abundance	Density	Frequency %	Relative dominance	Relative density	Relative frequency	IVI
Acanthospermum hispidum	1.0	0.2	25	0.73	0.40	2.78	3.91
Agerateum conyzoides L.	3.5	3.5	100	8.27	5.83	12.12	26.22
Anagallis arvensis L.	9.7	27	100	11.34	12.39	12.12	35.85
Chenopodium album L.	1.7	1.7	100	11.34	2.83	12.12	26.29
Cyperus rotundus L.	2.7	2.7	100	64.67	73.97	12.12	150.76
Cynodon dactylon Pers.	3.3	2.5	75	1.85	4.10	8.82	14.77
Eclipta alba Hassk.	3.5	1.7	50	2.61	2.83	5.71	11.15
Digitaria adscendens Henr.	7.0	6.7	80	10.89	11.89	12.12	34.90
Lagasca mollis	1.0	0.2	25	1.29	0.40	2.78	4.47
Lathyrus aphaca L.	1.5	11.2	75	8.91	21.53	8.82	39.26
Melilotus indica All.	4.0	2.0	50	3.00	3.25	5.71	11.96
Portulaca oleracea L.	2.0	0.2	25	1.10	0.79	2.78	4.67
Physalis minima L.	1.5	0.5	50	3.38	1.20	5.71	10.29
Vicia hirsuta S.F. Gray	2.0	0.5	25	0.36	0.79	2.78	3.93
Solanum nigrum L.	1.0	0.2	25	0.73	0.40	2.78	3.91
Fumaria indica Pugsley.	1.0	0.2	25	1.29	0.40	2.78	4.47

Table 5: Weed flora in brinjal fields.

Weed species	Abundance	Density	Frequency %	Relative dominance	Relative density	Relative frequency	IVI
Acanthospermum hispidum Dc.	3.5	1.4	40	3.60	2.77	3.36	9.73
Ageratum conyzoides L.	3.6	1.9	50	3.67	3.79	4.24	11.70
Amaranthus spinosus L.	3.0	0.6	20	2.29	1.17	1.65	5.11
Amaranthus viridis Hook. F.	4.4	2.2	50	7.33	4.42	4.24	15.99
Artemisia spp.	1.6	0.8	50	2.03	1.56	4.24	7.83
Chenopodium album L.	4.1	2.9	70	19.35	5.91	6.03	31.29
Chloris barbata Sw.	4.2	3.4	80	4.41	7.00	6.96	18.37
Cichorium intybus L.	1.5	0.3	20	0.94	0.58	1.65	3.17
Corchorus trilocularis L.	1.5	0.3	20	0.75	0.58	1.65	2.98
Cynodon dactylon Pers.	3.8	2.3	60	1.45	4.63	5.13	11.21
Cyperus rotundus L.	9.6	7.7	80	10.58	14.38	9.96	34.92
Eclipta alba Hassk.	4.0	1.6	4	3.07	3.17	3.36	9.60
Euphorbia hirta L.	4.0	1.2	30	1.51	2.36	2.50	6.37
Euphorbia geniculata Orteg.	3.3	1.0	30	2.55	1.96	2.50	7.01
Iseilima laxum Hack.	1.5	0.3	20	0.37	0.57	1.65	2.60
Lagasca mollis Cav.	2.0	0.6	30	2.29	1.17	2.50	5.96
Lathyrus aphaca L.	4.5	1.8	40	1.13	3.59	3.36	8.08
Melilotus alba Desr.	3.3	1.0	30	1.26	1.96	2.50	5.72
Physalis minima L.	1.7	1.0	60	4.55	1.96	5.13	11.64
Phyllanthus niruri Hook. f.	3.0	0.9	30	1.13	1.76	2.50	5.39
Portulaca oleracea L.	3.1	2.5	80	4.89	5.05	6.96	16.90
Digitaria adscendens Henr.	15.4	7.7	50	5.02	17.58	4.24	26.84
Rumex dentatus L.	2.2	0.9	40	3.47	1.76	3.36	8.59
Sida carpinifolia L.	1.2	0.5	40	0.94	0.97	3.36	5.27
Solanum nigrum L.	1.0	0.3	30	0.75	0.58	2.50	3.83
Sonchus arvensis L.	1.6	0.8	50	4.68	1.56	4.24	10.48
Vicia hirsuta S. F. Gray	5.0	2.0	40	1.26	4.00	3.36	8.62

Weeds in these fields included both kharif and rabi seasons' flora (Table 4). *Acanthospermum hispidum, Ag. conyzoides, E. alba, L. mollis, Ph. minima, S. nigrum* and *D. adscendens* were the most common weeds of kharif which were emerged during rabi. Amongst these *D. adscendens* had the highest IVI (39.9) followed by *Ag. conyzoides* (26.22), *E. alba* (11.15) and *Ph. minima* (10.29). Amongst rabi weeds the most common were *A. arvensis, Ch. album, L. aphaca, M. indica* and *V. hirsuta.* The highest IVI was noted in case of *L. aphaca* (39.26) followed by *A. arvensis* (35.85), *Ch. album* (26.29) and *M. indica* (11.96). Amongst perennial weeds occurring in these fields, *C. rotundus* had the highest IVI (150.76) as compared to all other weeds. The occurrence of *Cynodon dactylon* was also noted with 14.77 IVI.

Weed flora in brinjal fields

Soils of the fields under brinjal were sandy loam at Maharajapur farm irrigated with tube-well and clayey irrigated with Pariat river at Imalia Farm. In these fieldsthe highest dispersion was noted in case of *C. rotundus, P. oleracea, Chloris barbata* and *Ch. album*, the frequencies varied from 70 to 80%. The most dominant weeds were *Ch. album* and *C. rotundus.* The relative density was higher in *C. rotundus* and *D. adscendens.*

Greater dominance and ecological success based on IVI was noted in case of *C. rotundus, Ch. album, D. adscendens, Ch. barbata, P. oleracea* and *Amaranthus viridis.* IVI of these weeds were, 34.92, 31.29, 26.84, 18.37, 19.90 and 15.99 respectively. Total number of weed species were 27, out of these 15 were kharif weeds. Amongst these weeds *D. adscendens, Ch. barbata, Am. viridis, Ag. conyzoides* and *Ph. minima* had the higher IVI (Table 5). *Cichorium intybus* was the new weed in brinjal fields. Its IVI was 3.17. The weeds belonging to rabi consisted of only dicot weeds. The investigation revealed no specific weed association with a particular vegetable and most of the dominant weeds were common in fields of all vegetables. However, some new weeds were noted in different types of vegetable fields which seemed to be the matter of habitat conditions and previous weed dispersal.

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BIOLOGY OF *EUPHORBIA PRUNIFOLIA* JACQ. SEEDS

H. F. CHIN and SABUDIN M. ALI
Agronomy Department, University Pertanian Malaysia, Serdang
Selangor, Malaysia.

ABSTRACT

Euphorbia prunifolia Jacq. has a very short life cycle of 3 months and each plant is capable of producing an average of 720 seeds. An estimated 720.7 million seeds can be produced from a hectare in a season. From soil samples, 30 million seeds are found in the top 10 cm of soil. Seeds remain viable and dormant for a long period buried in soil, they germinate readily once brought to soil surface.

Mature as well as immature seeds from green pods germinate readily with 90 – 100% germination. Dry and moist heat treatment at above 50° C for 48 hr reduce their germination and killed seeds at 60° C. Moist heat is more effective, at 45° C there is a significant drop in percentage germination. Polythene sheets placed on top of soil raised soil temperature from 40° C to 66° C at noon and prevented the germination of these seeds. Thus polythene sheets can be used especially in undisturbed soil of minimal tillage to control *Euphorbia prunifolia* in annual crops.

INTRODUCTION

Euphorbia species are generally not found as noxious weeds. However, recently *Euphorbia prunifolia* Jacq. has become serious in annual crops. Their presence has been reported in various parts of Malaysia (Lo and Wong, 1980). In soybean growing regions of the United States and South America another species of Euphorbia i.e. *E. heterophylla* has also become a problem (Nester *et al.* 1979).

Euphorbia prunifolia by virtue of its short life cycle and ability of seeds to remain viable in soil for a long period presents problem in their control. Hence a thorough understanding of the biology of their seeds will be of value in formulating control methods. A study of their life cycle, reproductive capacity survival mechanisms, their dispersal and distribution was undertaken. Special emphasis was given to germination studies in relation to their maturity, moisture content and heat treatment, with the aim of finding a possible means of controlling this particular species which has become serious in annual crops.

MATERIAL AND METHODS

Population of *E. prunifolia* was estimated using the quadrat method. The number of seeds present in soil was estimated using the method of Standifer, 1980). The life cycle of this species was studied in the field as well as pot studies in glass house. Fifty seeds were planted in the field and fifty in pots and records were taken for date of flowering, fruiting, seed set and maturity. Germination tests were conducted in the laboratory at ambient temperature of 25 ± 5° C using replicates of 4 x 100 seeds per treatment.

Study of effect of moist and dry heat treatment was conducted in ovens at 30, 40, 45, 50, 55, 60° C for periods of 24 and 48 hr continuous heating. Seeds from both green fruits and fully mature brown fruits were used for comparison.

RESULTS

The life cycle of *E. prunifolia* is short and similar to a number of short term annual crops which is normally around three months. Hence it is more difficult to control such weeds. Seeds of *E. prunifolia* germinate readily, one month after germination the plants produce flowers and set seeds within the second month. Because of their branching habit and free flowering they produce seeds profusely in large numbers averaging 720 seeds per plant. The seeds are fairly large, rough in texture and measuring 2.4mm by 2.1mm. The seed is subglobose in shape and the 1,000 seeds weight is 6.8 g with moisture content of 9.8 percent.

A survey of weed population in a corn plot indicated the presence of 940,000 *E. prunifolia* per ha. From soil samples, it was estimated, there were 28 million seeds per ha on the top 10 cm of soil. The number of seeds below 10 cm was lower than the top 10 cm. The number also varies with locations. There were more seeds found in cultivated soil i.e. annual crops than in the less disturbed soil in the crop museum (Table 1).

Seeds become germinable when they are mature although the fruit is still green. But seeds were not germinable at the milky stage when seeds were immature. Mature seeds harvested from fruits while still green and from fully mature dry brown fruits both germinated readily with the same percentage of germination of above 80 percent. In a short term storage study over a duration of 6 months, the percentage germination increased with storage from 82% in the first month to 87% after the sixth month, but increase was not significant.

Moist and dry heat treatment studies of both seeds from green fruits and the fully mature seeds from brown fruits showed that seeds cannot tolerate temperature of above 45° C, the percentage germination declined significantly. At 60° C all the seeds were dead after 48 hr treatment (Fig. 1). However, after 24 hr fully mature dry seeds survived with 25% germination. Moist heat is more effective in reducing the percentage germination. The seeds from the green fruits were more susceptible to both dry and moist heat treatments. The percentage germination, in fact, increased from 80 to 90% with heat treatment up to a temperature of 40° C for both moist and dry heat treatments, above 45° C the percentage germination declined and ultimately all were dead at 60° C.

Table 1 : The estimated number of seeds at 2 different depths under 4 different cropping systems.

Location	Depth (cm)	Seeds/ha (Mil.)
Corn plot	0 – 10	28
	10 – 20	25
Vegetable plot	0 – 10	34
	10 – 20	33
Research plot	0 – 10	23
	10 – 20	17
Crop museum	0 – 10	15
	10 – 20	13

DISCUSSION

Euphorbia prunifolia has only been found to be a serious weed in our annual crops in the last three years. The origin is still mysterious, they could have been introduced among crops which have been imported or that the buried seeds lying dormant under rubber (*Hevea braziliensis* M. Arg.) a plantation crop, once the soil is cultivated the seeds are exposed resulting in germination of the buried seeds. There was rapid invasion by this species of weeds as indicated by plant population survey there were nearly a million plants per ha cropped land. The population may

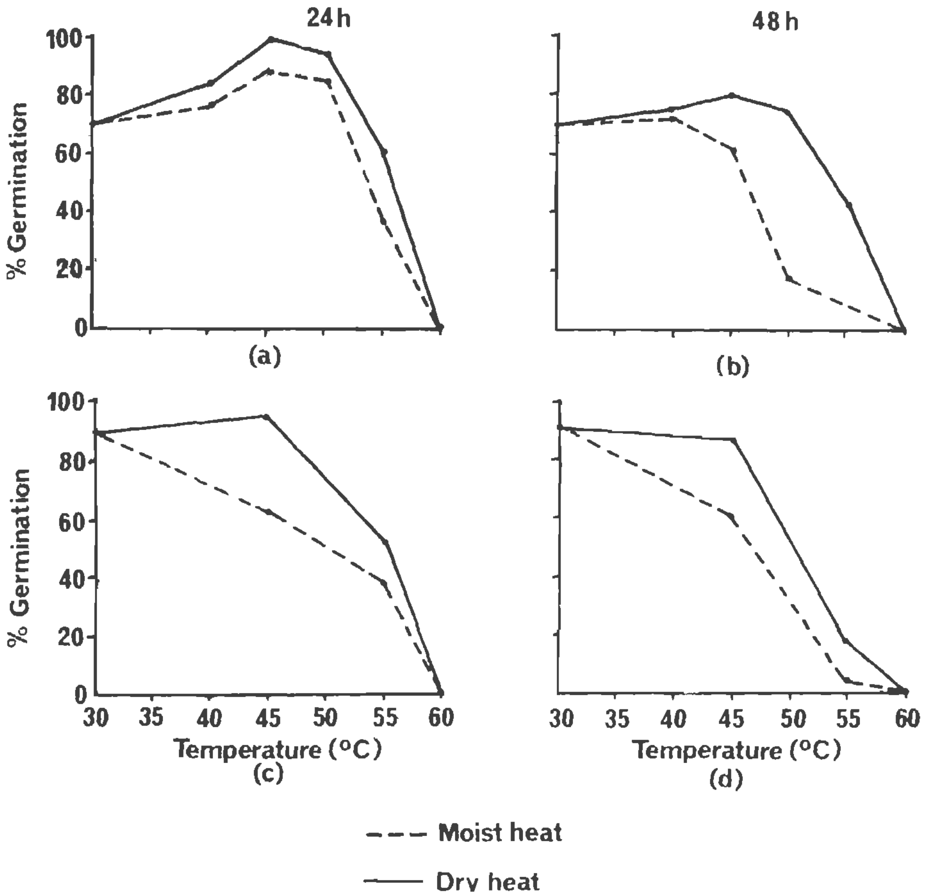

Fig. 1. The effect of moist and dry heat treatment over a range of temperatures from 30 to 60°C for seeds from green fruits (b and d) and fully ripe fruits (a and c)

further increase if they are not controlled because of the high seed producing capacity, with an average of 720 seeds per plant. The figure can rise to over 7,000 weeds per plant, when this species is found singly and when in stands the number is 375 (Lo and Wong, 1980). The average number of seeds per plant reported in this study is only about a third of those found by (Lo and Wong, 1980).

The seeds of *E. prunifolia* germinate readily and seedlings grow rapidly. These characteristics are contributing to the seriousness of this weed and has become a real threat to crop production. This weed has to be controlled at its early stage i.e., before seeding. If they are allowed to set seed, in the next crop the weed population will be greatly increased. Seeds from both green and brown mature fruits germinate readily once they are in the soil. Most of the seeds are found in the top 10 cm of soil and below that the number was less. Those located below 5 cm normally do not germinate. Seeds buried in soil are a potential source of danger (Chin, 1979). It was found in this study, in cultivated soil such as in the maize and vegetable plots the number seeds were much more than those found in the crop museum, in which the soil is not cultivated regularly. The seeds buried in the soil can remain viable for long period. Even in short term study of 6 month to 2 years they are germinable. Therefore if a system of no tillage could be practised this weed can be kept under control and prevent the spread of this weed to other locations by agricultural machineries. At present (Lo and Wong, 1980) herbicides showed unsatisfactory control on the Euphorbia weed due to high tolerance and continuous seed germination. Fluridone can suppress weeds at the initial stage, but alachlor gave the best result among the herbicides in terms of crop yield.

The effect of moist and dry heat treatment to seeds for 24 hr and 48 hr showed temperature above 45°C has been effective to prevent germination, infact, killing the seeds. Moist heat is more effective than dry heat in killing the seeds. Moist heat is more effective than dry heat in killing the seeds. The effective temperature of 45°C is of common occurrence in the soil surface, if it is covered with a sheet of polyethylene sheet. It has been found in this study the temperature under a plastic sheet under tropical conditions at noon the temperature rises to 66°C, between 12 noon and 4 pm the average temperature is 55°C. At this temperature it may possible to kill the seeds over a period of days. This has yet to be tested. Studies by Jacobsohn *et al.* (1980) showed polyethylene mulching have been effective as a method of weed control.

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STUDIES ON BIOLOGY AND HOST RANGE OF *PAULINIA ACUMINATA* DE GEER (ORTHOPTERA: ACRIDIDÆ) AND ITS EFFICACY FOR THE CONTROL OF *SALVINIA MOLESTA* MITCHELL–AN AQUATIC FLOATING WEED IN KERALA

P. J. JOY, K. C. VARGHESE and C. C. ABRAHAM
Kerala Agricultural University, Trichur, Kerala, India.

ABSTRACT

Salvinia molesta Mitchell has become a serious menace to paddy cultivation, inland navigation and fishing in Kerala. With the object of controlling *Salvinia, Paulinia acuminata* De Geer was imported and the present study is on the biology, host range and field release of the insect. *P. acuminata* mates within a day of emergence. The preoviposition period is 4 to 7 days. Eggs are laid on the upper or lower surfaces of the leaves. Incubation period varies from 12 to 18 days. The average larval instar periods from the first instar onwards are 7.81, 6.3, 5.81, 5.62, 5.71 and 7.0 days. Feeding trials showed that the females devoured an average of 0.59 g of *Salvinia* per day whereas the males consumed only 0.25 g.

Host range studies showed that *P. acuminata* causes no economic injury to about forty crop plants tested and hence it is safe for field release against the aquatic weed, *Salvinia*, in India. However, it can thrive well and complete its life cycle on other aquatic plants like *Azolla* sp., *Pista stratiotes* and *Monochoria vaginalis*. Field releases of *P. acuminata* were made at Mannuthy (Trichur District), Moncampu (Alleppey District) and Valiathara (Trivandrum District) to assess its efficacy in the control of *Salvinia*. Releases at Mannuthy and Moncompu failed. However, at Ambalathara near Vellayani, the insect has established, though its population build-up was not sufficient to effect any appreciable check on the explosive growth of *Salvinia*.

INTRODUCTION

Surveys conducted by the Commonwealth Institute of Biological Control, Trinidad, brought to notice a weevil, *Cyrtobagous singularis* Hulst., an aquatic grasshopper, *Paulinia acuminata* De Geer and a pyralid borer, *Samea multiplicalis* Guenee as promising natural enemies of *Salvinia molesta* Mitchell in South America (Bennett, 1966). Hence, with the object of controlling *Salvania, P. acuminata* was imported into India through the agency of the Commonwealth Institute of Biological Control, Bangalore. The present study stems from the fact that a basic idea of the biology of an agent is an essential pre-requisite for any biocontrol programme. The results obtained are discussed under three headings: Biology, Host range and field releases.

Biology

During 1964-65, life history studies and host specificity tests were undertaken with *P. acuminata* at Belam, Brazil and Curpe, Trinidad (Bennett, 1966). Sankaran and Ramaseshaiah (1973) also briefly worked out the biology of *P. acuminata* at Bangalore.

Observations on the biology of *P. acuminata* were made in transparent cylindrical polythene jars of 96 mm diameter and

144 mm height. The lids of the jars were provided with wiremesh screens. Fresh and clean *Salvinia* were fed on alternate days.

Mating has been observed to take place within 24 hr after the final moult. The male usually sits by the side of or behind the female and inserts its genitalia from below the female abdomen. During the insertion, the male's antennae, at times, are variably placed on the female's body (head, thorax, legs and the like). Afterwards, they normally remain quiet except for faint movements of the abdomen. The whole process of mating takes 10 to 30 minutes.

The preoviposition period lasts for 4 to 7 days. During oviposition, the female inserts its abdomen between the leaves and remains quiet while ovipositing except for slight movements of the abdomen. One female usually deposits one, or sometimes two oothecae per day. There are days when no eggs are laid, such days being frequent in the case of older females.

Eggs are laid both on the lower and upper surfaces of the leaves as well as in the leaf axils. The shape and size of the oothecae vary depending on the number of eggs it contains. The usual number of eggs in an oothecae is 2 to 4 under laboratory conditions and 4 to 5 under field conditions. The colour of the oothecae is whitish at first but turns straw-coloured in about half an hr whereas the eggs are golden yellowish with a transparent chorion. The incubation period has been found to vary from 12 to 18 days with an average of 15.1 days during October-November, 1975. Eggs are hatched, irrespective of being under water or above the surface.

The first instar larva is greenish in colour, banded in colour, banded with light brown on the legs and with a pale brownish tinge on the body surfaces. They devour *Salvinia* and moult into the second instar in about 7 to 13 days with an average of 7.81 days. The second instar larva is similar to the first instar but for the size. Immediately after moulting, the larva is pale greenish in colour and slowly the colour deepens to a dirty green colour. The second instar period lasts for 4 to 7 days with an average of 6.3 days. The third, fourth and fifth instar periods also last for 4 to 7 days with an average of 5.81, 5.62, and 5.71 days respectively. After the fifth moult the males become adults whereas the females become adults only after the sixth moult. No significant difference is noted between the larval instar periods of males and females. Based on the average of 10 individuals, it is calculated that the male larval instar periods are (from the first instar onwards) 7.5, 6.5, 6.0, 5.8 and 6.3 days whereas for females, they are 8.1, 6.1, 6.6, 5.5, 5.2 and 7.0 days. The total larval period for the males and females lasted for 32 days and 37.55 days respectively during January-February.

Both winged and wingless adults are given birth, and the wingless form far outnumbers the winged one under laboratory conditions. The life-span of the adult lasted up to 1 to 2 months.

Feeding trials with cleaned primary and secondary forms of *Salvinia* show that the adult females consumed the largest quantity of the weed. They had eaten up on an average 0.59 g of *Salvinia* per day whereas adult males consumed only about 0.25 g of *Salvinia*. The rate of consumption was only about 0.22 g for the first instar nymphs. The quantity gradually increased with the growth of the insects and the average consumption of a final instar nymph was found to be 0.43 g per day.

Host range

Host range studies are a must in every biological weed control programme. Often, such studies are repeated in different localities. Host range studies with *P. acuminata* have been conducted at four different places *viz.*, Trinidad (S. America), Rhodesia (Africa), Bangalore and Mannuthy (India). Trials at Trinidad proved *Paulinia* to be selective and have put on record *Azolla ficuloides, Pistia stratiotes, Lemna sp., Commelina elegans, Hydromystria stolonifera* and *Spirodella intermedia* as the major hosts (Bennett, 1966). Though initial nibbling of rice by both nymphs and adults under starvation conditions occurred, all individuals died before incurring any significant damage. Despite the attack on rice under starvation conditions, the release of *P. acuminata* has been recommended by the C.I.B.C., Trinidad for the biological control of *Salvinia*.

In Rhodesia, *P. acuminata* was tested on *Arachis hypogaea, Avena sativa, Citrus aurantium, Gossypium sp., Helianthus annuus, Hordeum vulgare, Ipomcea batatas, Medicago sativa, Nicotiana tabacum, Oryza sativa, Prunus persica, Saccharum officianarum, Sorghum vulgare, Triticum aestivum, Vigna sinensis* and *Zea mays* and they found that the larvae fed slightly on the edges of a few leaves of *O. sativa* (Sankaran and Ramaseshaiah, 1973).

At Bangalore, limited host range tests with *P. acuminata* were carried out (Sankaran and Ramaseshaiah, 1973). The test plants included *Amorphophallus companulatus, Cocos nucifera, Eleusine coracana, Oryza sativa, Manihot esculenta* and *Musa paradisiaca*. It has been found that a negligible amount of feeding occurred on *M. paradisiaca* and *E. coracana*. However, the insects lived only for 2 to 5 days.

Host range studies at Mannuthy were conducted by releasing newly hatched and 15 days old *P. acuminata* nymphs, five on each of the test plants and observing the time of death. The test plants were: *Momordica charantia, Lycopersicon esculentum, Solanum melongena, Vigna sinensis, Capsicum annuum, Amaranthus sp., Abelmoschus esculentus, Moringa pterigosperma, Arachis hypogaea, Cocos nucifera, Ricinus communis, Amorphophallus companulatus, Manihot utilissima, Colocasia antiquorum, Dioscorea sp., Citrus aurantifolia, Artocarpus integrifolia, Annona reticulata, Mangifera indica, Musa paradisiaca, Carica papaya, Achras sapota, Garcinia mangostena, Psidium guajava, Zingiber officinale, Curcuma longa, Myristica fragrans, Piper nigrum, Eugenia caryophyllata, Rosa alba, Michelia champaka, Pennisetum purpureum, Panicum maximum, Coffea arabica, Theobroma cocao, Hevea brasiliensis, Areca catechu, Anacardium occidentale, Gossypium sp., and Oryza sativa*. In these cases, except with *A. esculentus, M. pterigosperma, A. sapota, G. mangostena, P. guajava* and *M. champaka*, the test insects died within 48 hr and the mortality was complete on these plants also by the 55th hr. However, on *O. sativa*, one out of five nymphs lived for 6 days and this agrees with earlier observations at Trinidad and Bangalore.

Host range studies on certain common water weeds showed that it can very well thrive and complete its life cycle on *Azolla sp., Pistia stratiotes* and *Monochoria vaginalis*. It also feeds on *Lemna sp.* and minor feeding has been observed on *Eichhornia crassipes* and *Nymphaea sp.* Nymphs on *Azolla* reached adult stage within a shorter period than those fed with *Salvinia*. It is interesting to note that insects fed with *Azolla* exhibited colour differences too. They were found to be distinctly more blackish. On becoming adults the pronotum of males turned almost completely black and brownish or black stripes appeared on the hind femora. The females were less blackish in colouration and the pronotal portions were usually greenish with black borders.

When fed with *Salvinia* alone, the insects presented a more greenish appearance with brownish or black patches.

Considerable variations had been noted in the developmental period of *P. acuminata* on *Azolla* and *Salvinia*. For the first moult itself 6 to 7 days were needed when bred on *Salvinia* whereas on *Azolla*, 4 to 6 days were sufficient during the month of February. The total developmental period was around 22 to 28 days on *Azolla*, while on *Salvinia* 28 to 36 days were necessary.

Field release

In the light of the exhaustive host range studies undertaken, field releases of *P. acuminata* were made at Mannuthy (Trichur District), Moncompu (Alleppey District), Ambalathara (Trivandrum District), Koratti and Vyttila (Ernakulam District).

Mannuthy: It was the first field release centre. Initial releases of *Paulinia* were made under confined conditions. A field water tank of about 5 m^2 was selected and covered with plastic net fitted to a wooden frame. At first 140 *Paulinia* nymphs, 3 to 13 days old, were released during the month of September. The population level was satisfactory for the first few days but decreased rapidly after a week's time. In about four weeks, the number was significantly reduced to 30. When observed two weeks later, only four adults (3 males and 1 female) and 3 first-instar nymphs were alive although the nymphs were of the second generation. Even this meagre population did not last long and by about two months not even a single *P. acuminata* was surviving.

The same trial was repeated in november with 130 nymphs of fourth, fifth and final instar stages. But again the population diminished to less than fifteen within one month and just two adults (one male and one female) were left after two months. No insects survived till the third month.

One more trial was conducted in the same pond. This time 1055 nymphs of first, second and third instars were released. The rate of mortality, however, exceeded all calculations and within a single week, all but 50 nymphs disappeared from the tank. The whole culture perished in about 60 days.

During the next phase, an open site which appeared to be an ideal place for the insect was selected at Kalathode near Mannuthy. It was a sunlit pond without any shady trees around; the weed mat was fresh and succulent and the predatory spider population was rather low. One thousand and two hundred oothecae which might have contained around 3600 eggs and 1100 first instar nymphs were released during the month of March. After a week of release, a number of nymphs were observed near the release site but later inspections did not reveal the presence of any *P. acuminata* in the pond for a number of months. After six months, two egg masses of *P. acuminata* were obtained from the pond but not even a single *Paulinia* grasshopper could be spotted out showing that the population of the insect still remained very poor. By this time, the whole pond was thick with robust and mature *Salvinia*. This was a strong hindrance for the fast multiplication and establishment of the grasshopper. More over sudd plants were quickly establishing on the *Salvinia* mat cutting down considerably, the area available for the insect to feed and multiply.

Simultaneous with these experiments, about 600 first and second instar nymphs were released in another adjacent pond spread with a dense mat of mature *Salvinia*. Signs of initial establishment of *P. acuminata* appeared after some five months and about eight egg masses were collected from the pond. Later inspection revealed that the grasshopper population was very low and symptoms of damage quite inconspicuous.

Moncompu: The place is situated in the heart of Kuttanad where the problems created by *Salvinia* are felt in its worst form. The site of release was a small channel in the campus of the Rice Research Station, Moncompu. Altogether 600 nymphs of different ages and about 70 oothecae were released. About 10 grasshoppers comprising three males and one female and few nymphs were found in the site when examined after two months. But later inspections proved the failure of *P. acuminata* to establish at Moncompu.

Ambalathara: Breeding and field release of P. acuminata in Trivandrum district has been carried out by the Division of Entomology, College of Agriculture, Vellayani. A nucleus culture of 800 nymphs and 25 adults were supplied to Vellayani, from the biological control scheme at Mannuthy during October-November, 1975. Reports from Vellayani confirm that initial releases failed due to flood havoc. But subsequent releases gave relatively encouraging results. At Ambalathara, a population level of about one insect/m^2during August, 1976 and about 4 to 5 per m^2 in April, 1981 was noted.

Kodakara and Vyttila: Releases were made at these places but with no positive results. In addition to these places, spot releases were made in a few ponds and canals in Kole lands in Trichur district and Athirampuzha village in Kottayam District; but there are no signs of establishment.

DISCUSSION

Bennett (1966) reported from Trinidad, South America, that the egg of *P. acuminata* failed to hatch unless kept under water and because of this the insect is bound to survive only in an aquatic habitat. The present study shows that the eggs hatch even when they are above the water surface and the high humidity prevalent in Kerala may be responsible for this.

P. acuminata is colour polymorphic, adopting the colour of its background on which it is reared. This explains the colour differences noted on *Paulinia* when reared on *Azolla*. The shades usualy seen are, brown or almost black, but when reared on reddish *Azolla* at Gaudeloupe (S. America), it became distinctly red imitating the host plant (Mitchell and Thomas, 1972).

Azolla appears to be the more preferred food plant of *P. acuminata*. Mitchell and Thomas (1972) reported that no indication of preferential feeding was found on *Azolla* in S. America. However, one spot with a stand of almost pure *Azolla* was noticed by Mitchell and Thomas (1972) where the density of *Paulinia* was at least twice as high as anywhere on *Salvinia*.

The polyphagous habit exhibited by *P. acuminata* has its own advantages and disadvantages. The presence of alternative food plants helps the insect to tide over periods of *Salvinia* scarcity. Yet we should always be alert on the risk of such insects turning to economic plants. Multilocational host specificity trials conducted so far indicate that *Paulinia* is relatively safe to crop plants and the chance of it turning into a pest is very distant.

Both biotic and climatic factors might have been involved in the failure of establishment of *Paulinia* in the protected tank at Mannuthy. The shady surrounding, the covering net and the protective walls should have created a little cooler microclimate whereas the insect shows a clear preference to moderately warm climate. Same was the case with lake Naivasha in Kenya and Kakki reservoir in Kerala where the lack of establishment of *P. acuminata* has been suspected to be due to the cooler climate prevalent. No parasites have so far been noted on the oothcae, larvae or adults of *P. acuminata*. However, a variety of predators like spiders, frogs and ants were detected in the tank, in spite of their occasional hand removal, and they are believed to have accounted for partial mortality of *Paulinia*. The population level of 4 to 5 *P. acuminata* per m^2 at Ambalathara (Trivandrum) is not at all satisfactory for effecting any profitable check on the explosive growth of *Salvinia*. The trials in Trinidad (S. America) demonstrated that *Paulinia* confined on *Salvinia* at populations of $30/m^2$ rapidly reduced *Salvinia* growth to the water level.

The factors that favoured a moderate establishment of *Paulinia* at Ambalathara are not very distinct. Climatic factors may be one. The *Salvinia* mat at the place of release was not thick and robust enough to promote sudd growth. The presence of predatory spiders was detected at Ambalathara too though the species complex of spiders is not yet worked out.

Taking an overall view into consideration, *Paulinia* as an agent for the biological control of *Salvinia* in Kerala is not at all encouraging. The grasshopper has failed to establish in most of the areas of release. Even where it has established, the population growth is far from the desired level to effect any apreciable check on this fast growing weed.

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ECOLOGY AND DISTRIBUTION OF UPLAND WEEDS IN JAPAN

MINORU TAKABAYASHI
Kyushu National Agricultural Experiment Station
Izumi Chikugo-shi, Fukuokaken 833, Japan.

ABSTRACT

Upland farming areas in Japan can be roughly divided into four regions: cold, cool, mild and warm regions. The annual mean temperatures of the four regions are 5～9℃, 9～13℃, 13～16℃, 16～18℃ respectively, and naturally the types of crops and weeds differ according to the region.

In both the cold and the cool regions, *Chenopodium album*, *Commelina communis*, *Polygonum lapathifolium*. *Stellaria media* and *Echinochloa crus-galli* are principal as annual weeds. *Rumex obtusifolius* is principal as perenial weeds. In addition, *Cgropyron repens* is principal as perennial weeds in the cold region.

In both the mild and the warm regions, *Amaranthus lividus*, *Cyperus microiria*, *Portulaca oleracea* and *Digitaria ciliaris* (= *adscendens*) are principal as annual weeds. In addition, *Eleusine indica* as annual weeds, *Cyperus rotundus* and *Oxalis corymbosa* (= *martiana*) as perennial weeds are principal in the warm region.

Equisetum arvense is widely distributed in Japan.

Growing stage and growing rate of main annual weeds

Main annual weed seeds (10 species) were sown in Wagner pots (1/2,000 are) at Kitamoto-shi, Saitamaken (in mil region) in 1972 and 1973.

On the cases that were sown at May, June and July, days from emergence to beginning of seed fall were as follows:

Amaranthus lividus, Acalypha australis, Portulaca oleracea, Polygonum lapathifolium	30 to 55 days
Echinochloa crus-galli var. praticola, Commelina communis, Cyperus microiria, Fatoua villosa	50 to 75 days
Digitaria adscendens	65 to 100 days
Chenopodium album	80 to 130 days

Digitaria adscendens was the largest on dry weight at harvesting time, and the descending orders were *Echinochloa crus-galli* var. *praticola*, *Commelina communis*, *Chenopodium album*, *Cyperus microiria* and *Polygonum lapathifolium*, *Portulaca oleracea*, *Amaranthus lividus*, *Acalypha australis*, *Fatoua villosa* were very little.

Seed production rates (seeds/plant) of May sowing were as follows:

C. microiria = *P. oleracea* (50,000 to 100,000) > *Che. album* = *D. adscendens* = *A. lividus* (10,000 to 20,000) > *E. crus-galli* var. *praticola* = *P. lapathifolium* (2,000 to 5,000) > *F. villosa* (1,500 to 3,000) *C. communis* (800 to 1,000) *A. australis* (150 to 300).

Longevity of buried weed seeds in soil

Two hundred seeds of main annual weed with sterilized soil were put into the plastic cylinders and they were buried at a depth of 20 cm in soil, at Kitamoto-shi, Saitamaken, November 1971. Samples were exhumed periodically for four and a half year to determine the viability.

Cyperus microiria, Commelina communis and *Chenopodium album* and above 80% of emergence after four and a half year. After four and a half year, emerged seed numbers of *Acalypha australis* were about a half of that after half a year.

Polygonum lapathifolium, Portulaca oleracea and *Amaranthus lividus* had above 10% of emergence after two and a half year. After four and a half year, emerged seed numbers of *Acalypha australis* were about a half of that after a half year.

Digitaria adscendens, Echinochloa crus-galli var. *praticola* and *Fatoua villosa* showed below 10% of emergence after two and a half year. Longevity of buried seeds of these species in soil was shorter than that of other seven species.

From the result mentioned above, we found that longevity of buried seeds of main annual weeds in soil was considerably long, except gramminaceous weeds such as *Digitaria adscendens* and *Echinochloa crus-galli* var. *platicola.*

Emergence depth of main weed seeds

Seeds of main annual weeds were sown in Wagner pots (1/2,000 are) at 1, 5 and 10 cm depth on May 1974, and in the field at 0, 1, 3, 5 and 10 cm depth on November 1978. These studies were carried out at Kitamoto-shi, Saitamaken.

The maximum emergence depth of each species were as follows:

Echinocloa crus-galli var. *pratiola,* *Commelina communis*	10 cm
Digitaria adscendens, Polygonum lapathifolium, *Acalypha australis, Chenopodium album*	5 cm
Fatoua villosa	3 cm
Portulaca oleracea	2 cm
Cyperus microiria	1 cm

The maximum emergence depth of *Amaranthus lividus* varied from 1 cm to 5 cm.

Emergence percentage of *Digitaria adscendens* and *Cyperus microiria* varied with days after harvest. Namely, emergence percentage of these species passed over one year afrer harvest were higher than that of these species within one year after harvest. This fact correlated with light requirement for germination. Especially, *Cyperus microiria* seeds maintained high light requirement even at one year after harvest.

Emergence percentage at soil surface of *Polygonum lapathifolium* and *Commelina communis* were very low as compared with that at 1 or 3 cm depth.

Dormancy of main annual weed seeds is now demonstrated.

BIOLOGY OF SOME OBNOXIOUS WEEDS OF KARNATAKA

G. BORAIAH and BALAKRISHNA GOWDA
Department of Botany, University of Agricultural Sciences
Bangalore 560 065, India.

ABSTRACT

About 400 species of weeds have been recorded in dry lands, wet lands, plantations, gardens, forests and other places of Karnataka, India. Among these, weeds *Acanthospermum hispidum* DC., *Cuscuta, sp., Cynodon dactylon* Pers., *Cyperus rotundus* L., *Echinochloa, spp., Eichhornia crassipes* (Mart.) Solms., *Eupatorium odoratum* L., *Impomoea hispida* (Vahl) R. & S., *Marsilea, sp., Merremia gangetica* (L) Cufod., *Oldenlandia, spp., Orobanche cernua* Lœfl., *Oxalis sp., Panicum repens* L., *Parthenium hysterophorus* L., *Salvinia sp., Solanum elæagnifolium* Cav., *Striga lutea* Lour., *Tribulus terrestris* L., *Typha angustata* C. & B., and *Xanthium strumarium* L., are considered as obnoxious since they cause damage to a greater extent compared to other weeds. Some of these weeds have been introduced and are at present invading and displacing the indegenous vegetation. In this paper attention is drawn to the diagnostic characters (illustrations with colour slides), origin, dispersal mechanisms and propagation of these obnoxious weeds and also the damage they cause.

There are instances where the crop loss incurred due to weeds reaching up to 95%. The enormous harm on account of weeds is also seen in water tanks and waterways by water plants and also the damage caused by the parasitic weeds directly attacking the individual crop plants. The dominance of these weeds is mainly due to their biology which help them to thrive and adapt to the prevailing conditions. The factors helping this are : (i) capacity to reproduce vegetatively by tubers, rhizomes and their perennation, (ii) a large number of minute seeds with longer viability and late physiological maturity and (iii) the modification and mechanism of dispersal of fruits and seeds.

The weed survey in the State of Karnataka, India has indicated the existence of about 400 species. Out of these about 21 are found to cause most of the damage to crop plants. Among them 10 have been listed in the worlds worst weed list. In this paper, the origin, distribution, habitat, diognostic characters and means of propagation have been briefly discussed.

Acanthospermum hispidum DC. (Bristly sandbur)

Asteraceæ

The original home of *Acanthospermum hispidum* has been considered to be American tropics and now widespread in tropics of the world. It grows in all types of soil (Thomas, 1970) from sea level to 1300 m. It is an erect hispid herb prominent in bearing achenes with 2 strong terminal spines and numerous small prickles on the surface. This facilitated the dispersal of fruits. It produces as many as 455 fruits per plant (Hosmani *et al.* 1971). This plant is noticed with all dryland and garden as a serious weed.

Cuscuta sp. (Dodder)

Convolvulaceæ

Loc. name : Swarnalatha

Cuscuta, a complete parasite is distributed in temperate and warmer parts of the world. *Cuscuta reflexa* Roxb. and *Cuscuta chinensis* Lamk. are the two common species. They parasitise a majority of ornamental plants, vegetable crops, forest trees, hedge plants, *Eleusine coracana*, fodder and wild grasses and also other wild plants. The plant body is whitish yellow in colour. They grow on the host plant penetrating through haustoria for good and other requirements resulting in poor growth of host, ultimately causing its death. These parasites are rapidly spreading in the State.

Cynodon dactylon (L.) Pers.
(Bahama grass)

Poaceæ Loc. name : Garike hullu

Cynodon dactylon is Indo-Malaysian in origin and has spread in tropical and subtropical regions and also entering the temperate zones. It is adapted to all types of drained soils and can tolerate drought. This species grows from sea level to 2,000m. It is a perennial grass with scaly rhizome and stolon and covers the soil like a lawn. The plant multiplies by rhizome which has high potential to develop numerous shoots. Seeds are also found predominently in warm areas and have longer viability. It grows commonly in open lands, places moderately shaded, paddy fields, coffee estates and also in garden land. This has become a very serious weed in the State agriculture in the land infested with this weed is an impossible task.

Cyperus rotundus L.
(Nut grass)

Cyperaceæ Loc. name : Konnari

Cyperus rotundus is a native of India, distributed throughout tropics and subtropics of the world. It is adapted to all soil types and thrives well in semi-irrigated regions. The plant is a perennial herb with rhizomatous stem which gives rise to a numerous underground tubers. A single tuber can produce vegetatively 146 tubers in 3-5 months. It infests paddy, wheat, sugarcane, potato, tobacco, mulbery, *Eleusine coracana*, coffee estate, garden land and waste land etc. The weed draws and holds large quantities of nutrients in the tubers (Bharadwaj and Verma, 1968). It is one of the worst weeds in the State. Cultivation of crops in areas infested with this weed is extremely difficult.

Echinochloa spp.
Poaceæ

The two important species are –

Echinochloa colonum (L) Link
Loc. name : Kadu haraka

Echinochloa crus-galli (L) P. Beauv.
(Barnyard grass)
Loc. name : Kadu dabbe hullu

The probable origin of *E. colonum* and *E. crus-galli* is Europe and India. These are cosmopolitan in distribution, grown on all types of soils, in irrigated and semi-irrigated lands and dies out on the onset of dry period. They are annual grasses and grow up to 1.5m. *E. crus-galli* has awned acuminate lema and this plant resembles rice plant. Hence it is difficult to eradicate this before flowering. *E. colonum* is unawned and it differs from *E. crus-galli* in height and it is having purple tinge at the margin of the leaf and stem. Multiplication is by seeds which have longer viability and each plant produce thousands of seeds. *E. colonum* can also propagate by vegetative means. They infest a number of crop lands especially paddy and they are also found in association with potato, sugarcane, tobacco and some vegetable crops. *E. crus-galli* accumulates nitrates in leaves, poisonous to animals feeding on it (Schmutz *et al.* 1968). The seeds of *E. crus-galli* are invariably present along with paddy because of their association. This has been considered a very serious weed in paddy causing considerable damage to rice production.

Eichhornia crassipes (Mart.) Solms.
(Water hyacinth)
Pontederiaceæ Loc. name : Pishachi tavare

Eichhornia crassipes is the worst weed in the world. The probable origin is tropical America but it is widespread in tropical and sub-tropical regions of the world occurring in tanks, canals and marshy areas. The plant is a free floating offset and produces roots in marshy areas. It has swollen petioles and flowers at 20 days, produces up to 5000 seeds per plant and are viable up to 15 years. Vegetative propagation is also seen where 2 plants can produce 300 offsets in 23 days and 1200 in 4 months (Holm and Richard yeo, 1980). It invades water tanks, channels and cuts down water flow and damage the tanks by silting. It also invades paddy crop. A huge amount of water loss and silting of tanks and channels have been noticed in the State.

Eupatorium odoratum L.
(Communist weed)
Asteraceæ

It is a tropical American weed which has spread all over tropics. It profusely grows in forest lands and plantations with numerous flowering branches bearing white-purple coloured heads and propagation is by seeds. This weed invades rubber, teak, coffee and other forest plantations. It provides a natural habitat for wild boars and bandicoots which destroy nearby paddy fields. It is also known to suppress the development of newly established plantations. Recently these plants have been noticed even in the interior scrub jungles and other forest areas where it does not allow the development of grass and other flora.

Ipomoea hispida (Vahl.) R. & S.
Convolvulaceæ
Loc. name : Mille balli

Ipomoea hispida is distributed in India, Ghana, Pakistan and other tropical countries. It has now occupied a dominant place in the weed-list of Karnataka. It grows in dry lands in association with horsegram. The plant is a small herbaceous twiner having simple cordate leaves with lilac flowers and the capsules are 4-lobed. They produce 388 seeds per plant on average (Muniyappa *et al.* 1973). The propagation is by seeds through contamination of horsegram seeds.

Marsilea minuta L.
Marseliaceæ

Marsilea minuta is distributed in the tropics and temperate regions of the world. It occurs in marshy areas and invades rice fields. The plant is a prostrate amphibious herb with characteristic sporocarps. It propagates vegetatively. *Marsilea* has become one of the weeds that cause damage to crops such as paddy.

Merremia gangetica (L.) Cufod.
Convolvulaceæ
Loc. name : Mushika parni

Merremia gangetica is distributed in the tropics of the world. In Karnataka, it is alarmingly increasing in the semi-irrigated lands. It is a runner rooting at nodes with reniform undulate leaves, margins having purplish tinge. The propagation is by runners and also through seeds. It infests crops like *Eleusine coracana*, groundnut, cowpea, blackgram and others. The perennating parts are resistant to heat, foliar damage and herbicides etc., providing more vigour for growth (Dubey and Mall, 1973).

Oldenlandia sp.
Rubiaceæ

The common species of *Oldenlandia*

are *Oldenlandia corymbosa* L. and *Oldenlandia umbellata* L. They are distributed in the warmer parts of the world. In Karnataka they are widely spread among dry-land crops especially in *rabi* season. They are small bushy herbs, leaves narrow, flower white to lilac, inflorescence variable from solitary to umbellate. The propagation is by seeds which are small and numerous in number. These weeds are seen in crop lands like *Eleusine coracana,* sorghum, groundnut, bajra, castor, Cajanus etc.

Orobanche cernuva Loefl.
(Broom rape)

Orobanchceæ Loc. name: Benkimari

Orobanche cernuva distributed in tropical and temperate regions of the world especially in the arid zones. It is a parasitic herb devoid of chlorophyll, flowers in terminal racemes and are bilipped. Seeds are minute and numerous up to 1,32,000 Hosmani *et al.* (1971) and readily mix with tobacco seeds. The seeds of the hosts cannot be distinguished from the seeds of the parasite. The seeds are dispersed by wind, water and through contamination and they are viable up to 12 years. The parasite grows well on specific hosts predominantly attacking dicots that grow on nitrogen deficient soils. The weed infests crops like sunflower, tobacco, tomatoes, potato, brinjal and other solanaceous plants in particular.

Oxalis sp.

It is originated from Europe and India and the plants are cosmopoliton in distribution. There are two species in *Oxalis* namely *Oxalis corniculata* L. and *Oxalis latifolia* H. B. & K. All these are stolonifer ous perennial herbs with trifoliately compound leaves having obcordate leaflets. *O. corniculata* L. has creeping branched stolons with small non succulent leaves whereas *O. latifolia* has unbranched stolons with large succulent leaves. Vegetative propagation by stolons is seen in all the species. They also produce many seeds. These occur in lawns, pastures and also along with rice, coffee, tea, potato and other vegetable crops.

Panicum repens L. (Ginger grass)

Poaceæ Loc. name: Shunti Hullu

Panicum repens orginated from East Asia and distributed in tropics and sub-tropics. It grows in all most all types of soils. It is an errect perennial grass developing thick underground rhizome with loose panicle. The propagation is by creeping rhizome and also by seeds. This weed infests pastures, plantations, field crops and garden plants particularly in moist soils.

Parthenium hysterophorus L.
(White head)

Asteraceæ Loc. name: White top

It originated in American tropics and widely spread in Asian countries. This weed grows in plain to high mountain, in light and medium soils of irrigated and non-irrigated lands. It is an aromatic much branched erect herb up to 1 m with pinnatifid leaves. Fruit possesses 2 recurved awans. Each plant produces a large number of fruits that possess persistant dissected sepals. The distribution of this weed in a vast area within a short period is due to the parachute mechanism of the dispersal of fruits. It infests all crop lands of dry and semi irrigated fields, bunds and waste lands. This weed has parthenin, sedative to humans, allergic to human skin and also acts as growth inhibitor. The leaves and roots of *P. hysterophorus* are known to contain chemicals of bactericidal and insecticidal effects.

Salvinia sp.

Salviniaceæ

Salvinia originated in South America and is cosmopolitan in distribution. It is a free floating form with green leaves forming thick mat and has nùmerous club shaped hairs on the upper surface of leaves. The propagation is by vegetative means. It infests rice fields, water tanks, slow flowing waterways and causes water loss and silting.

Solanum elæagnifolium Cav.

Solanaceæ

Solanum elæagnifolium is a tropical American in origin and now spread in India especially in Tamil Nadu and also in some parts of Karnataka. It grows on black as well as on red soils and loams and spreads well in moist conditions. The plant is short, prickly perennial with deep root system up to 2.4 m. The propagation of this weed is by underground stoloniferous stem but has low seed germination. It infests agricultural lands during monsoon and gives out profuse shoots and cultivation is very difficult.

Striga lutea Lour.
(Witch weed)

Scrophulariaceæ

Striga lutea is distributed in tropics and sub-tropics of the world. It occurs on light soils to heavy soils and infest host plants on poor sandy soils. The plant is a semiparasite with weak root system and haustoria of roots penetrate the host and suck water and nutrients. The flowers are sessile and yellow in colour and produce seeds up to 50,000 per plant. The propagation is by seeds. The seeds have a tremendous viability period up to 20 years. The weed infests crops like sorghum, maize, sugarcane, tobacco, tomato, sunflower etc and reduce the yield to a great extent.

Tribulus terristris L. (Bulls head)

Zygophyllaceæ Loc. name : Neggila mullu

It originated in the meditaranian region and spreads into southern Europe, Africa, North America and parts of Asia. It grows well in loose, dry, sandy soils and pasture lands. It is an annual herb with pubescent short petioled pinnate leaves. Fruits are woody with hard spines split into 3 to 5 woody cocci. The propagation is through seeds. Seeds are well protected with woody wall and each plant produces numerous seeds. The weed spreads like a mat. It infests vegetable crop lands and all dry land crops. The plant contains saponin which causes liver diseases in pasture animals (Hau, *et al.* 1968). The fruits injure animal mouth.

Typha angustata C. & B.
(Bull rush)

Typhaceæ Loc. name : Ane jondu

It is distributed in temperate and tropical regions of the world. It is an aquatic weed occurring in ponds, drains, waterlogged fields and also in back waters of tanks. It grows in shallow water up to 80-100 cm depth and 3-4 m height. The rhizomes are formed when plants reach 20-30 cm height. One plant may produce up to 2,00,000 fruits and are dispersed by wind. The seeds remain viable up to 5 years (Indu Mehta and Sharma, 1975).

Xanthium strumarium L.

Asteraceæ

Xanthium strumarium is a South American plant and has spread throughout the world. It thrives well on sandy soils, water margins, fallow lands and poor pastures. The plant is an erect annual herb having hard ovoid fruit with spiny hooks. The propagation is mainly by spiny fruits attached to the clothes and animal body. The weed is predominent in cotton, sugarcane, wheat and garden lands.

It is needless to add that a detailed study of the biology of weeds is of paramount importance. It not only helps in the identification of the weed concerned but also indicates its degree of establishment, spread and the amount of damage it causes to the cultivated plants. It is high time that we should concentrate on the domancy of weed seeds and their physiological maturity in order to control their spread effectively. Further, it is also time that we should incorporate into our agricultural practices new technologies especially involving appropriate measures to control weeds.

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CHEMICAL CONTROL OF CUSCUTA IN PULSES AND OTHER CROPS

K. NARAYANA RAO and K. MAHADEVA GUPTA
Weed Science Division, A. P. Agricultural University, Agricultural College, Bapatla A.P., India.

ABSTRACT

The parasitic weed Cuscuta is a problem in Krishna and Guntur districts in pulses, raised after paddy crop. In *rabi* (winter) 1980, a trial was laid out with different herbicides. The herbicides tested were pronamide at 1.25, 2.50 kg/ha, nitrofen (Nitrotul) at 1.87, 2.50 kg/ha, nitrofen (TOK. E. 25) at 1.87 kg/ha, fluchloralin at 1.25 kg/ha and CIPC at 1.0 and 2.0 kg/ha. All the herbicides were sprayed immediately after sowing except fluchloralin which was sprayed as pre-sowing incorporated spray.

The test crops included in the trial plot were blackgram (*Vigna radiata* var. mungo), greengram (*Vigna radiata* var. aureus.), pillipesara (*Phaseolus trilobus*, Roxb.), sannhemp (*Crotalaria juncea* L.) and gogu (*Hibiscus cannanibus* L.). Complete control of Cuscuta was observed in pronamide treated plots, both at 1.25 and 2.5 kg/ha which was followed by fluchloralin at 1.25 kg/ha. Among the crops under test, blackgram is found to be more susceptible to Cuscuta. Next to pronamide, fluchloralin at 1.25 kg/ha was efficient.

INTRODUCTION

Cuscuta spp. (dodder) is a complete stem parasite with slender thread like yellow to orange twining stems. The stems fasten to their hosts with the attachments known as haustoria. The twining vines not only deprive the host plants of nutrients, but also inhibit the growth and seed formation in host plants. They also transmit the diseases to the hosts. They are rootless and leafless. The plant flowers within 25 to 30 days after germination.

Greengram (*Vigna radiata* var. aurens) and blackgram (*Vigna radiata* var. mungo) are the important pulse crops parasitised by Cuscuta in Andhra Pradesh. The other crops subject to attack by this parasite are *Crotalaria* Juncea and *Hibiscus cannanibus*. Large areas of pulse crop raised as a second crop after paddy in Krishna and Guntur districts of Andhra Pradesh are infested by this weed.

Slaster *et al.* (1969) observed that Chloropropham (Isopropyl m-Chlorocarbanilate) killed emerging and emerged dodder seedlings. Tosh *et al.* (1977) reported that Chloropropham at 4.0 kg/ha applied to the moist soil, at 6 days after sowing controlled Cuscuta most effectively. He also reported that pronamide [N-(1,1-dimethyl-2-propynyl) 3, 5-dichloro-benzamide] at 4.5 kg/ha applied 15 days after germination of Cuscuta and at 2.0 kg/ha at 20 days after sowing controlled Cuscuta infestation selectively without phytotoxic effect on the niger crop.

MATERIAL AND METHODS

An observation trial in duplicate plots was laid out at the Agricultural College Campus, Bapatla during *rabi*, 1980. The size of the plot was 40 m^2. The crops tested were blackgram, Phillipesara, deccan hemp (gogu) and sannhemp.

Each crop was sown in separate lines. Cuscuta seed was sown along with crop

Table 1 : Number of plants parasitised in different crops at 30 days after sowing the crop.

Treatments	*Hibiscus cannabinus*	*Crotalaria juncea*	*Phaseolus trilobus*	*Vigna radiata* var. aureus	*Vigna radiata* var. mungo	Total No. of plants infested *Cuscuta* in herbicide treatments
		(Mean of two replications)				
Fluchloralin at 1.25 kg/ha	–	–	–	–	–	–
CIPC at 1.0 kg/ha	1	0.5	2.5	3.0	1.0	8.0
CIPC at 2.0 kg/ha	–	0.5	0.5	1.5	1.0	3.5
Nitrofen at 1.87 kg/ha (TOK. E. 25)	–	2.0	0.5	4.0	–	6.5
Nitrofen at 1.87 kg/ha (Nitrotul)	0.5	1.0*	2.0	2.0	1.0	6.5
Nitrofen at 2.50 kg/ha (Nitrotul)	–	0.5	1.0	0.5	0.5	2.5
Pronamide at 1.25 kg/ha	–	–	–	–	–	–
Pronamide at 2.50 kg/ha	–	–	–	–	–	–
Control (Unweeded check)	3.0	2.5	2.5	4.5	3.5	16.0

seed. All the herbicides were sprayed as pre-emergence spray except fluchloralin which was sprayed as pre-sowing incorporated spray and the spray fluid used was 500 l/ha. The following are the details of treatments.

1. Pre-sowing incorporated fluchloralin at 1.25 kg/ha, 2. Pre-emergence CIPC at 1.0 kg/ha, 3. Pre-emergence CIPC at 2.0 kg/ha, 4. Pre-emergence nitrofen (TOK. E. 25) at 1.87 kg/ha, 5. Pre-emergence nitrofen (nitrotul) at 1.87 kg/ha, 6. Pre-emergence nitrofen (nitrotul) at 2.50 kg/ha, 7. Pre-emergence pronamide at 1.25 kg/ha, 8. Pre-emergence pronamide at 2.50 kg/ha and 9. Unweeded check.

RESULTS AND DISCUSSION

Observations were recorded up to 60 days after sowing. It was observed that Cuscuta seed germinated 15 days after sowing. The following are the observations in different herbicide treatments.

Pronamide: Observations recorded one month after spraying indicated that all the five crops raised in the plots were free from Cuscuta infestation. The same trend was noticed throughout the crop growth period. Due to the toxic action of the herbicide the growth of the crop was inhibited during the early period of crop growth and later it recovered (Table 1).

Fluchloralin: All the crops sown in the plots were not infested by Cuscuta up to 30 days after sowing. One month after spraying *Hibiscus cannabinus* was infested by Cuscuta. But the flowering was delayed in Cuscuta.

CIPC: All the crops were parasitised by Cuscuta. The infestation was maximum is *vigna radiata* var. aureus and minimum in *Hibiscus cannabinus.* Flowering of Cuscuta was delayed in both the treatments.

Nitrofen: At lower dose two different products *viz.,* TOK. E. 25 and

Nitrotul were tested in this trial. In TOK. E. 25 *Hibiscus cannabinus* and *Vigna radiata* var. mungo were not affected, whereas in nitrotul all the crops were infested with Cuscuta. In higher dose of nitrotul treatments the total number of plants parasitised by Cuscuta were less than that of the lower dose of nitrotul treatment. Cuscuta growth was inhibited and flowering was less in higher dose than at lower dose.

Degree of infestation in different crops: Observations in control plot indicated that maximum number of plants were parasitised in *Vigna radiata* var. aureus and this was followed by *Vigna radiata* var. mungo.

Minimum infection was noticed in *Phaselous trilobus.*

Study of parasitised plants in different crops is all the herbicide treatments indicated that *Vigna radiata* var. aureus parasitised by Cuscuta and this was followed by *Phaselous trilobus.* Minimum number of plants were infected in *Hibiscus cannabinus.*

The observations on the spread of Cuscuta vines indicated that *Vigna radiata* var. mungo was more susceptible to Cuscuta and this was followed by *Vigna radiata* var. aureus and *Phaseolous trilobus.*

The observations on flowering of Cuscuta in control plot indicated that flowering was profuse in *Hibiscus cannabinus* and *Phaseolus trilobus.* It was also observed that flowering of Cuscuta was delayed in *Vigna radiata,* var. aureus.

LITERATURE CITED

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INTEGRATED CONTROL OF PERENNIAL WEED *SCIRPUS MARITIMUS* L. IN WETLAND RICE

S. K. DE DATTA and P. C. BERNASOR
Department of Agronomy, The International Rice Research Institute, P.O. Box 933 Manila, Philippines.

ABSTRACT

Experiments 1978-80 at IRRI included chemical and integrated control of *S. maritimus* L. in transplanted rice. Use of 2,4-D herbicide, cultivar type, and tillage practices were tested in separate trials. In one, susceptibility of *S. maritimus* to control at various growth stages was examined.

Regardless of rates of application, 2,4-D controlled *S. maritimus* as effectively as bentazon and fenoprop when applied post-emergence. The grain yield increase resulting from control of *S. maritimus* with 2,4-D was between 2 and 3 t/ha.

In studies with 14 successive rice crops, considerable shift of weed species occurred between *Paspalum distichum* L. and *S. maritimus*, depending on tillage treatments. The long-term results suggested that intermediate-statured rices compete better against perennial weeds than semidwarf rices.

In developing combinations of practices to control *S. maritimus* and other perennial weeds, consideration should be given to resources available to the farmers.

INTRODUCTION

S. maritimus poses serious problems for wetland rice farmers. It is a highly competitive weed that, if uncontrolled, almost overwhelms most semidwarf modern rices. *S. maritimus* propagates mainly from tubers and rhizomes produced in the soil.

S. maritimus has been reported from many rice-growing countries. Paller *et al.* (1971) found it in the wetland rice fields at the University of the Philippines at Los Banos. Ghosh *et al.* (1973) observed a natural stand of 500 plants/m^2 in rice fields at IRRI. It was found in farmers' fields in Isabela, Nueva Vizcaya, and Samar provinces in the Philippines (De Datta and Lacsina, 1972, 1974). It has also been reported in Spain (Frias, 1970), Portugal (Vasconcellos, 1954), Romania (Chirila, 1967) and Italy (Pirola, 1964). Luib and van de Weerd (1976) reported it in Europe and the temperate Americas.

The control and management of perennial weeds in rice were recently discussed in detail by De Datta (1977). Our paper summarizes recent results on the chemical control of *S. maritimus* weed in wetland rice. A long-term experiment monitoring weed shifts as affected by various degrees of tillage is also summarized and integration of control measures to minimize competition of *S. maritimus* weed in wetland rice is discussed.

MATERIAL AND METHODS

Experiments on chemical control of *S. maritimus* and weed shifts developed under tillage, tested technology to control and manage *S. maritimus* in wetland rice.

Chemical Control of *Scirpus maritimus*

Five expriments at IRRI (Aquic Tropudalf; pH, 6.5; organic matter, 2%; total N, 0.14%; CEC, 45 meq/100 g soil) from 1978 through 1980 checked chemical control of *S. maritimus* in transplanted rice. Controls tested were the use of 2,4-D (2,4-dichlorophenoxy acetic acid) herbicide, cultivar, and tillage in separate experiments. In one trial, susceptibility of this weed at various growth stages was examined.

This principle annual weeds common in all experiments were *Echinochloa glabrescens* Munro ex Hook f., *E. crus-galli sp. hispidula* (Retz.) Honda and *Monochoria vaginalis* (Burm.f.) Presl. In all experiments either butachlor (*N*-butoxymethyl- -chloro-2', 6'-diethylacetanilide) or thiobencarb (*S*- 4-chlorobenzyl diethylthio-carbamate) in a proprietary mixture with 2,4-DIPE was applied pre-emergence to control annual weeds. The extent of *S. maritimus* infestation was monitored. Hand weeded (usually 20 and 35 days after transplanting) and untreated plots checked the degree of control provided by the treatments. Other management practices such as water, pest control and fertilizer were maintained at optimum levels.

Weed samples were taken shortly before senescence of *S. maritimus*, except in the fifth experiment where samples were at maximum tillering and maturity of the crop.

Grain yield at 14% moisture was sampled from 5 m² of all plots.

Experiment 1.

An experiment during the 1978 dry season evaluated the effects of a single applica-tion of 2,4-D on *S. maritimus*. 2,4-D was applied post-emergence at the rates of 1.0 and 1.5 kg ai/ha 20 days after transplanting IR 36. The standard chemicals for *S. Maritimus* control, bentazon [3-isopropyl-(1*H*)-benzo-2,1,3-thiadiazin-4-one 2,2,-dioxide] and fenoprop [(±)-2-(2, 4, 5 - trichlorophenoxy) propionic acid], where applied at the same time. Fosamine (ethyl hydrogen carbamoyl phosphonate), are new herbicide that is supposed to reduce tuber production, was sprayed on the weeds 27 days before initial land preparation.

Both rates of 2,4-D control *S. maritimus* as effectively as bentazon and fenoprop (Table 1). Fosamine had little effect. There was significant increase in grain yield in plots where *S. maritimus* was con-

Table 1 : Effects of herbicide on control of *S. maritimus* and yield of transplanted IR 36 rice. IRRI, 1978 dry seasons.

Treatment [a]	Application Rate [b] (kg a.i./ha)	Application Time [c] (DT)	Weed wt [a] (g/m²) *Scirpus maritimus*	Weed wt [a] (g/m²) Annual weeds	Grain yield [d] (t/ha)
Hand weeded check	–	20 fb 35	1 a	4 a	5.0 a
Thiobencarb–2,4–D fb bentazon	1.0 – 0.5 fb 1.0	4 fb 20	4 ab	12 a	4.8 a
Thiobencarb–2,4–D fb 2,4–D	1.0 – 0.5 fb 1.0	4 fb 20	5 b	17 a	4.8 a
Thiobencarb–2,4–D fb fenoprop	1.0 – 0.5 fb 1.0	4 fb 20	5 b	7 a	4.7 a
Thiobencarb–2,4–D fb 2,4–D	1.0 – 0.5 fb 1.5	4 fb 20	3 ab	16 a	4.0 ab
Fosamine fb thiobencarb–2,4–D	4.0 fb 1.0 – 0.5	27 BT fb 4 DT	100 c	9 a	3.5 bc
Fosamine fb thiobencarb–2,4–D	8.0 fb 1.0 – 0.5	27 BT fb 4 DT	179 cd	12 a	3.0 bcd
Thiobencarb–2,4–D	1.0 – 0.5	4	281 d	8 a	2.6 cd
Untreated check	–	–	162 cd	178 b	2.1 d

[a] A spaced dash (–) means that the herbicides were formulated as a proprietary mixture. fb = followed by. [b] a.i. = active ingredient. [c] DT = days of transplanting. BT = foliar application of chemical to *S. maritimus* before tillage. [d] Av of 3 replications. In a column, means followed by the same letter are not significantly different at 5% level.

Table 2. Effect of rate and time of 2,4–D application on the control of *Scirpus maritimus* and yield of transplanted IR42 rice. IRRI, 1978 wet season.

Treatment[a/]	Application		Dry wt of *S. maritimus*[d/] (g/m^2)	Grain yield[d/] (t/ha)
	Rate[b/] (kg a.i./ha)	Time[c/] (DT)		
Thiobencarb–2,4–D fb bentazon	1.0–0.5 fb 1.0	5 fb 20	12 a	4.0 a
Thiobencarb–2,4–D fb 2,4–D	1.0–0.5 fb 0.5	5 fb 15	108 b	3.3 ab
Thiobencarb–2,4–D fb 2,4–D	1.0–0.5 fb 0.5	5 fb 20	93 b	3.3ab
Thiobencarb–2,4–D fb 2,4–D	1.0–0.5 fb 1.0	5 fb 20	9 a	3.0 ab
Hand weeded check	–	15 fb 30	8 a	3.0 ab
Thiobencarb–2,4–D fb 2,4–D	1.0–0.5 fb 1.0	5 fb 15	52 b	2.6 b
Thiobencarb–2,4–D	1.0–0.5	5	477 c	0 c
Untreated check	–	–	535 c	0 c

[a/] A spaced dash (–) means that the herbicides were formulated as a proprietary mixture. fb= followed by. [b/] a.i.=active ingredient. [c/] DT=days after transplanting. [d/] Av of 3 replications. Means followed by the same letter are not significantly different at 5% level.

trolled. Generally, when *S. maritimus* was purely controlled, even though the annual weeds were adequately controled by thiobencarb 2,4-D, yields were not significantly different from the unweeded check, indicating once again the capacity of *S. maritimus* to reduce crop yields.

Experiment 2.

An experiment during the 1978 wet season evaluated rates and times of 2,4-D application on *S. maritimus* control. IR42 was grown as the test cultivar and 2,4–D was applied at 0.5 and 1.0 kg/ha 15 and 20 days after transplanting. Bentazon applied at 20 days was the standard herbicide treatment.

The infestation *S. maritimus* was so great that no grain yield was obtained from the unweeded check or from plots treated with thiobencarb-2,4-D (Table 2). Regardless of the rate and time of application, 2,4-D greatly reduced the stand of *S. maritimus*. 2,4–D applied at 1.0 kg/ha, 20 days after transplanting was as effective as bentazon in controlling *S. maritimus* and superior to other 2,4–D treatments. Yields from plots treated with 2,4–D were generally comparable to those from the hand weeded check and the bentazon-treated plots (Table 2). These results suggest that a single application of 2,4–D is effective against *S. maritimus*. Although control provided at the rate of 0.5 kg/ha was slightly inferior to that at 1.0 kg/ha, differences were not reflected in the yields obtained.

Experiment 3.

The effects of cultivar, tillage, and herbicide on the control of *S. maritimus* and yield of two rices were studied during the 1979 dry season. Regular seedlings of IR36 (short-statured semidwarf) and IR42 (a somewhat taller semidwarf rice) were planted on plots after minimal (one plowing and one harrowings) or conventional (one plowing and two harrowing) preparation. Final harrowing in both cases was one week after plowing. Nine herbicide treatments were added to cultivar and tillage treatments (Table 3).

All chemical treatments provided adequate weed control and gave yields significantly higher than those of the untreated check (Table 3). Yields from plots

Table 3. Effects of herbicides on the control of *Scirpus maritimus* and annual weeds and on yield of transplanted rices. IRRI, 1979 dry season.

Herbicide Treatment[a/]	Application		Weed wt[d/] (g/m²)		Grain yield[d/] (t/ha)
	Rate[b/] (kg a.i./ha)	Time[c/] (DT)	*Scirpus maritimus*	Annual weeds	
Weed-free check	–	–	0 a	0 a	5.1 a
Butachlor fb bentazon	1.0 fb 1.0	4 fb 28	11 bcd	37 b	5.1 a
Butachlor fb 2,4-D fb hand weeding	1.0 fb 1.5	4 fb 28 fb 40	9 bc	10 b	5.1 a
Butachlor fb 2,4-D	1.0 fb 1.0	4 fb 28	24 de	20 b	5.1 a
Butachlor fb 2,4-D fb hand weeding	1.0 fb 1.0	4 fb 28 fb 40	5 b	8 b	5.0 a
Butachlor fb 2,4-D	1.0 fb 1.5	4 fb 28	42 e	33 b	4.7 a
Butachlor	1.0	4	108 f	33 b	3.9 b
2,4-D	1.0	28	18 cd	135 c	3.7 b
Untreated check	–	–	112 f	196 c	2.6 c

a/fb=followed by. b/a.i.=active ingredient. c/DT=days after transplanting. d/Av of three replications, two cultivars (IR36 and IR42) and two tillage levels (conventional and minimal). In a column, means followed by the same letter are not significantly different at 5% level.

Table 4 : Effects of cultivar and tillage on *S. maritimus* control and grain yield. IRRI, 1979 dry season.

Tillage	Rice cultivar			
	IR36	IR42	IR36	IR42
	Weed wt[a/] (g/m²)		Grain yield[a/] (t/ha)	
One plowing + 1 harrowing	43 a	31 a	4.1 a	5.0 a
One plowing + 2 harrowings	33 a	39 a	3.9 b	4.9 a
Mean	38 a	35 a	4.0 b	5.0 a

a/ Av of three replications and nine herbicide treatments. In a column/row, means followed by the same letter by the same letter are not significantly different at 5% level.

treated with 2,4-D where both *S. maritimus* and annual weeds were controlled were similar to those from the bentazon treatment and the weed free check. Yields were markedly lower in plots where only either *S. maritimus* or the annual weeds were removed by sole applications with 2,4-D and butachlor, respectively, than when both weed groups were controlled. These results indicate that under a mixed-weed situation where one herbicide cannot control all weeds, herbicide combinations must be adopted in order to obtain maximum yield return. Results confirm earlier findings of Dr. Datta and Lacsina (1974) and De Datta (1977).

No significant interaction between cultivar and tillage was observed. Regardless this tillage levels, *S. maritimus* stand in IR36 did not differ much from that in IR42 (Table 4). IR42 was only about as tall as *S. maritimus* at harvest, and was not able to compete against the weed adequately. Furthermore, a conventional tillage did not provide better control of *S. maritimus* than minimal tillage, irrespective of cultivar. This suggests that the time interval between tillage operations, rather than frequency, could be a more effective technique in reducing *S. maritimus* infestation.

Experiment 4.

Tubers of *S. maritimus* have been reported to germinate 5 days after the first

Table 5 : Effects of herbicide and tillage treatments on the control of *S. maritimus* IRRI, 1980 dry season.

Treatment[a/]	Application		*S. maritimus* wt[d/] (g/m²)			Herbicide mean
	Rate (kg a.i./ha)[b/]	Time (DT)[c/]	Reharrowing time (days)			
			5	10	15	
2,4-D	0.5	4	173 a	170 abc	129 ab	157 ab
2,4-D	0.5	26	91 abc	90 abc	59 abc	80 bc
2,4-D	1.0	4	58 abc	131 abc	132 ab	107 ab
2,4-D	1.0	26	26 cd	81 cd	40 bcd	49 cd
2,4-D fb 2,4-D	0.5 fb 0.5	4 fb 26	67 abc	74 abc	64 abcd	68 bc
2,4-D fb 2,4-D	0.5 fb 1.0	4 fb 26	18 d	29 cd	26 cdef	24 de
2,4-D fb 2,4-D	1.0 fb 0.5	4 fb 26	22 d	97 bcd	12 ef	44 de
Butachlor fb 2,4-D	1.0 fb 0.5	4 fb 26	40 bcd	63 abc	91 ab	65 bc
Butachlor fb 2,4-D	1.0 fb 1.0	4 fb 26	8 d	9 d	17 def	12 e
Butachlor	1.0	4	140 ab	198 a	222 a	187 a
Hand weeded check	–	20 fb 35	1 e	2 f	1	f
Untreated check	–	–	262 a	177 ab	149 ab	196 a

a/fb=followed by. b/a.i.=active ingredient. c/DT=days after transplanting. d/Av of 3 replications. In a column, means followed by the same letter are not significantly different at 5% level.

plowing and harrowing of a field and tuber formation to start 13 to 20 days after the initial tillage.

During the 1980 dry season, a study was designed to find out if a properly timed final harrowing would reduce the stand of *S. maritimus*. Reharrowing was done 5, 10, and 15 days after the first tillage operations of one plowing and one harrowing performed in one day. Tillage treatments were synchronized to permit planting on the same date. IR50 was transplanted the following day after reharrowing the field. 2,4-D treatments at rates of 0.5 and 1.0 kg a.i./ha, applied either singly or sequentially as pre- and post-emergence spray were superimposed in each tillage plot.

Significant reductions in *S. maritimus* stand resulted mainly from postemergence application of 2,4-D. The differences in *S. maritimus* control between plots reharrowed at 5 days and those at 10 and 15 days were negligible, indicating that the interval of harrowing time did not make any difference (Table 5). Generally, plots treated with postemergence 2,4-D gave yields significantly higher than the untreated check; when applied as pre- and post-emergence in sequence, 2,4-D controlled both *S. maritimus* and the annual weeds and gave yields comparable to that of the hand weeded check (Table 6). 2,4-D applied pre-emergence controlled the annual weeds as effectively as butachlor but had no effect on *S. maritimus*. However, when applied post-emergence, 2,4-D controlled *S. maritimus* and *M. vaginalis* but not the grassy weeds.

Experiment 5.

Most studies on *S. maritimus* control with foliar herbicides have dealt with applications based upon the growth stage of the rice crop rather than that of the weed. Although success had been obtained with such herbicides as the pheno-

Table 6: Effects of herbicides on the control of *Scirpus maritimus* and annual weeds and on yield of transplanted IR50 rice. IRRI, 1980 dry season.

Treatment[a/]	Application		Weed wt[d/] (g/m²)		Grain yield[d/] (t/ha)
	Rate[b/] (kg a.i./ha)	Time[c/] (DT)	*Scirpus maritimus*	Annual weeds	
Hand weeded check	–	20 fb 35	1 a	17 a	4.6 a
Butachlor fb 2,4-D	1.0 fb 0.5	4 fb 26	65 de	58 ab	4.3 ab
Butachlor fb 2,4-D	1.0 fb 1.0	4 fb 26	12 b	53 ab	4.1 ab
2,4-D fb 2,4-D	1.0 fb 0.5	4 fb 26	44 bc	74 bc	4.0 ab
2,4-D fb 2,4-D	0.5 fb 1.0	4 fb 26	24 bc	61 bc	3.8 bcd
2,4-D fb 2,4-D	0.5 fb 0.5	4 fb 26	68 de	75 bc	3.8 bcd
2,4-D	1.0	26	49 cd	135 c	3.6 bcde
2,4-D	1.0	4	107 ef	50 ab	3.3 cdef
Butachlor	1.0	4	187 f	47 ab	3.2 cdef
2,4-D	0.5	26	80 de	102 bc	3.1 def
2,4-D	0.5	4	157 ef	65 bc	2.9 ef
Untreated check	–	–	196 f	103 bc	2.5 f

a/fb=followed by. b/a.i.=active ingredient. c/DT=days after transplanting. d/Av of 3 replications and 3 tillage treatments. In a column, means by the same letter are not significantly different at 5% level.

Table 7: Effects of 2,4-D applied at various leaf stages of *Scirpus maritimus* on control of this weed and yield of transplanted IR36 rice. IRRI, 1980 dry season.

Leaf stage treatment[a/]	*S. maritimus* dry wt[b/] (g/m²)		Yield[b/] (t/ha)
	Max. tillering	Crop maturity	
Hand weeded check	21 a	10 a	5.5 a
Shoot emergence	100 b	237 cd	3.4 bc
2 leaf stage	90 b	206 bcd	3.4 bc
4 leaf stage	104 bc	202 bcd	3.5 bc
6 leaf stage	86 b	160 bc	3.9 b
8 leaf stage	138 cd	127 b	3.8 bc
10 leaf stage	166 d	157 bc	3.6 bc
Untreated check	173 d	312 d	2.7 c

a/Butachlor was applied pre-emergence to all treatments. b/Av of 3 replications, 2 formulations and 2 rates of 2,4-D. In a column, means followed by the same letter are not significantly different at 5% level.

xyacetics, the phenoxy-propionics, and bentazon, the growth stage at which the applications were made has not yet been carefully studied.

An experiment during the 1980 dry season, identified stages in its growth and development at which *S. maritimus* is susceptible to 2,4-D. The dimethylamine salt and isopropyl ester of 2,4-D were used at 0.5 and 1.0 kg a.i./ha. These were applied at 6 different stages of *S. maritimus* growth. The first application (at shoot emergence) was made 1 week after transplanting and the last (at 10-leaf stage) 7 weeks after.

S. maritimus was effectively controlled by both rates and both formulations of 2,4-D in all treatments stages. By and large, differences in weed control and yield among the treated plots were not significant (Table 7). When 2,4-D was applied at 6-leaf stage of *S. maritimus*, the control of that perennial weed resulted in significantly higher yield over the untreated check (Table 7). Results also showed that *S. maritimus* was susceptible to 2,4–D at all its postemergence stages but was not affected when the herbicide was applied as preemergence. However, in relation to the crop's growth stage, application time became apparently critical. Very early application of 2,4–D enabled *S. maritimus* to regrow freely due to the absence of a sufficient crop cover to suppress it.

Weed shifts under reduced tillage

Research in the Philippines and elsewhere has suggested that minimum and zero tillage for land preparation shorten turnaround time between crops and result in considerable savings in time, labor, capital and energy without loss in grain yield (Mabbayad and Buencosa, 1967; Elias, 1969; Moomaw *et al.* 1968; Brown and Quantrill, 1973). Reduced tillage has been shown capable of replacing conventional tillage operations in various climates and soils (De Datta *et al.* 1979; Moody and De Datta, 1980).

We did a series of experiments with 14 successive rice crops on Maahas clay soil to evaluate the effects of rice cultivar type and degree of tillage on weed shifts and savings in time and labor.

In a split-plot design, the main plots consisted of three cultivars of distinctly different plant types (IR30, a semidwarf; IR34, of intermediate stature; and IR1632-93-2-2, a rapid tillering semidwarf), and the subplots on tillage treatments (conventional, minimum, and zero). When IR30 and IR1632 succumbed to existing diseases, they were replaced with IR40 and IR42, respectively.

The conventional tillage treatment consisted of one plowing and two harrowings completed in 10 days during the first 4 crops. Minimum tillage for most crops was cutting the rice straw of the previous crop low followed by 3 passes of a harrow. The zero tillage treatment also involved cutting near ground level and removal of rice straw and weeds of the previous crop followed by a 0.5 kg a.i./ha paraquat (1,1'-dimethyl-4,4'-bipyridylium ion) spray the following day as needed. All tillage treatments were adjusted to permit planting on the same date.

The predominant weed species were the annuals *E. glabrescens, E. crus-galli ssp. hispidula* and *M. vaginalis*; and the perennials *P. distichum and S. maritimus.*

Generally, as the area with conventional tillage was changed to zero tillage, weeds shifted toward the perennials *P. distichum and S. maritimus* (Fig. 1). Until the fifth crop, *P. distichum* was the predominant perennial weed in the minimum and zero tillage plots. However, in the sixth, seventh, twelfth and thirteenth crops, *S. maritimus* became the dominant weed. *S. maritimus* generally appeared to increase with decrease in *P. distichum* density rather than be affected by tillage level. For example, a decline in the *P. distichum* and annual weed components in conventional tillage plots was accom-

Table 8 : Effect of combinations of preplant herbicides, tillage, and flooding on grain yield of rice.[a] (Adapted from De Datta *et al.* 1979).

Treatment	Weed wt. (g/m^2)	Grain yield (t/ha)
Herbicide-tillage	174 a	4.2 a
Herbicide-tillage-flooding	138 a	4.1 a
Tillage-flooding	239 ab	3.7 a
Conventional tillage	268 ab	3.2 a
Tillage-herbicide	271 ab	3.0 a
Tillage	257 ab	3.0 a
Herbicide-flooding	411 bc	0.8 b
Herbicide	784 c	0.4 b
Flooding	635 bc	0 b

[a]In a column, means followed by the same letter are not significantly different at the 5% level.

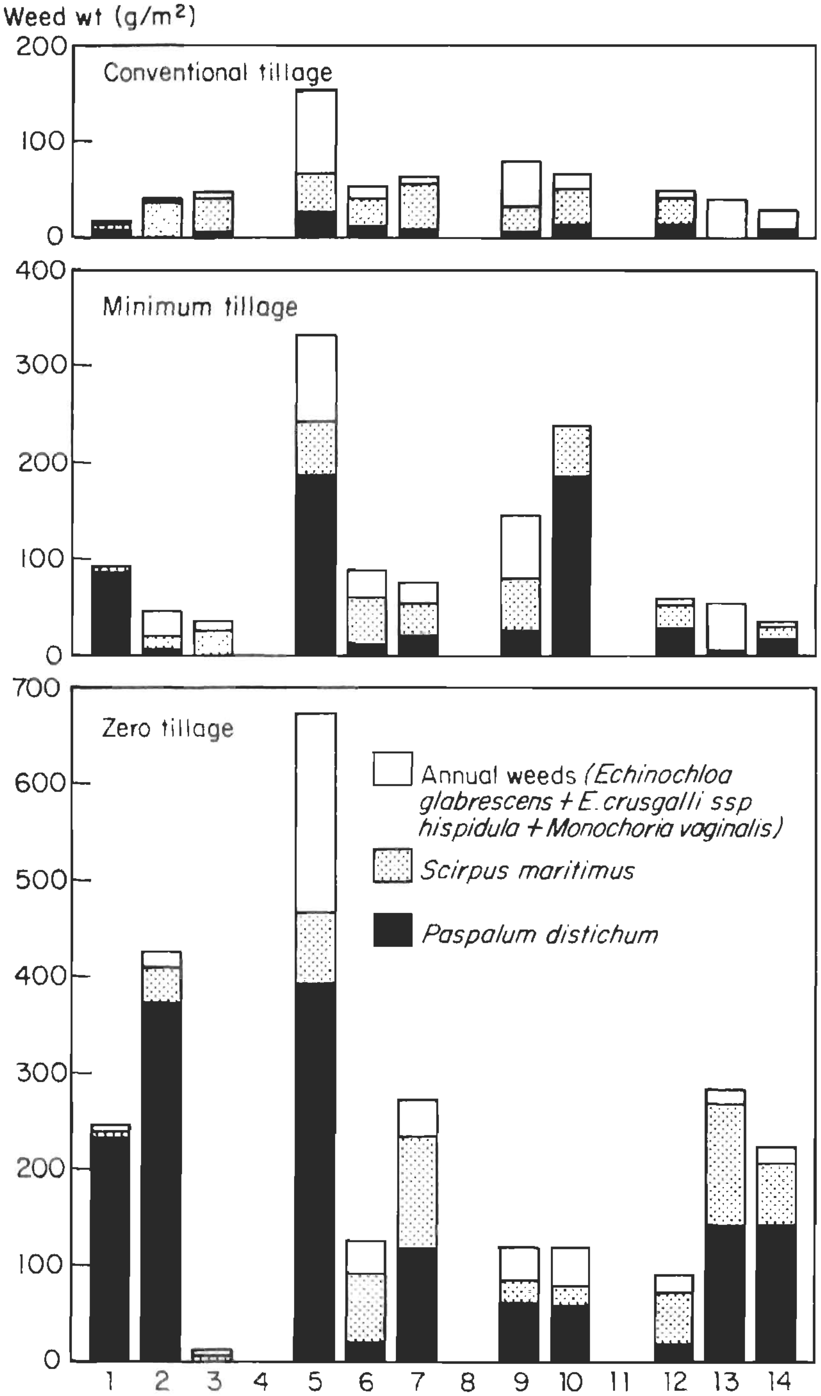

Fig. 1 : Weed dry weights at harvest as indices of weed control by three tillage levels (av. of 3 cultivars/tillage level per crop).

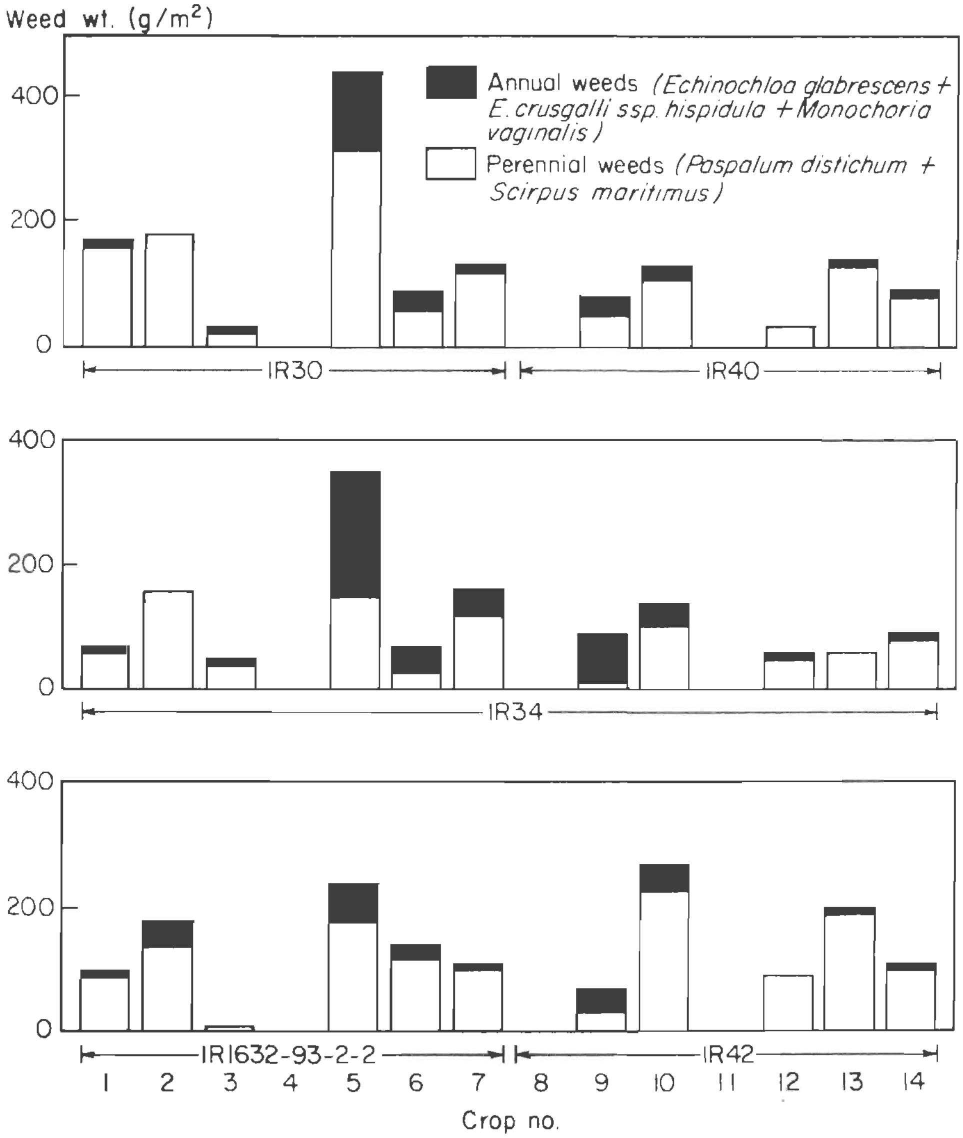

Fig. 2 : Weed dry weights at harvest of fourteen crops as indices of weed control by cultivar types (av. of 3 tillage treatments per crop).

panied by a shift toward *S. maritimus* (Fig. 1). This confirms earlier findings that not all perennials are controlled by tillage (De Datta and Lacsina, 1974; De Datta, 1977). The virtual absence of weeds in the fourth, eighth, and eleventh crop was mainly due to recultivation which completely controlled the perennial weeds and the effective control of the annual weeds by pre-emergence herbicide.

There seemed to be no consistent differences between rice cultivars in perennial weed control across all 14 crops (Fig. 2). However, lower weed weights were generally recorded on plots of IR34, suggesting that an intermediate-statured cultivar is a better competitor against *P. distichum* and *S. maritimus*.

Integration of practices for controlling Scirpus maritimus

In an earlier paper, De Datta (1977) suggested that various approaches should be followed to develop suitable management of perennial weeds such as *S. maritimus* in rice. The efficient management systems for perennial weed in rice should integrate preventive measures, crop rotation, soil and water management practices, tillage practices, use of competitive cultivars, and herbicides. Furthermore, in developing suitable integrated weed management practices, care should be taken to provide favourable stand establishment and growth of the crop that are unfavourable to the weeds particularly, if such practices are economically attractive to farmers (De Datta, 1981).

A paper by Mittra and Pieris (1968) suggested that the relative roles of preplant herbicides, cultivation and flooding were complementary and to a limited extent compensating in obtaining good preplant weed control. Another example of combination of practices was discussed by De Datta *et al.* (1979). In that, a preplant treatment of dalapon (2,2-dichloropropionic acid) followed by paraquat, which was comparable in cost to conventional tillage, failed to give satisfactory control of *P. distichum, Fimbristylis littoralis* Gaud., and *S. maritimus* and yields were significantly lower than those from the conventionally tilled plots. When the herbicide treatment was followed or preceded by tillage or reduced tillage was used alone, control of these weeds was improved and the rice yield did not differ significantly with that of conventional tillage (Table 8). Those results clearly determined the need to develop careful integration of weed control practices in controlling difficult perennial weeds such as *S. maritimus* in wetland rice.

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OXALIS LATIFOLIA CONTROL PROGRAMMES WITH OXADIAZON AND GLYPHOSATE

T. I. COX and R. M. KERR
Horticultural Research Centre, Private Bag, Levin, New Zealand.

ABSTRACT

Several herbicide programmes using oxadiazon and glyphosate appear capable of controlling both foliage and underground organs of *Oxalis latifolia.* When assessed the year following treatment, oxadiazon 2 kg/ha applied at first emergence of foliage and repeated at regular intervals two or three times during the subsequent seven-month growing season gave almost complete control. Four applications of glyphosate 2 kg/ha gave a result almost as good, as did combination treatments of early oxadiazon application followed 3 1/2 to 4 months later by glyphosate, or glyphosate and oxadiazon.

The most cost-efficient annual control programme was judged to be oxadiazon 2 kg/ha in the early part of the season followed by glyphosate 2 kg/ha four months later.

INTRODUCTION

The biology of *Oxalis latifolia* and development of control measures has been a research theme at Levin for over ten years. The remarkable ability of this species to thrive in cropped soil and survive most control measures short of complete chemical soil sterilization can be attributed to its ability to form bulbs and bulbils successively during a single season. At any particular time in an established population many of these underground organs are dormant. This makes the timing of effective herbicide applications particularly difficult.

Significant progress in control programmes has been made with the development of glyphosate [N-(phosphonomethyl) glycine]. Several applications during a growing season, can substantially eliminate foliar growth (Cox, 1978). Below ground however, bulbs survive and multiply, albeit on a reduced scale. Further work (Cox and Kerr, 1979) has demonstrated the value of oxadiazon [3-(2,4-dichloro-5-isopropoxyphenyl)-5-t-butyl-1, 3, 4 - oxadiazolin - 2 - one) in control programme.

The studies reported here follow the effects of oxadiazon and glyphosate applications made during one season into the following season culminating in the extraction of below-ground organs. Based on the results obtained, more effective control measures are suggested for *O. latifolia* using these two herbicides.

MATERIAL AND METHODS

In early October 1979 six replicates of plots each 1.5 m × 6 m were marked out on a freshly cultivated site known to be heavily and uniformly infested with *O. latifolia.* Treatments of oxadiazon and glyphosate were applied between mid-October 1979 and mid-April 1980, as detailed in Fig. 1. Herbicides were applied with a pressurised plot sprayer in a spray volume of 350 l/ha, and when oxadiazon was applied to dry soil it was followed by an application of 5 mm irrigation. Throughout the season of treatment and the following season growth was assessed by fortnightly, leaf counts made on a 0.16 m^2 fixed quadrat in each plot. Other weed growth in quadrats was cut off at

Table 1 : Analysis of underground organs of *Oxalis latifolia* at the end of the growing season following herbicide treatment; numbers per m².

Treatment*	(a) Parent bulbs with tubers	(b) Bulbils attached to (a)	(c) Parent bulbs without tubers	(d) Bulbils attached to (c)	(e) Bulbils detached, active	(f) Bulbils detached, dormant	Total Bulbs and bulbils
2	48	138	–	–	19	399	604
3	3	18	–	–	8	49	78
4	21	210	6	96	6	318	657
8	16	209	15	255	3	434	932
9	34	230	5	23	8	255	555
11	1,024	2,180	50	109	815	9,806	13,984
L S D 1%	331	1,110	33	N. S.	262	2,618	3,690

*See Fig. 1 for details.

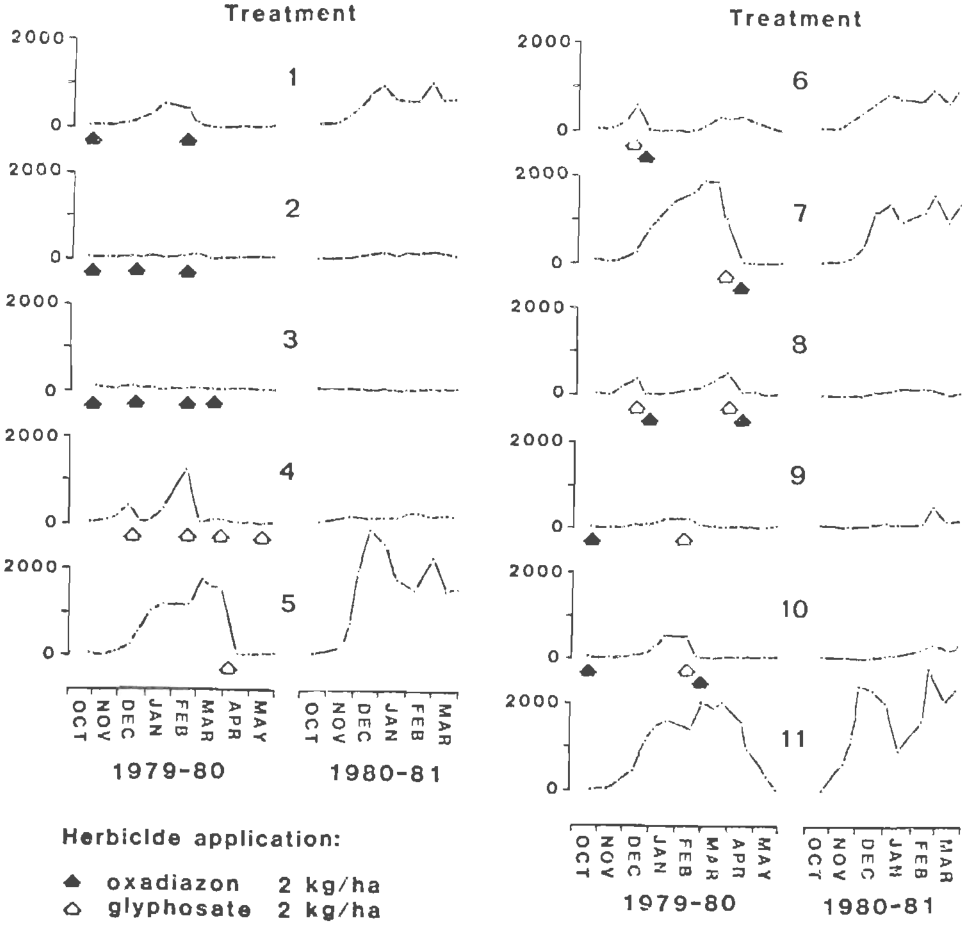

Fig. 1: Foliage growth of *Oxalis latifolia* over two seasons according to treatments, numbers of leaves per m².

ground level and removed, without soil disturbance. In April 1981, each quadrat was excavated and below-ground plant organs were extracted, categorised (Table 1) and counted.

RESULTS

The typical pattern of foliage growth in the untreated plots is shown in Fig. 1 (treatment 11). Leaves began to appear in October and growth stopped the following May. In both seasons leaf densities fell in mid-season. High densities were recorded in January and March in 1980 and about a month earlier in each case the following season. Highest numbers were recorded in the second 'flush' of leaf growth each season, approximately 2,000 leaves m^{-2} in March 1980 and 2,800 leaves m^{-2} in February 1981.

Two applications of oxadiazon spaced four months apart (treatment 1) gave a peak leaf count of 1,000 m^{-2} in 1981. Oxadiazon applied three times at approximately two-monthly intervals (treatment 2) was considerably more effective and almost completely prevented leaf production. When a fourth application of oxadiazon was made after a further six weeks (treatment 3) leaf growth ceased altogether in 1980 and 1981.

Four applications of glyphosate, beginning in early December and repeated at intervals of nine, six and five weeks approximately (treatment 4) also resulted in very low leaf numbers the following season. A single glyphosate application at peak leaf production in March 1980 (treatment 5) had little effect on leaf production the following year. A dual treatment of glyphosate followed ten days later by oxadiazon in December 1979 (treatment 6) resulted in a leaf count of 950 m^{-2} whereas the same treatment applied the following March (treatment 7) gave 188 m^{2}. When these treatments were applied in both December and March (treatment 8) the leaf count was less than 100 m^{-2}.

An early application of oxadiazon followed by glyphosate after four months (treatment 9) and a similar treatment with a dual application on the second occasion (treatment 10) both prevented further leaf growth in 1980 but gave a small peak in 1981.

The total number of all living bulbs and bulbils, active and dormant, attached and detached, in untreated plots amounted to almost 14,000 m^{-2}. This was significantly reduced by all herbicide treatments. Treatments can be divided into two major groups according to density of underground organs. Treatments 1, 5, 6, 7 and 10 all fell within the range 4,600 to 8,300 m^{-2} and although this was a significant reduction compared with the untreated level it is a massive infestation and hence of little practical interest. Thus further data on these treatments are not given. Populations in a second group, treatments 2, 3, 4, 8 and 9 were substantially lower and an analysis of these is presented in Table 1. Apart from category (d), bulbils attached to tuberless parent bulbs, all organs were significantly reduced in number by all these treatments.

DISCUSSION

Two peaks of foliar growth, especially apparent in 1980-81, have been noted in earlier studies (Cox and Kerr, 1979). A possible explanation of this phenomenon is that the first flush of foliage arose from parent bulbs which then produced bulbils. These, in turn, sprouted and contributed to the late-season flush of leaves. Jackson (1960) noted foliar growth from primary bulbils in their first season and this part of the vegetative cycle was characterised by Chawdhry (1974) as marking the end of bulbil production prior to the onset of senescence.

The growth characteristics of *O. latifólia* make long-term evaluation of chemical control measures particularly difficult. Monitoring this by leaf counting is laborious but provides a useful index to rate the different control programmes. In the current investigation this enabled a preliminary selection of the better programmes to be made in the year of application. However, this method did not always reflect the population of viable underground organs and sometimes over-rated the effectiveness of treatments. Of the apparently effective treatments only a sequence of four applications of oxadiazon achieved near-complete elimination of underground organs in the season following treatment.

If any of the better programmes were repeated over a number of seasons eradication should be feasible and, taking costs into account an early season application of oxadiazon 2 kg/ha followed four months later by glyphosate 2 kg/ha should provide an adequate annual programme for lasting control.

ACKNOWLEDGEMENTS

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EVALUATION OF NEW TECHNIQUES FOR OROBANCHE SEED GERMINATION IN VITRO

G. V. G. KRISHNAMURTHY, K. NAGARAJAN and RAMJI LAL
Central Tobacco Research Institute, Rajahmundry 533 104, Andhra Pradesh, India.

ABSTRACT

Broomrape *Orobanche cernua* Loefl is a menacing root parasite on tobacco crop in Andhra Pradesh (India). Development of suitable techniques would help much in studying this serious parasite in greater depths. On the aspect of identifying crop plants which induce high germination of *Orobanche* seed, a few possible methods are tested for their usefulness. The methods consisted of (a) supplying root exudate to Orobanche seed by wick-method in a beaker (b) applying root exudate to Orobanche seed by direct method in a beaker (c) providing continuous natural supply of root exudate *in situ* to Orobanche seed in a petridish and (d) providing root exudate from external source to Orobanche seed in a petridish. The test crop used for root exudate production was *Phaseolus mungo* (Greengram). The percentage germinations of Orobanche seed by the above method were 2.0%, 5.0%, 35.0% and 2.0% respectively. Of these four methods continuous natural supply of root exudate in a petridish was found to be the most suitable method.

INTRODUCTION

Broomrape, *Orobanche cernua* Lœfl is the most debilitating root parasite on tobacco crop in Andhra Pradesh (India). On the aspect of identifying crop plants which include high germination of Orobanche seed a few possible methods are tested for their usefulness and their performances are presented in this paper.

MATERIAL AND METHODS

Four new methods were tested for Orobanche seed germination and all methods were on the principle of exposing Orobanche seed to root exudate of *Phaseolus mungo* (greengram). The methods chiefly consisted of (a) supplying root exudate to Orobanche seed by wick-method in a beaker (termed as upward root exudate absorption method), (b) applying root exudate to Orobanche seed by direct method in a beaker (downward root exudate absorption method), (c) Providing continuous natural supply of root exudate *in situ* to Orobanche seed in a petridish (*in situ* root exudate absorption method) and (d) providing root exudate from external source to Orobanche seed in a petridish (applied root exudate absorption method). The methods are described below.

Upward root exudate absorption method

One g of absorbant cotton, moulded to a circular pad (5 cm dia. and 3 mm thick) was placed in a 100 ml beaker (Fig. 1). The cotton was wetted with water and 8 seeds of *P. mungo* were sown over it. Two blotting paper strips of microscope glass slide size were wetted with water and about 500 Orobanche seeds were dusted on one side. The blotting strips were dabbed vertically against the inner wall of glass beaker, at two opposite sides, taking care to see that the lower end of blotting paper strip was in contact with the cotton pad below, while the other end was free. A belljar was covered over the beaker and the whole unit

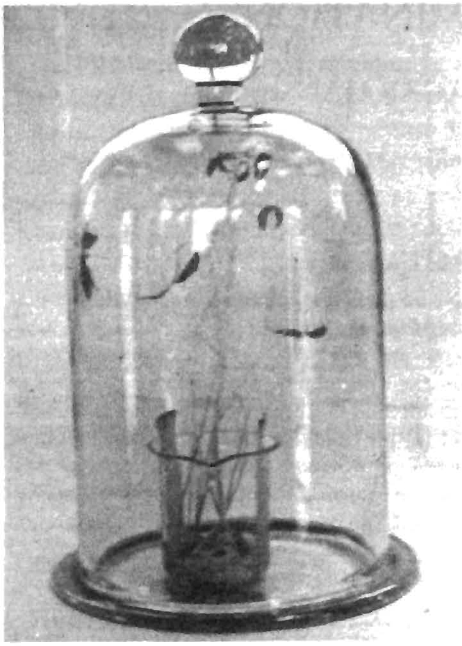

Fig. 1: Upward root exudate absorption (Method - 1) and Downward root exudate absorption (Method - 2)

Fig. 2: *In situ* root exudate absorption (Method - 3)

was kept in pot house where the temperature range was 25 to 39°C. Watering was given twice daily on to cotton with an ink filler. Since the bottom of blotting strip was in contact with cotton pad, it provided upward absorption of root exudate through blotter and kept the Orobanche seed continuously moist.

Downward root exudate absorption method

This method was similar to the first method up to watering stage on to cotton pad with ink filler (Fig. 1). Later, the root exudate water mixture in the beaker was thoroughly mixed by working an ink filler and 2 to 4 drops of the exudate were applied at the place between top of the blotter and rim of the beaker, to provide downward absorption of root exudate by the blotter.

In situ root exudate absorption method

About 500 Orobanche seeds were dusted in a wet blotting paper disc (4.5 cm dia.) and covered with a similar disc, sandwiching the seed between the two discs. The discs were kept in a petridish base (4.5 cm dia.) (Fig. 2). One g of absorbant cotton, moulded to a circular pad (4.5 cm dia. and 3 mm thick) was placed over the blotting paper discs, wetted with water and eight greengram seeds were sown on the cotton pad. A belljar was covered over the petridish and the whole unit was kept in potculture. Watering was given twice daily on to cotton pad with an ink filler. This provided *in situ* absorption of root exudate by Orobanche seed.

Applied root exudate absorption method

Orobanche seeds (about 500) were dusted on a wet blotting paper disc (4.5

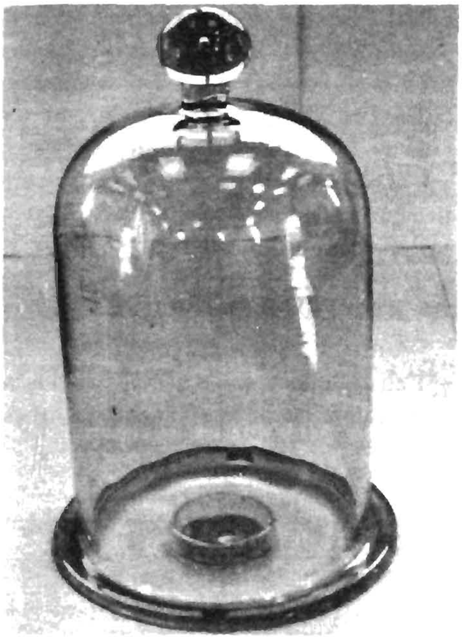

Fig. 3 : Applied root exudate absorption (Method-4)

cm dia.) with a central hole (8 mm dia'). A similar disc, without the parasitic seed, was placed beneath the first disc. The two layered disc thus formed, was put in a petridish (4.5 cm dia.) covered with its lid and finally placed under a belljar (Fig. 3). For root exudate collection the 100 ml beaker + cotton pad + greengram seed unit, as prepared for method-1 (but without blotting paper strips) was arranged and watered twice daily. Root exudate from this unit was collected with an inkfiller and 2 drops were applied twice daily at central hole of the disc to facilitate absorption of applied root exudate by parasitic seed.

Blotting paper strips and discs from all units were carefully taken the aid of clicker counter, germinated Orobanche seed from a random population of 100 seed. Usefulness of the methods was judged on the basis of percentage germination of Orobanche seed. The data are presented in Table 1. The test was repeated and the results were confirmed.

Table 1 : Evaluation of four new techniques on *Orobanche* seed germination *in vitro*.

Mean	Mean percentage germination of *Orobanche* seed
Upward root exudate absorption method	2.0
Downward root exudate absorption method	5.0
In situ root exudate absorption method	35.0
Applied root exudate absorption method	2.0

RESULTS AND DISCUSSION

It is evident from Table 1 that the method-3 i.e., *In situ* root exudate absorption method, gave maximum germination (35%), followed by downward (5%), upward (2%) and applied root exudate absorption (2%) methods. The potculture house temperature during the period was 25°C to 39°C. The Orobanche seed in methods 1, 2 and 4 were also exposed to this temperature range which was not ideal for Orobanche seed germination. In method-3 the cotton pad acted as a cooler and reduced the temperature to 26°C which was more favourable to germination. In addition there was *in situ* absorption of root exudate by Orobanche seed in method-3. These two factors must have favoured higher germination in method-3 than other methods.

The earlier bio-assay technique developed in this laboratory (Krishnamurthy and Nagarajan, 1978) involved growing the test crop in infested soil in pots and recovery of germinated Orobanche seed by sieving method followed by examination under sterioscopic microscope. But the seed cannot be reused for subsequent examinations. The present method-3 is advantageous in the sense that no sieving is involved and the Orobanche seed can be examined repeatedly at any period of investigation. However, in this method since the roots of the crop do not come in contact with Orobanche seed, due to the presence of blotting paper disc in between, it cannot be determined whether the crop roots received infection or not. Subsequently when the method-3 was tested in a low temperature incubator at a constant temperature of 25°C the germination of Orobanche seed tremendously increased to 95%, while this test under potculture house with 25 to 39°C temperature range gave 35% germination. Methods 1, 2 and 3 appeared to be new, while method 4 is a modification of method described by Kasasian and Parker (1971). It is concluded that out of the four methods tested, the *in situ* root exudate absorption method has been identified as the best method for screening crop plants against Orobanche.

ACKNOWLEDGEMENTS

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NEW ATTEMPT TO CONTROL *SAGITTARIA TRIFOLIA* – A PERENNIAL PADDY WEED BY APPLICATIONS OF PLANT GROWTH REGULATORS

JIRO HARADA
Hokuriku National Agricultural Experiment Station Jœtsu, Niigata 943-01, Japan.

ABSTRACT

Propagation of *Sagittaria trifolia* L., one of the most serious perennial paddy weeds in Japan is made by both seeds and tubers. Herbicide application could easily control *S. trifolia* plants emerged from seeds but could not control the ones emerged from tubers because of their dull sensitivity to herbicides and irregular emergence. In order to control this weed emerged from tubers, some attempts were made and the following results were obtained.

Cotylenin E, a new plant growth regulator isolated from culture filtrates of *Cradosporium* sp. broke the dormancy of *S. trifolia* tubers in concentration range of 1 to 50 ppm, and consequent sprouting occurred easily.

Foliar sprays of 50 to 100 ppm gibberellic acid (GA) to *S. trifolia* plants during the early stage of tuber formation (which almost corresponds to ripening stage of rice) strongly inhibited the tuber formation and consequently reduced the amount of this weed emerged from tubers in the following year. A slight increase of rice yield by GA was observed.

These attempts will be a stepping-stone to establish new control methods of perennial weeds by the use of plant growth regulators.

INTRODUCTION

Recent development of new herbicides has made it possible to conrol perennial paddy weeds as well as annual weeds. However, some perennial weeds such as *Eleocharis kuroguwai* and *Sagittaria trifolia* still remain as the most difficult to control with herbicide applications at an early growth stage because of their irregular emergence (Kusanagi, 1975). One of the reasons for this irregularity seems to be the uneven sprouting habit of their tubers which possess a long dormant period (Kusanagi, 1975). If this dormancy could be broken by some means, the control of these weeds could possibly become easier. Hence, the first experiment dealing with the effect of cotylenin E on dormant tubers was carried out using *S. trifolia*. Furthermore, if the tuber formation could be inhibited by certain means, satisfactory control of these weeds could also be possible. Hence the second experiment dealing with gibberellic acid (GA) was carried out using the same weed. All the results obtained are presented in this paper.

MATERIAL AND METHODS

Experiment 1.

Tubers of *S. trifolia* L., a perennial *Alismataceæ*. collected from the paddy field of this station in November, 1979 and kept at 4 °C, were used. Experiments were repeatedly conducted in January, 1980 and almost all tubers used were dormant at this time. Each ten-tuber lot was soaked in a 50 ml aqueous solution of 0, 1, 5, 10 and 50 ppm cotylenin E, vaccum-infiltrated twice and then kept at room temperature for 2 hr. They were placed in groups of five in 9 cm petri dishes with wet filter paper and covered with wet cellulose powder. The dishes were kept in darkness in an incubator controlled at 25° C, and the sprouting percentage was measured every day. Four dishes in each plot were used and the experiment was repeated three times.

Experiment 2.

Experimental fields (the area of each plot is 6 m^2, duplicated) were ploughed and puddled with a hand power tiller after uniform applications of 0.5 kg/acre N)as urea), 1 kg/acre P_2O_5 (as fused phosphate) and 1 kg/acre K_2O (as muriate of potash). Four days later (16 May, 1979), 37-day-old rice seedlings (cv. Koshijiwase) grown in the semi-upland nursery bed covered with polyethylene film, were transplanted two to a hill at a spacing of 15 by 30 cm in the field plots. Three days after transplanting, 27 g/acre of chlornitrofen (9% granule) was applied to the field. *S. trifolia* plants (7 to 8 leaf stage) were transplanted to the field plots at the rate of 22.2 plants per m^2 on 26 May. GA solutions (50 and 100 ppm) with a small quantity of wetting agent were sprayed on plants at the rate of 2 l/acre after heading of rice (1979 shown in Table 1). Rice plants were harvested on 14 September and the ripening percentage and kernel weight were measured. In the following spring (14 May, 1980), all the plots were ploughed and puddled the same way as in the previous year and 60 days later, the amount of *S. trifolia* which emerged from seeds and tubers was measured separately.

RESULTS AND DISCUSSION

Effect of cotylenin E on the dormant tubers

Cotylenin E used in the experiment was first isolated together with cotylenins A, B, C, D, F and G by Sassa *et al.* (1975) from culture filtrates of *Cradosporium sp.* These substances were termed "cotylenins" based on their promoting effect in the growth of Chinese cabbage, radish and cucumber cotyledons. The chemical structure of cotylenin E is shown in Fig. 1 together with the experimental results. Cotylenin E apparently broke the dormancy of *S. trifolia* tubers in a concentration range of 1 to 50 ppm. and consequently sprouting started 4 days after the treatment. Although the mechanism of this enormous effect of cotylenin E on

Table 1 : Effect of foliar application of GA on the ripening of rice and the emergence of *S. trifolia* in the following year.

Treatments	(Date)	Rice plants: Ripening %	Rice plants: Kernel wt. (mg)	Rice plants: Ripening index *	Amount of weed emerged from **: tubers		Amount of weed emerged from **: seeds	
Control		76.6	19.9	1524	52.3	g/m²	4.2	g/m²
GA 50 ppm	(10 Aug., 20 Aug.)	80.0	20.0	1600	0	%	112	%
	(20 Aug., 30 Aug.)	84.3	19.9	1678	0		103	
	(30 Aug., 10 Sep.)	86.1	20.5	1765	6.7		121	
GA 100 ppm	(10 Aug., 20 Aug.)	82.5	19.3	1592	0		105	
	(20 Aug., 30 Aug.)	88.6	20.3	1799	0		151	
	(30 Aug., 10 Sep.)	83.5	19.9	1662	0		98	

* Ripening percentage by kernel weight.

** Expressed as dry weight (g/m^2) in control plot and percentage against control in other plots.

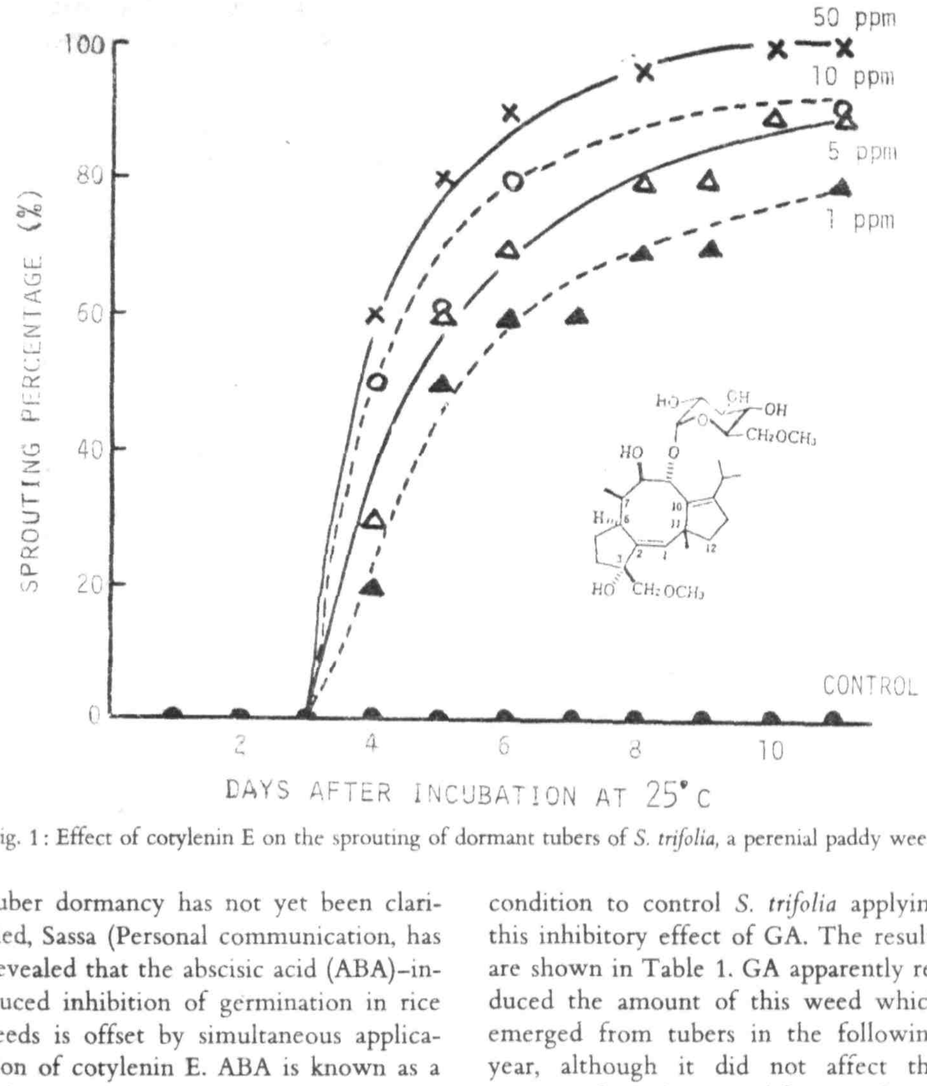

Fig. 1: Effect of cotylenin E on the sprouting of dormant tubers of *S. trifolia*, a perenial paddy weed.

tuber dormancy has not yet been clarified, Sassa (Personal communication, has revealed that the abscisic acid (ABA)-induced inhibition of germination in rice seeds is offset by simultaneous application of cotylenin E. ABA is known as a substance causing dormancy in many plants (Walton, 1980). From these facts, it appears that ABA might be related to the dormancy of *S. trifolia* tubers. Further studies for practical use of cotylenin E are now under way.

Inhibition of tuber formation by GA

The author reported previously that foliar applications of GA inhibited tuber formation of *E. kuroguwai* and *S. trifolia* in pot experiments (Harada *et al.* 1978). Further studies were conducted under field condition to control *S. trifolia* applying this inhibitory effect of GA. The results are shown in Table 1. GA apparently reduced the amount of this weed which emerged from tubers in the following year, although it did not affect the amount of weed emerged from seeds. Ripening of rice increased with GA application in all plots. The reasons for such an increase may be related to the GA-induced retardation of leaf senescence as reported previously (Harada and Nakayama, 1975). It is relatively easy to control *S. trifolia* emerged from seeds with herbicide application, compared with this weed emerged from tubers (Harada, unpublished). From these results, it is suggested that GA can be used to control *S. trifolia* in paddy fields.

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STUDIES ON CHEMICAL CONTROL OF HONEY MESQUITE

C. I. NIMBAL, Y. C. PANCHAL and V. S. PATIL
University of Agricultural Sciences, Dharwad Campus,
Karnataka, India.

ABSTRACT

Honey mesquite [*Prosopis juliflora* (Swartz) DC Var. glandulosa (Torr.) Cockerell] a perennial, owing to its invasive nature, is disliked all over the world as a notorious tree weed. Chemical control studies on young brushes at Dharwad and on trees at Jamakhandi Research Stations indicated that, 2, 4-D + 2, 4, 5-T treatment at both 1.24 and 2.5 a.e.l/ha caused high mortality as compared to 2, 4, 5-T, Pentachlorophenol and Ammonium sulphamate individually. Whereas, chemical control on naturally grown trees (10-15 cm stem diameter) was effective by the stump treatment with Ammonium sulphamate at 4.0 kg in 5.0 l of water (100% mortality without any regrowth of side shoots as compared to 2, 4-D + 2, 4, 5-T (5.0 and 10.0 a.e. l/ha) and pentachlorophenol (1.2 a.e. l/ha).

INTRODUCTION

Honey mesquite [*Prosopis juliflora* (Swartz) DC Var. glandulosa (Torr.) Cockerell] a perennial, owing to its invasive nature, is disliked all over the world as a notorious tree weed. Through its extensive and massive root system, mesquite robs the trees, grasses and crops of a major part of nutrients and moisture. These infestations will seriously interfere with livestock management and often reduce the production of desirable range forage plants. Mesquite when planted as hedge develops extensive lateral root system that extend in cultivated fields and have a suppressive effect on crop growth, posing a threat to economic crop production (Shah, 1957; Marion and Fisher, 1957; Prajapati and Nambiar, 1977).

Mesquite is widely distributed all over the arid and semi arid areas of the world. In India most of the sourthern States, Rajasthan and Maharashtra, it has become a menace.

Mesquite popularly called as "Bellary jali" grows all along the roadways, drianage ditches, waste lands, vacant sites and salt affected soils. It even persists in areas that receive less than 62.5 cm of rainfall because of its xerophytic nature (Bogusch, 1951).

Typically the nature of mesquite plant is either a single stemmed tree or a many stemmed shrub. Mature tree attains a height of six to seven metres in three to four years with a good crown spread (Prajapati and Nambiar, 1977). The impressive thorn is a modified stem (2.5 to 5.0 cm long) and generally occurs singly on young branches. The dormant buds are buried in living tissue immediately under the corky stem surface which render mesquite the tremendous ability to regrow following the injury.

Several uses of mesquite as a fuel, fodder, shelter belt, green manure etc., have been reported by Marion and Fisher (1957) and Prajapati and Nambiar (1977).

Because of its high tolerance nature to drought (Oppenheimer, 1957) and salt (Eshel and Waisel, 1965) and exhibition

Table 1 : Per cent mortality at four months after herbicide treatment of three, six and nine months old honey mesquite brushes.

Treatment	Three months old brushes	Six months old brushes	Nine months old brushes	Mean
2, 4, 5-T at 0.5 l/ha	*8.7190 (100.00)	4.5313) (32.33)	4.1967 (21.33)	(51.22)
2, 4, 5-T at 1.0 l/ha	8.7190 (100.00)	5.2052 (58.00)	4.6486 (36.30)	(64.77)
2, 4-D + 2, 4, 5-T at 1.25 l/ha	8.7190 (100.00)	7.9713 (97.67)	7.9474 (97.40)	(98.36)
2, 4-D + 2, 4, 5-T at 2.50 l/ha	8.7190 (100.00)	7.9926 (98.00)	8.7190 (100.00)	(99.33)
PCP at 0.3 l/ha	8.7190 (100.00)	1.2810 (00.00)	2.3003 (01.00)	(33.67)
PCP at 0.6 l/ha	8.7190 (100.00)	1.2810 (00.00)	3.0039 (02.33)	(34.11)
AMS at 12.0 kg/ha	8.7190 (100.00)	3.3065 (04.65)	3.2412 (04.00)	(36.22)
AMS at 20.0 kg/ha	8.7190 (100.00)	3.6019 (09.00)	3.6019 (09.00)	(39.67)
Hand cut	–	–	–	–
Untreated control	–	–	–	–
Mean	(100.00)	(37.58)	(33.92)	
S. Em±	–	0.3781	0.3101	
C.D. at 5 per cent	–	1.1445	0.9385	

* Percentage figures are transformed to probit values and figures in parenthesis indicate original mortality values in percentage.

of crassulacean acid metabolism (CAM) (Gour, 1968), those tree weeds can survive under extreamly unfavourable situations. With their allelopathic effects on other plants it has added another point to its aggressive nature.

Chemical control of mesquite have been reported by Scifres and Hoffman (1972), Bovey and Mayer (1974), Panchal and Prabhakar Setty (1977) on using several herbicides by different methods of application.

MATERIAL AND METHODS

Field experiments to study the efficacy of four herbicides were tried at two locations, one on the planted plants at the Agricultural College Farm and another on the woody mesquite trees at the Agricultural Demonstration Centre at Jamkhandi in Bijapur District during 1978. Herbicides used in the experiments were: i) 2, 4, 5-T 20% æ) (2, 4, 5-Tri-chloro-phenoxy acetic acid), ii) 2, 4-D + 2, 4, 5-T (Brush killer, 64, 2 : 1 mixture) (2,4-dichlorophenoxy acetic acid and 2, 4, 5-T), iii) PCP (12% æ) (Pentachlorophenol), and iv) AMS (95% a.i.) (Ammate-X) (Ammonium sulphamate).

Experiment-1 : Effect of herbicides on the mesquite control

At the college Farm Dharwad, each herbicide was tried at two concentrations and compared with hand cut (near the ground level) and the unsprayed control. These 10 treatments were imposed on three units of plants aging three, six and nine months after transplanting the 25 days old seedlings raised in ploythene bags was laid out in a randomised block design with three replications. Each plot had a gross size of 0.6m by 0.6m to accomodate six plants with a spacing of 60 cm by 30 cm.

Spraying of herbicides as per treatments (Table-1) was taken up on the unit I. Plants after three months of transplanting and similar sprayings were done on unit II (6 months) and unit III (9 months) respectively. Required quantity of herbicides were formulated in water (at the

Table 2: Percentage mortality of honey mesquite tree, six and nine months after herbicide treatments.

Treatment	Mortality values at			Mean
	3 MAA	6 MAA	9 MAA	
2, 4, 5-T at 2.0 l/ha	*6.286 (90.00)	6.140 (87.33)	6.010 (84.30)	(81.21)
2, 4, 5-T at 4.0 l/ha	6.508 (93.33)	6.428 (92.33)	6.407 (92.00)	(92.55)
2, 4-D + 2, 4, 5-T at 5.0 l/ha	6.463 (92.66)	6.321 (90.66)	6.192 (88.33)	(90.55)
2, 4-D + 2, 4, 5-T at 10.0 l/ha	7.507 (98.00)	6.942 (97.00)	6.723 (95.60)	(96.87)
PCP at 1.2 l/ha	6.041 (85.00)	5.685 (75.33)	5.186 (57.30)	(72.54)
PCP at 2.4 l/ha	6.176 (88.00)	5.855 (80.33)	5.288 (61.30)	(76.54)
AMS at 4.0 kg in 5 l of water	8.719 (100.00)	8.719 (100.00)	8.719 (100.00)	(100.00)
AMS at 5.0 kg in 5 l of water	8.719 (100.00)	8.719 (100.00)	8.719 (100.00)	(100.00)
PCP at 1.2 l/ha	6.433 (92.33)	6.227 (89.00)	6.116 (86.70)	(89.34)
2, 4-D + 2, 4, 5-T at 5.0 l/ha + PCP at 1.2 l/ha	6.483 (93.00)	6.362 (91.33)	6.263 (89.62)	(91.31)
Untreated cut-stump	–	–	–	–
Mean	(93.23)	(90.33)	(85.51)	
S. Em ±	0.1978	0.0687	0.0469	
C.D. at 5 per cent	0.5874	0.2043	0.1392	
MAA – Months after application				

* Percentage figures are transformed to probit values and figures in parenthesis indicate mortality values in percentage.

rate of 1000 l/ha) and sprayed uniformly with the help of the Aspee Marut hand sprayer. Spray drift to adjoining plots was prevented by holding plastic cloth around the plot.

Observations on plant mortality was recorded at four months after spraying. Plants with 100 percentage foliage reduction and stems killed completely without any regrowth were considered 100 per cent mortality.

Experiment 2.

Effect of herbicides on mesquite trees

In this experiment 11 treatments (Table 2) were imposed on the naturally grown trees with the stem diameter of 10-15 cm at the Agricultural Demonstration Centre, Jamkhandi. Every treatment was imposed on four trees and replicated three times in a randomised block design. Required quantities of herbicides were formulated in diesel oil (450 l/ha) except AMS in water and the freshly cut stumps were wetted with herbicides by using a hand brush.

Counts of new shoots were recorded based on which the mortality percentage was worked. Mortality percentage was estimated based on the number of sprouts in relation to the total number of sprouts occurred in control plants (Table 2).

EXPERIMENTAL RESULTS

Percentage mortality at four months after herbicide treatment in three, six and nine-month old mesquite brushes are presented in Table 1. 2, 4-D + 2, 4, 5-T at both 1.25 and 2.5 l/ha was significantly superior to other treatments causing on an average 98.36 and 99.33 per cent mortality, respectively whereas PCP at 0.3 l/ha caused least mortality (33.67%) on an average. Irrespective of herbicides treated, all the brushes of three months age were killed, but no such trend was noticed in six and nine month old brushes.

In Table 2, data on mortality of

woody mesquite plants (tree stage) at 3, 6 and 9 month after herbicide treatment showed significant differences among the treatments. High mortality (100%) of honey mosquite trees were observed by treatment with AMS at both dosage levels and this observations was on par with 2,4,5-T at higher dosage which recorded on an average 96.87 per cent mortality.

Herbicide combinations such as 2,4,5-T with PCP and 2,4-D + 2,4,5-T with PCP were not significantly superior to 2,4,5-T and 2,4-D + 2,4,5-T respectively. Herbicide treatments, except 2,4-D + 2,4,5-T at high dosage and AMS, declined in their effectiveness at later stages as evidenced by appearance of regrowth on stumps. Similar to the observations made at brush stage, PCP treatment resulted in least mortality recording 85.00, 77.33 and 57.30 per cent at 3, 6 and 9 months after herbicide treatment respectively.

DISCUSSION

Mesquite–a notorious tree weed owing to its xerophytic nature, tolerant to high salinity levels, with its CAM mechanism and allelopathic effects on other plants grows successfully under any harsh environmental conditions. Ecologically, mesquite is a strong competitor for moisture and plant nutrients (Hoffman, 1974) and thus can cause a substantial reduction in growth and yield of crops and forage grasses. Its complex growth habit and prolific sprouting nature have not yielded satisfactory control either by mechanical or burning methods. The only alternate way left for mesquite control is by chemical means alone.

Various environmental, physical and physiological factors influence the phytotoxicity to mesquite. These factors may influence herbicide adsorption, translocation or physiological activity at the site of action (Scifres and Hoffman, 1972). Varied morphological responses and extent of defoliation were observed following application of different herbicides.

The response of mesquite to the heavy application of herbicide is complex and thus difference in plant responses existed among different chemicals. To effectively control mesquite all plant parts capable of branching must be killed (Scifres and Hahn, 1971).

Application of 2,4,5-T on mesquite brushes of three months age, although, resulted in complete mortality of plants, but the effectiveness decreased as the plants grew older thus, killing 58.00 and 36.30 per cent plants at six and nine months of age respectively. 2,4-D + 2,4,5-T treatment was superior to 2,4,5-T treatment alone. There was high mortality in three months old plants because of their susceptibility to chemical phytotoxicity as they had not developed secondary (woody) tissue. Similar results of high mortality (86%) were observed by Bovey and Meyer (1974) at early age of two months. Further it is evident that for an effective killing of mesquite a four day (minimum) retention of leaves after spraying is essential and necessary for thorough absorption and translocation of herbicides to various plant parts.

Compared to 2,4,5-T alone, 2,4-D + 2,4,5-T mixture has emerged as a superior herbicide killing mesquite brushes at all ages because of high retentivity of herbicide effectiveness in leaves and in plant tissues.

Lower effectiveness in causing mortality to mesquite brushes by PCP and AMS may have been due to their dosage levels and minor absorption and translocation within the leaf. Ashton and Crafts (1973) have stated that none of the phenolic herbicides are translocated symplastically to any appreciable extent. AMS as foliar spray even at higher dosages were not effective.

Shoot cutting alone did not reduce the mortality of mesquites. Visual observations on sprouting of underground buds indicated that mesquite has tremendous ability to regrow following top removal. A multi-stemmed shrub is stimulated after apical dominance is broken through top removal (Scifres and Hahn, 1971).

With regard to mortality of mesquite trees (Table 2), herbicides varied in their effectiveness to kill dormant buds. Application of AMS resulted in high mortality (100%) which was almost equal in effectiveness to 2, 4-D + 2, 4, 5-T (at 10.0 l/ha). The mode of action of AMS in killing the trees may be through clogging of conductive tissues. Least mortality was observed with PCP treatments. Application of 2, 4, 5-T in combination with PCP showed that the combination was almost equally effective compared to 2, 4, 5-T alone. A similar trend was followed in 2, 4-D + 2, 4, 5-T when combined with PCP at equal ratio.

In general, AMS and 2, 4-D + 2, 4, 5-T herbicides were successful in controlling regrowth and thus enabled high mortality of the tree.

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THE SELECTIVITY OF SOME HERBICIDES AGAINST *CYPERUS ROTUNDUS* IN COTTON

C. PARKER
Overseas Development Administration, Tropical Weed Specialist
Agricultural Research Council Weed Research Organisation
Begbroke Hill, Yarnton, Oxford, OX5 IPE.

ABSTRACT

The results of three pot experiments are described, in which the selectivity of seven herbicides against *Cyperus rotundus* L. in cotton was evaluated. Each compound was tested as pre-emergence treatments applied to the soil surface, or as pre-planting treatments incorporated to 6 cm depth. *C. rotundus* was planted at 2 or 8 cm and cotton at 2 or 4 cm. Most compounds required incorporation for control of *C. rotundus* planted at 8 cm. All compounds were selective under ideal conditions but none provided a substantial margin of safety.

INTRODUCTION

Cyperus rotundus L. is commonly referred to as the world's worst weed and while that reputation is perhaps a little exaggerated there can be little argument about its pre-eminence as a problem in irrigated crops. Excluding rice in which the normal prolonged flooding tends to discourage it, the most commonly irrigated tropical crops are probably sugarcane, cotton and a complex of vegetable crops in all of which *C. rotundus* can become dominant, especially where herbicides are used which control annual weeds and leave the perennials to flourish. In sugarcane 2, 4-D can be used to reasonable effect to suppress, if not to eradicate, *C. rotundus.* In several vegetable and other broad-leaved crops there are thiolcarbamates to turn to, but in cotton no reliably selective compound has yet been developed.

The ODA Tropical Weeds Group at WRO regularly evaluates new herbicides on about 30 tropical crop and weed species and further investigates compounds of interest on specific problems, including *C. rotundus*. This paper reports the results of three experiments conducted over the past three years to test interesting new herbicides with potential for the control of *C. rotundus* in cotton. The experiments were designed particularly to take account of the variable depth from which *C. rotundus* may emerge, and the possible influence of soil incorporation on the performance of the herbicides.

MATERIAL AND METHODS

All the three experiments were conducted in the WRO glasshouses near Oxford, UK. In each case a neutral sandy loam soil was used in pots 10 cm diameter and 12 cm high. Proprietary fertilizer mixture was added to a level to provide optimum growth of both crop and weed.

In the first experiment cotton (var. S71 ex Nigeria) was planted (five seeds per pot) at 2 and 4 cm. In the latter two experiments it was planted only at 2 cm. In all three *C. rotundus* (ex Zimbabwe) was planted (five tubers per pot) at 2 cm and at 8 cm.

Herbicides were applied by a labora-

Table 1 : Effects of three herbicides on cotton and *Cyperus rotundus*

		Shoot fresh weights (as % of untreated)							
		Surface				Incorporated			
		Cotton		*C. rotundus*		Cotton		*C. rotundus*	
Herbicide	kg a.i./ha	2 cm	4 cm	2 cm	8 cm	2 cm	4 cm	2 cm	8 cm
Perfluidone	1.0	67.1	66.4	31.8	49.0	82.8	57.0	15.3	35.8
	2.0	66.8	71.3	1.7	40.1	77.7	74.4	1.1	21.8
	4.0	63.5	55.6	0.5	7.1	48.1	48.1	0	0.6
Norflur-azon	0.25	96.7	92.1	86.8	108.3	93.4	94.4	64.3	71.1
	0.5	79.0	98.4	14.4*	98.2	94.9	96.4	3.5*	2.3*
	1.0	18.8	5.0	3.1*	33.7*	6.0	3.2	0.4*	2.8*
Fluridone	0.25	83.6	95.5	39.6*	92.9	104.7	73.0	12.8*	22.3*
	0.5	83.1	78.9	26.4*	77.6	93.1	90.9	2.0*	15.1*
	1.0	89.1	66.0	12.1*	66.1*	97.4	97.4	0.6*	1.8*
Control	0	100	100	100	100				
(g/pot)		(37.3)	(37.2)	(27.0)	(18.8)				
L.S.D. (P = 0.05)		27.3	27.5	12.0	17.2				

* More than 50% albino growth
Note : Experiment started 14 February 1979. Assessed 5-10 April 1979.

tory spraying device in approximately 400 l water/ha. In each case the herbicides were applied either to the soil surface after planting or mixed into the top 6 cm to simulate an incorporated pre-planting treatment. For this purpose they were applied first to a 6 cm layer of soil in shallow metal containers; the soil was then mixed by passing four times through a wide funnel and the mixed soil was used to form the top 6 cm layer in the pots.

The treatments were replicated three times and arranged in randomised blocks. All watering was from above to the soil surface.

Cotton was treated with fungicide to combat damping off but some losses still occurred contributing to somewhat high variability.

Glasshouse temperatures were mainly in the range of 18 to 25° C for the first experiment and 18 to 28° C for the second and third. Supplementary lighting for 12 hours per day was provided for the first experiment only.

Assessment was by measurement of fresh weight of above ground parts and observation of root vigour. Regrowth of *C. rotundus* was also observed for about one week after "harvest".

RESULTS

Experiment 1.

Perfluidone [4'-(phenyl sulphonyl) trifluromethyl sulphono - potoluidide] gave excellent control of shallow planted *C. rotundus* at 2 kg/ha and of both shallow and deep-planted tubers at 4 kg/ha but cotton was significantly retarded at both these doses (Table 1). There was little difference between surface and incorporated treatments, presumably because of the relatively high water solubility and hence mobility of this compound.

Norflurazon [4-chloro-5methylamino-2 - (trifluoromethylphenyl) pyradazin-3-one] at 0.5 kg/ha controlled only the

Table 2: Effects of four herbicides on cotton and *Cyperus rotundus*.

Herbicide	kg a.i./ha	Shoot fresh weights (as % of untreated)					
		Surface			Incorporated		
		Cotton 2 cm	*C. rotundus* 2 cm	*C. rotundus* 8 cm	Cotton 2 cm	*C. rotundus* 2 cm	*C. rotundus* 8 cm
Perfluidone	2.0	75.8	55.2	85.2	45.9	87.5	118.5
Norflurazon	0.5	94.2	88.7*	86.0	97.9	59.5*	104.3
Fluridone	0.5	96.1	68.8*	104.1	103.4	0.5*	111.5*
UBI S 734	0.5	93.1	6.2	79.9	81.6	5.0	32.7
	1.0	91.4	1.6	56.7	61.0	1.0	17.0
	2.0	79.9	0.1	35.1	29.1	0	4.2
Control	0	100	100	100			
(g/pot)		(48.8)	(27.1)	(22.5)			
L.S.D. (P = 0.05)		24.2	33.7	40.6			

* More than 50% albino growth
Note: Experiment started 8 May 1980. Assessed 18 June 1980.

shallow planted tubers when applied as a surface spray but both shallow and deep, when incorporated at this dose. Cotton fresh weights were not significantly affected but there were chlorotic symptoms and the higher dose of 1 kg/ha caused severe damage suggesting very limited selectivity.

Fluridone [1-methyl-3-phenyl-5-(3-tri fluoromethyl phenyl) pyridin-4-one] performed in a very similar way to norflurazon on *C. rotundus* giving good control of both shallow and deep tubers at 0.5 kg/ha, provided it was incorporated. The need for incorporation was more pronounced suggesting less mobility than for norflurazon. Even with incorporation, however, tolerance by the cotton was good with only mild symptoms of chlorosis at the higher dose of 1 kg/ha.

Experiment 2.

Perfluidone at 2 kg/ha gave much poorer control of *C. rotundus* in this test perhaps because of more rapid degradation of the herbicide and/or more rapid recovery under the warmer conditions of the experiment (Table 2). Once again cotton was significantly damaged.

Norflurazon at 0.5 kg/ha also gave poorer control, quite inadequate even with incorporation, but cotton was completely healthy, so a higher dose could have been tried.

Fluridone at 0.5 kg/ha was effective on shallow tubers when incorporated but was not effective on deep planted tubers. Again the crop was undamaged.

UBI S 734 {2-[1-(2,5-dimethylphenyl) ethyl sulphonyl]pyridine - N - oxide} was highly effective on shallow tubers at 0.5 kg/ha but incorporation of at least 1 kg/ha was required for good control of deep tubers and cotton was then significantly weakened both above and below ground. Although 0.5 kg/ha incorporated gave only 67% suppression of *C. rotundus* shoots from deep tubers, regrowth following shoot harvest was very weak.

Experiment 3.

Perfluidone again failed to show adequate selectivity at 2 kg/ha (Table 3).

Norflurazon at 1 kg/ha provided good control of shallow-planted *C. rotundus* but failed to control the deep tubers. Cotton was showing some chlorotic symptoms at this dose.

Table 3: Effects of five herbicides on cotton and *Cyperus rotundus.*

Herbicide	kg a.i./ha	Shoot fresh weights (as % of untreated)					
		Surface			Incorporated		
		Cotton 2 cm	C. rotundus 2 cm	C. rotundus 8 cm	Cotton 2 cm	C. rotundus 2 cm	C. rotundus 8 cm
Perfluidone	2.0	77.1	12.8	46.2	55.6	3.1	74.9
	4.0	51.2	0.0	16.5	52.2	0.1	8.3
Norflurazon	0.5	121.2	96.7	106.6	100.9	64.2	100.5
	1.0	91.2	71.3*	94.0	90.2	1.0*	99.3
Fluridone	0.5	105.3	42.3*	88.8	111.8	0.3	68.3*
	1.0	125.9	14.2*	56.5*	93.1*	0.0*	18.1*
UBI S 734	0.5	93.6	9.7	50.1	91.9	0.1	28.4
	1.0	93.2	0.0	26.2	82.5	0.0	10.5
NC 20484	0.25	98.1	44.8	67.2	104.1	30.1	86.9
	0.5	90.3	3.0	31.4	107.6	11.8	13.8
	1.0	89.1	0.1	0.4	101.9	0.9	0.8
Control	0	100	100	100			
(g/pot)		(31.3)	(35.5)	(31.6)			
L.S.D. (P = 0.05)		39.0	22.7	25.5			

* More than 50% albino growth

Note: Experiment started 20 May 1981. Assessed 1-11 May 1981.

Fluridone incorporated at 0.5 kg/ha gave effective control of both shallow and deep tubers. The latter produced abundant foliage but it was predominantly albino. Without incorporation 1 kg/ha was required to give comparable control. Mild symptoms were observed on the cotton at the higher dose.

UBI S 734 controlled shallow-planted *C.rotundus* at 0.5 kg/ha and both shallow and deep tubers at 1 kg/ha, especially when incorporated. Cotton shoots were unaffected but roots were slightly reduced at 1 kg/ha.

NC 20484 (2,3-dihydro-3,3-dimethyl - 5-benzofuranyl ethane sulphonate) at 0.5 kg/ha gave comparable results to those achieved with UBI S 734 at 1 kg/ha and without significant adverse effect on the cotton. Control of *C.rotundus* was particularly good at 1 kg/ha but there were then some symptoms of distortion on cotton foliage. Root systems were not apparently affected.

DISCUSSION

Although perfluidone has been recommended for use against *C. rotundus* in parts of the USA it did not appear adequately selective in any of the three experiments reported here. Only one cotton variety was used and it is possible that others are more tolerant.

Norflurazon could provide selective control of shallow-planted *C. rotundus* but selectivity was extremely narrow and practical usefulness appears very doubtful.

Fluridone gave more reliable selectivity than norflurazon. A dose of 1 kg/ha safely controlled both shallow and deep tubers but this appears to be a relatively immobile compound and incorporation is needed for effective control of the deeper *C.rotundus.* While selectivity appears just adquate at a dose of 1 kg/ha it is not anticipated that this treatment can be adopted in any but a few situations, owing to very long persistence in the soil. At this dose there is likely to be damage to almost any other rotational crops with the possible exception of groundnut.

UBI S 734 provided near perfect selectivity when incorporated at 1 kg/ha in one experiment (No. 3) but this dose was damaging in another (No. 2); thus selectivity cannot be regarded as reliable, at least with this cotton variety. Evidence from Experiment 3 and other work at WRO suggests a very long persistence of UBI S 734 which may be cause for some concern.

NC 20484 was only tested in one experiment, but it was more active and marginally more selective than UBI S 734. Incorporation improved control of the deeper-planted tubers but might not be essential for acceptable results. Persistence was moderate and while adequate for 1 to 2 months control, should present no problem.

Of the five compounds tested, only fluridone and norflurazon killed the tubers. They allowed albino growth resulting eventually in exhaustion of tuber reserves and rotting. The other three compounds had effects comparable to the thiolcarbamates in inhibiting growth, but even after very prolonged suppression (several months) the tubers were still sound and apparently capable of eventual recovery.

Although the results reported here do not indicate a very wide margin of selectivity for NC 20484, they provide support for the claims made by Horne and Hoogstraten (1980) and suggest that this new compound is worth extensive testing in the field in comparison with UBI S 734.

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HERBICIDAL AND SELECTIVE EFFECT OF PRONAMIDE FOR CONTROL OF DODDER IN NIGER

A. MISRA, G. C. TOSH, D. C. MOHANTY and G. K. PATRO
Orissa University of Agriculture and Technology, Bhubaneswar, Orissa, India.

ABSTRACT

Dodder (*Cuscuta chinensis* Damk) parasitic on niger, inhibits the growth and reduces the grain yield to a considerable extent. Trials were undertaken with a selective herbicide pronamide applied as pre-emergence soil treatment on the next day of sowing and as post-emergence foliage treatment at 20 days after sowing with the object of finding a treatment capable of being applied overall without injury to niger.

It is revealed that the control of dodder was 90-99% by application of pronamide without damaging the associated crop of niger. The yield increase was 109-262% over untreated control with pronamide application, being highest (262.47%) with foliage treatment at 2.0 kg a.i./ha.

INTRODUCTION

In Orissa, niger [*Guizotia abyssinica* (L.f) Cass] has long been recognised as an economically important oilseed crop and is extensively grown on the hill slopes and in coastal plains. In many areas niger fields are heavily infested with an annual dodder (*Cuscuta chinensis* Damk) of the genus cuscuta of the family convolvulaceæ, a parasitic twining weed which poses a major problem for successful cultivation. The weed emerges along with the germinating niger seedlings and parasitises them soon by attaching themselves to the host and bring down the grain yield by 60-65%. The usual control measure is frequent inter row cultivation before the parasite attaches to the host plant which is laborious and often not effective. Once the parasite is attached to the host it remains parasitic until harvest. Thus, herbicides which can control the dodder seed germination or kill at early stage of infestation, would greatly aid niger cultivation.

Sepasgosarian *et al.* (1974) and Svetievski *et al.* (1975) have reported successful control of dodder with propyzamide in lucerne and sugarbeet respectively. Earlier studies by Tosh *et al.* (1977) showed very promising control of dodder in niger crop by propyzamide [3,5-dichloro-*N*-(1,1-dimethyl-2-propyl) benzamide]. The present work was undertaken to investigate the effect of pronamide (syn. propyzamide) on dodder control at two different agroclimatic situations.

MATERIAL AND METHODS

During 1977 crop season, field trials were conducted at the Central Research Station, Bhubaneswar. There were six treatments which were replicated four times in randomised block design. At Bhubaneswar, the trial was taken on artificially infested crop of niger (cv: Alasi-1). The seeds of niger and dodder were mixed together (1:1) by weight and sown on 2nd September 1977 in rows 30 cm apart at a combined weight of 15 kg/ha in all the treatments except in pure cultural control where only niger seeds (at 10 kg/ha) were sown. But at Pottangi, a predominantly niger growing area the

Table 1 : Effect of pronamide on dodder (*Cuscuta chinensis* Damk) and grain yield of niger.

Treatment	Niger plants/m on row		Dodder/m² 10 DAS*		Dodder infested niger plants/m² 45 DAS*				Grain yield of niger in kg/ha			
	1	2	1	2	1	†	2	†	1	§	2	§
Pronamide at 1.0 kg ai/ha 1 DAS	40.2	31.0	3.2 [a]	1.4 [a]	7.4 [ab]	90.89	3.8 [a]	97.06	987 [a]	141.63	1255 [a]	229.40
Pronamide at 1.5 kg ai/ha 1 DAS	22.8	29.2	2.0 [a]	0.8 [a]	2.2 [a]	97.29	1.2 [a]	99.07	854 [ab]	109.06	1302 [a]	241.73
Pronamide at 1.5 kg ai/ha 20 DAS	39.2	33.8	9.4 [b]	11.2 [b]	4.6 [a]	94.33	3.2 [a]	97.53	904 [ab]	121.15	1207 [ab]	216.80
Pronamide at 2.0 kg ai/ha 20 DAS	38.4	29.8	6.8 [b]	10.8 [b]	3.4 [a]	95.81	2.0 [a]	98.45	1004 [a]	145.72	1381 [a]	262.47
Untreated control	43.4	30.4	8.8 [b]	9.4 [b]	81.2 [c]	–	129.4 [c]	–	409 [c]	–	381 [d]	–
Pure cultural control	41.0	32.8	–	7.8 [b]	–	–	78.4 [b]	34.85	1064 [a]	160.47	794 [c]	108.40
C. D. ($p = 0.05$)	N. S.	N. S.	3.68	4.02	3.88	–	12.34	–	85.6	–	124.2	–

N. B. 1 – at Bhubaneswar 2 – at Pottangi * mean of five samples.
DAS – days after sowing N.S. – not significant
† percentage control over untreated treatment
§ percentage increase in yield over untreated control

trial was taken on a naturally infested land (where the previous crop grown was niger which was severely infested with dodder). The niger seeds (cv: Alasi-1) were sown on 17th September 1977 at seed rate of 10 kg/ha in all the plots in rows 30 cm apart. The plots were 5 m by 6 m at both the locations. Pronamide was applied as pre-emergence soil spray at rates 1.0 and 1.5 kg/ha (a.i.) 20 days after sowing as foliage treatment. The spray solution used was 650 and 1125 l/ha for pre-emergence and post-emergence treatment respectively. At Pottangi, cultural control treatment received two hœings at 15 and 25 days after sowing while at Bhubaneswar the same treatment received only one light hœing at 25 days after sowing. A manual weeding was taken 10 days after post-emergence spray to remove weeds other than dodder in all plots. Insect control measures and other management practices were done at optimum levels. The number of germinated niger plants and those parasitised were recorded in representative fixed samples at 10 and 45 days after sowing. Yield of clean dry seeds was recorded after threshing and sun drying.

RESULTS AND DISCUSSION

Germination and plant population of niger

Pre-emergent soil treatment of pronamide showed marked selectivity and did not cause any phytotoxic effect on the germination of niger seeds and also on the seedling stand under both the locations (Table 1).

Germination and population of dodder

At both the locations application of pronamide with 1.0 and 1.5 kg per ha was found to be successful in inhibiting the germination of dodder seeds drastically (90-99%) as compared to untreated plots along with many dominating grassy and broad leaved weeds (*Echinochloa colona* L.; *Digitaria sanguinalis* Gærtn; *Dactyloctenium ægyptium* Beauv; *Celosia argentea* L. and *Acanthospermum hispidum* DC at Bhubaneswar and *Dicantheum annulatum*, *Setaria glauca* Beauv, *Portulaca oleracea* L.

Eupatorium glandulosum HB and K and *Achyranthus aspera* L. at Pottangi.

Effect on the grain yield of niger

Grain yields of niger were increased by pronamide application due to efficient control of dodder. Highest yield of niger was obtained (1004 and 1381) kg/ha) with pronamide at 2.0 kg/ha as foliage treatment at both the locations. This treatment gave yields approximately two and half times at Bhubaneswar and three and half times at Pottangi compared to untreated control. At Bhubaneswar, herbicide treatments recorded yields comparable to pure cultural control where the crop was free from dodder infestation from germination to harvest, but at Pottangi the yield in cultural control was much less than herbicide treatments as the crop was infested with dodder and mechanical practice followed did not control the dodder effectively. The heavy infestation and unchecked growth of dodder in the control plot resulted in poor crop growth and yield.

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STUDIES ON THE CHEMICAL CONTROL OF JOHNSON GRASS

R. S. BALYAN, R. K. MALIK, R. K. KAMBOJ, S. P. SINGH and V. M. BHAN
Haryana Agricultural University, Hissar, India.

ABSTRACT

The effect of glyphosate [N-(phosphonomethyl) glycine] at 2, 4 and 6 kg/ha, bromacil [5-bromo-6-methyl-3-(1-methylpropyl uracil)] at 4, 6 and 8 ha/ha, dalapon (2, 2-dichloropropionic acid) at 8, 12 and 16 kg/ha on control of Johnson grass [*Sorghum halepense* (L.) Perse] and its persistence through wheat, barley and mustard was evaluated. Application of glyphosate at 4 and 6 kg/ha reduced the reproductive potential (sprouts/m^2) and controlled the Johnson grass. This was followed by dalapon. Oil content in the rhizomes was not influenced significantly. The total sugar in the rhizome was maximum in untreated control and in mechanical shoot cut treatments. Lower doses of all herbicides did not exhibit any significant effect on total sugar but at high doses sugar content was significantly reduced by all herbicides. Protein content in rhizome was significantly reduced at 4 and 6 kg glyphosate and asulum per hectare respectively. The germination and growth of wheat, barley and mustard revealed adverse effect on growth by application of bromacil at all the doses. Glyphosate did not influence the germination and growth of any crop in study. Wheat and barley were found to be sensitive to asulam compared to mustard.

INTRODUCTION

Johnson grass is a troublesome weed throughout the world, causing substantial yield losses in several crops (Millhollon, 1970). The effective herbicides applied to foliage and have been used for control of this weed are Dalapon (Hamilton, 1969) Glyphosate (Connell and Derting, 1973) and Asulam (Overton *et al.* 1974). Since Johnson grass has a high sprouting capacity (Horowitz, 1972) and its seedlings produce new rhizomes in few weeks after emergence the use of herbicides and cultivation only partially control this weed (McWhorter, 1974). Moreover, post-emergence sprays of herbicides like glyphosate are toxic to some crops (Overton *et al.* 1974).

The object of this study was to compare the effectiveness of several herbicides for the control of this weed and their residual effect on the emergence of some winter season crops.

MATERIAL AND METHODS

An experiment was conducted on low organic matter sandy loam soils of Haryana Agricultural University, Hissar. The plots of 7 m x 6 m size were first fertilized, prepared and planted with 3 node single sprouted rhizomes at 2.5 cm depth. The planting was done on 7th and 10th July during 1977 and 1978, respectively. The plants were allowed to grow until maximum growth was achieved, so that they could retain, absorb and translocate maximum amount of herbicide. Foliar spraying of bromacil, glyphosate, Dalapon and asulam (Methyl sulfanilyl carbamate) at three rates each (Table 1) was done with hand operated knapsack sprayer on 13th and 17th September, 1977 and 1978, respectively. The plots in mechanical control were harvested near the soil surface on the day of herbicide treatment and in untreated control the plants were allowed to grow as usual. Johnson grass plants were cut close to the ground 6 weeks after spraying in whole experiments. A fortnight later number of sprouts were counted. Dry matter production was recorded by taking weight of sprouts and rhizomes 2 and 4 months after spraying.

Biochemical analysis of rhizomes: Oil, total sugars and crude protein were determined in rhizomes according to standard methods.

Bioassay for herbicide residue in soil: In each plot an area of 4 x 1 m was manually prepared to test the residual effect of the applied herbicides on the germination and growth of some winter season crops. Wheat (*Triticum æstivum* L.), barley (*Hordeum vulgare* L.) and mustard (*Brassica juncea* L.) were planted on all plots on 18th and 15th November during 1977 and 1978, respectively. The germination percentage was recorded after 15 days of sowing in each crop. The growth of each crop was closely observed by measuring dry weight of shoots one month after sowing.

RESULTS AND DISCUSSION

Dry matter production of johnson grass/shoots: Glyphosate, dalapon at all rates, bromacil at 6 and 8 kg/ha and asulam at 6 and 8 kg/ha reduced the dry matter production of shoots significantly over untreated plants (Table 1). Good control of johnson grass with glyphosate as compared to dalapon has also been reported by Parochetti *et al.* (1975). Low response of bromacil particularly at low concentrations may presumably be due to the reason that bromacil is a root absorbed herbicide and its activity through foliage might have been poor.

Effect on reproductive potential: All the herbicides reduced the dry matter of rhizomes significantly. Application of glyphosate reduced the dry matter of rhizomes and the number of sprouts significantly over untreated check (Table 1 and 2). There were minimum sproutings of rhizomes at all the rates of glyphosate as compared to other herbicides. The data on dry matter of sprouts indicated that most of the buds from the plants treated with 4 and 6 kg glyphosate/ha did not germinate. Similar results in quackgrass have also been reported by Claus and Beherns, (1976). They also suggested that glyphosate treatment applied to taller foliage caused maximum bud mortality. Application of this herbicide at peak growth stage, might have resulted in better translocation of the herbicide to the rhizomes. This supports the earlier concept that glyphosate moves to greater extent into the underground portions along with photosynthates (Rioux *et al.* 1974). Dalapon at all the concentrations also inhibited the sprouting (Table 2), which was significantly less when compared to bromacil and asulam. Less dry matter of rhizomes and sprouts in plots where glyphosate and dalapon was applied could be attributed to the reason that glyphosate and dalapon are slow acting herbicides and are translocated in the plants from shoots to roots and accumulate in the rhizomes to inhibit their further growth. Significant reduction in dry matter of rhizomes by asulam and no appreciable effect on dry matter and number of sprouts indicates that this herbicide must be repeated for optimum and long season control. Less effectiveness of asulam as compared to glyphosate and dalapon has also been reported by Overton *et al.* (1975).

Biochemical composition of rhizomes: The oil percentage in the rhizomes analysed six month after spraying (Table 3) indicated that oil content in 4 and 8 kg bromacil and 6 kg glyphosate was significantly lower than control and mechanical

Table 1 : Effect of various treatments on dry matter production of johnson grass shoots and rhizomes.

Treatments a.e. or a.i. kg/ha	Dry matter of shoots 6 weeks after spray (g/m²)		Dry matter of rhizomes (g/m²) 2 months after spray		Dry matter of rhizomes (g/m²) 4 months after spray	
	1977	1978	1977	1978	1977	1978
Bromacil 4	233.5	243.3	285.0	190.0	205.0	160.0
Bromacil 6	217.6	200.0	190.0	170.0	185.0	135.0
Bromacil 8	225.2	194.1	170.0	160.0	75.0	120.0
Glyphosate 2	239.3	217.5	148.5	145.0	135.0	115.0
Glyphosate 4	210.8	197.5	156.5	175.0	130.0	85.0
Glyphosate 6	202.4	190.0	86.5	115.0	105.0	80.0
Dalapon 8	227.4	223.2	235.0	210.0	188.5	151.0
Dalapon 12	210.8	201.6	170.0	175.0	128.5	140.0
Dalapon 16	149.9	201.6	160.0	160.0	138.5	145.0
Asulam 4	252.4	235.0	240.0	195.0	230.0	185.0
Asulam 6	210.8	218.2	190.0	180.0	176.5	170.0
Asulam 8	222.4	202.4	215.0	155.0	183.5	165.0
Mechanical Control	230.7	245.7	350.0	290.0	241.5	290.0
Untreated Control	.260.7	254.1	385.0	305.0	333.5	395.0
S Em ±	10.3	8.3	62.0	24.5	51.2	8.8
C. D. at 5%	29.7	24.0	180.0	71.0	149.0	25.4

Table 2 : Influence of various treatments on number and dry matter of johnson grass sprouts.

Treatments a.e. or a.i. kg/ha	Number of sprouts/m² 2 months after spray		Dry matter of sprouts (g/m²) 2 months after spray	
	1977	1978	1977	1978
Bromacil 4	432	348	22.3	18.8
Bromacil 6	323	330	16.7	18.1
Bromacil 8	259	273	8.5	12.9
Glyphosate 2	70	16	0.8	0.6
Glyphosate 4	7	7	0.3	0.3
Glyphosate 6	5	5	0.1	0.3
Dalapon 8	108	149	5.5	7.0
Dalapon 12	71	109	2.5	3.9
Dalapon 16	23	63	0.4	1.2
Asulam 4	295	204	27.1	15.6
Asulam 6	194	216	16.7	14.5
Asulam 8	208	202	13.9	12.4
Mechanical Control	648	616	43.3	35.0
Untreated Control	411	473	26.9	31.1
S Em ±	10.02	6.50	2.5	0.6
C. D. at 5%	29.13	18.84	7.1	1.7

Table 3 : Effect of various treatments on oil percentage, total sugars and crude protein of rhizomes of **johnson grass.**

Treatments a.e. or a.i. kg/ha	Oil content (%)		Total sugars (%)		Crude protein (%)	
	1977	1978	1977	1978	1977	1978
Bromacil 4	8.5	8.6	5.5	6.1	2.2	1.9
Bromacil 6	7.4	8.0	6.7	6.6	1.3	1.2
Bromacil 8	7.5	7.7	6.7	1.4	1.4	0.9
Glyphosate 2	9.5	9.5	4.2	4.6	1.1	1.2
Glyphosate 4	8.3	8.2	3.7	3.9	1.3	1.1
Glyphosate 6	7.3	7.5	2.5	2.9	0.9	0.9
Dalapon 8	7.7	8.0	3.5	3.9	1.7	1.5
Dalapon 12	8.1	7.9	3.0	2.2	1.4	1.4
Dalapon 16	8.0	7.9	2.1	1.3	0.9	1.0
Asulam 4	8.2	8.3	7.2	5.8	1.4	1.4
Asulam 6	8.6	8.4	5.7	4.6	1.2	1.3
Asulam 8	8.9	9.4	3.4	3.5	0.8	0.9
Mechanical Control	8.6	8.9	7.3	7.4	1.4	1.4
Untreated Control	8.8	8.9	5.5	5.8	1.7	1.6
S Em ±	0.32	0.27	0.65	0.52	0.22	0.18
C. D. at 5%	0.93	0.80	1.89	1.51	0.64	0.54

Table 4 : Residual effect of various treatments on germination and growth of wheat, barley and mustard.

Treatments a.e. or a.i. kg/ha	Germination percentage						Dry matter of different crop plants (g/m^2)					
	Wheat		Barley		Mustard		Wheat		Barley		Mustard	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Bromacil 4	4.0	3.0	14.0	12.0	5.0	7.0	0.12	0.15	0.05	0.02	0.02	0.02
Bromacil 6	–	1.0	4.0	8.0	–	5.0	–	–	–	–	–	–
Bromacil 8	–	–	0.3	2.5	–	3.3	–	–	–	–	–	–
Glyphosate 2	50.3	61.0	60.3	59.0	51.0	55.3	2.32	1.75	5.87	5.32	6.07	6.90
Glyphosate 4	46.0	57.0	55.3	56.0	51.0	54.0	1.80	1.55	5.57	5.60	5.92	5.12
Glyphosate 6	45.6	58.0	50.6	56.5	56.0	59.0	2.12	1.67	5.47	6.25	5.92	6.50
Dalapon 8	38.6	46.0	47.3	47.0	52.0	49.3	1.65	1.27	4.82	4.25	4.45	2.65
Dalapon 12	36.3	41.0	49.3	4.0	47.0	48.3	1.25	1.37	3.62	3.0	3.92	4.22
Dalopan 16	44.3	42.0	53.6	41.5	50.0	45.0	2.15	1.87	3.22	4.0	4.15	4.55
Asulam 4	29.6	36.0	56.6	35.0	52.0	51.0	0.57	0.95	3.22	2.75	4.07	3.30
Asulam 6	29.3	42.0	47.6	31.0	47.0	47.0	0.47	1.1	2.52	3.0	3.70	2.80
Asulam 8	33.0	30.0	51.0	29.5	46.0	44.0	0.32	0.6	2.57	1.6	3.82	1.62
Mechanical control	44.0	48.0	62.0	46.5	48.0	61.0	2.65	1.42	7.27	5.0	4.80	4.32
Untreated control	48.6	52.0	60.0	53.0	53.0	62.0	2.67	1.72	6.55	4.85	5.2	4.95
S Em ±	3.54	1.25	4.70	1.50	1.84	1.28	0.14	0.17	0.30	0.19	0.30	0.57
C. D. at 5%	10.29	3.63	13.66	4.36	5.33	3.72	0.33	0.49	0.87	0.56	0.87	1.66

control. The data on total sugar in rhizomes revealed that the concentration of total sugars in rhizomes which were treated with bromacil at 8 kg/ha, glyphosate 6 kg/ha and dalapon at 12 and 16 kg/ha was significantly less than untreated and mechanical control. Crude protein were significantly reduced by the application of glyphosate. The highest dose of other herbicides also reduced the protein content in rhizomes but this magnitude of decrease was much more conspicuous due to application of glyphosate. Lower reproductive potential (Table 2) and reduction in crude protein by glyphosate and dalapon suggests that these herbicides are effective in controlling johnson grass.

Herbicide residues in soil: Glyphosate did not exhibit any adverse effect on the germination of wheat, barley and mustard (Table 4). The effects of different herbicide on the germination of different crops was of the order of Bromacil > Asulam > Dalapon > Glyphosate. Seed germination was almost completely inhibited by the residues of bromacil at 6 and 8 kg/ha.

Germination of wheat and mustard due to bromacil was found to be more inhibitory than barley, whereas, wheat and barley were comparatively more susceptible to asulam and dalapon than mustard.

Dry matter per plant: Dry matter accumulation was prevented most by Bromacil at 6 and 8 kg/ha. Glyphosate allowed more accumulation of dry matter in all the plants as compared to asulam and dalapon, respectively. In general, the effect of different herbicides was more during 1978 as compared in 1977.

Wheat was most susceptible to asulam as compared to barley and mustard, respectively. Although the dry matter of mustard was reduced by dalapon but the effect was comparatively less than wheat and barley respectively.

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PRELIMINARY SURVEY FOR NATURAL ENEMIES OF HERBACEOUS WEED – *EUPATORIUM ODORATUM* L.

B. R. DAYAKAR YADAV, BALAKRISHNA GOWDA and G. BORAIAH
Department of Botany, University of Agricultural Sciences
Bangalore-560 065, India.

ABSTRACT

The possibility of using natural enemies to suppress herbaceous weed warrants further efforts. During preliminary survey, colonies of plant-sap feeders: *Toxoptera odinæ* Van der Goot, were inhabited on herbaceous weed – *Eupatorium odoratum* L. growing all along western region of India. Bioecological investigations revealed the synchronization of aphid colonies on plants at pre-flowing stages; facilitated more in bringing down the number of tillers and plant population appreciably. Further studies in combined use of insects and plant pathogenic micro-organisms in the control of weed are in progress.

INTRODUCTION

Eupatorium odoratum L. (Siam weed) a native of America, from where it has spread to other parts of the tropics, recorded in south-west India (Mom and George, 1959), Nigeria (Ivens, 1974). Presently the plant population has reached alarming proportions all along south-western region of India.

An obnoxious weed, herbaceous and succulent when young but become woody at maturity, recorded growth up to 8 m height (Rai, 1976), and capable of growing throughout the year. Its spreading capacity through seeds (cypsella) and power of regeneration are tremendous. In most places many thousands of acres of valuable grazing land between 670-1160 m elevation being densely covered with.

The objective of this survey was to bring the weed densities to non-economic levels, which was accomplished by indirect action of the natural enemies. Earlier (DeBach, 1964; Sweetman, 1958) felt that the action of insects which attack flowers or seeds were more effective as a natural enemy. Further, in Hawaii, Australia and North India – the shruby weed *Eupatorium adenophorum* Spreng. (croften weed) were effectively brought under control with the introduction of *Procecidochares utilis* Stone, in a matter of few years in the areas of the better range lands (Bess and Haramoto, 1958; Kapoor and Malla, 1978). But a fortunate development was the buildup of a leaf-spot disease of croften weed caused by *Cercospora eupatorii* Peck., which was coincidental with the introduction of *P. utilis* (Dodd, 1961; Wilson, 1969).

Natural enemy: Toxoptera odinæ Van der Goot. During the survey for natural enemies against *E. odoratum* three insect parasites were noticed. Among them the sap-sucking aphid – *T. odinæ,* which feeds on the sap of inflorescence, branches and tender shoots was promising where infestation was high enough to carry out further work. The other two parasites of

Table 1: Aphid parasitization on shoot tips of ***Eupatorium odoratum*** at several localities.

Locality	Height of Plants, m (Avg. of 30)	No. of main and lateral shoot tips affected (per 100 plants)	No. of aphids on top 8 cm (of 10 samples each)	
			Above 1.3 m ground level	Up to 1 m ground level
N. Kanara (Supa)	2.0	76	180 ± 5	130 ± 6
Shimoga	2.4	68	140 ± 4	135 ± 4
S. Kanara	2.1	60	130 ± 3	114 ± 2
Hassan	2.6	20	42 ± 3	40 ± 3
Coorg	2.6	26	40 ± 2	40

little importance are being discussed later.

These aphids inhabitate naturally, and adults were conspicuously numerous in some areas like Supa (North Kanara), Shimoga and South Kanara, but relatively scarce in others. For the study, a collection site was selected in a dense stand at about 800-930 m elevation at Supa. Studies were made in August-September when the aphid colonies on plants were heavy. Random sampling and hand picked observation for number of insects per branch was recorded (Table 1). Aphids inhabited mainly on stem between the young paired leaves at shoot tip and succeeding 2-3 leaf pairs. The average number recorded per shoot tip (of 10 samples) were 180 ± 5 on all top shoot portion above 1.3 m ground level. The lower strata up to 1 m above ground level averaged 130±6, mostly young seedling and tillers formed among the lot. Though rainfall in most districts is high – North Kanara (2800 mm, average annual rainfall), Shimoga (3500 mm), South Kanara (3930 mm), Hassan (3000 mm), Coorg (4268 mm) but they experience short duration from 1-2 weeks without rains, during August-November; hence, seasonal variation in aphid population noticed. Adults small 1-3 mm long, delicate, soft bodied, globular to pear shape, green to blue-green, nymphs resemble adults in most characteristics except size. How ever, during the survey no attempt was made to study the habitats of the aphid.

The other insect parasite *Myzus persicæ* Sulz. (Kulkarni, 1980) which has been previously reported did not show any adverse effect on the weed and also with the mango hoppers – *Idocerus sp.* recently encountered during the survey.

RESULTS AND DISCUSSION

The success of the aphid – *Toxoptera odinæ* Van der Goot, is due to a better synchronization of the adult insects with the climate and the growth phases of the plant. During the early spring there is flush growth, which increases the number of stems available for oviposition sites. In addition continued heavy attack by the aphids during spring and autumn cause leaf-curl, deformed and death of branch of the growing tips. Observations made so far led to state that the destruction of shoot tips and procumbent growth each year prevented flowering and seed production appreciably which in turn reduced the plant population (Table 2). But, light plays a major role in determining the growth and distribution of *E. odoratum* which promotes and hastens germination per cent. Hence, light requirement for germination does not impose any serious limitation on *E. odoratum* (Ambika and Jayachandra, 1980) and *E. adenopho-*

Table 2: Degree of tolerance of *E. odoratum* towards aphids recorded at Supa (N. Kanara) area.

Year	Tolerence	
	% decrease in plant no. in 6 x 6 m plot (of 10 plots)	Damage rating* (1 – 5)
1978	50	2 – 3
1979	56	2 – 3
1980	68	3 – 4

* Scale: 1-5 (1 = nil, 3 = dying, 5 = dead)

rum Spreng. population (Auld and Jayachandra, 1975).

CONCLUSION

The objective of this survey was to bring the weed densities to non-economic levels, if not complete eradication through the use of natural insect enemies. Massive invasion of lands with *E. odoratum* were mostly due to erratic seed (cypsella) production from year to year all along south-west region of India. The vegetative destruction (floral branches) and the curtailment of seed production of *Eupatorium* was satisfactorily been met with the aphid – *Toxoptera odinæ* where feeding is sufficiently intense and sustained, branch killing and even plant killing noticed. Further studies to control the weed are under way with the effective utilization of viruses, bacteria and fungi.

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CIRSIUM ARVENSE—A CONTINUING PROBLEM IN WESTERN CANADA

W. H. VANDEN BORN
Department of Plant Science, University of Alberta, Edmonton, Alberta, Canada.

ABSTRACT

Cirsium arvense (L.) Scop., Canada thistle, is widespread in Canada and the northern half of the United States. Prospects for biological control of this species are considered poor and, with the current emphasis on minimum tillage and decreased summer fallow, selective chemical control is the most likely answer. Several morphologically different ecotypes of *C. arvense* have been recognised but no significant differences in response to herbicide treatment have been observed.

Glyphosate is considerably more mobile than picloram in *C. arvense*, following foliage application. Studies of the correlation between translocation of herbicides and of assimilates have been only partly successful, particularly with glyphosate. Results of field experiments indicate that glyphosate is most effective at the bud or flowering stage while dicamba and picloram are most effective at the prebud or bud stage. DOWCO 290 was equally effective at all three stages and is the most promising herbicide for selective control of *C. arvense* in wheat, barley and rapeseed.

INTRODUCTION

Cirsium arvense (L.) Scop., Canada thistle, is a deep-rooted perennial weed that continues to cause serious problems in many crops throughout the world. It was introduced to Canada from Europe in the 17th century and now occurs in relative abundance across all of southern Canada. It is estimated that infestations of this species occur on 40% of the cultivated land in the prairie provinces of western Canada. Losses in 1980 due to *C. arvense* competition in Saskatchewan wheat alone were estimated at over 4 million dollars. In eastern Canada the weed is not a particular problem. It is frequently seen but the percentage coverage is usually less than 1%. *C. arvense* also is a very serious weed in the United States north of approximately 37° north. It is troublesome in the eastern states (west to longitude 97°) and in the Pacific states but does not survive in the more southerly states. Four varieties of *C. arvense* have been described in Canada (Moore and Frankton, 1974). The variety *horridum* is the commonest and is the weed known to most persons. The variety *integrifolium*, with thin and flat leaves, most leaves entire, spines few and fine, is the only other variety found in Alberta.

Herbicide translocation

Much has been written and said about translocation of foliage-applied systemic herbicides in plants. Unfortunately, because annual weeds are easier to manipulate than perennials, much of the information regarding such translocation has come from research with annual weeds. The transport system in perennial weeds is much more complicated than that in annuals, especially with respect to the relationship between growth stage of the plant and translocation to underground roots or rhizomes. Dicamba and picloram are readily absorbed by foliage or by roots of *C. arvense* and they are translocated both in the phloem and in the xylem (Chang and Vanden Born, 1968; Sharma *et al.* 1971). After application of small amounts of radioactive dicamba or picloram to a full-grown leaf, radioactivity accumulated in the young growing leaves near the tip of the treated shoot although, in the case of picloram, even after 20 days half of the total radioactivity in the plant was still in the treated leaf (Sharma and Vanden Born, 1973). There was also some radioactivity in the tips of secondary untreated shoots. Uptake of dicamba or picloram by *C. arvense* roots from nutrient solution resulted in fairly uniform distribution of radioactivity throughout the plants within 4 days, with no marked accumulation in the young leaves.

Müller (1969) was able to relate the amount of MCPA taken up and the trend of its distribution in *C. arvense* in various stages of growth to changes in the amount of reserve food materials and the direction of assimilate movement during shoot development. Some uncertainty was expressed by Fykse (1977), however, about the supposed correlation between MCPA translocation and assimilate transport in *C. arvense*. He observed that, at least during the period from shoot emergence in early summer to the 10 or 11-leaf stage, the time of greatest translocation of MCPA to the roots did not correspond to the time at which spray treatment with MCPA resulted in most effective control. He suggested that the relative inability of the root system to produce new shoots during the above period probably was more important than the extent of MCPA translocation for effective control.

Sprankle *et al.* (1975) concluded that glyphosate moved to areas of highest metabolic activity in *C. arvense* following foliage application. The results of Gottrup *et al.* (1976), however, indicate that the translocation pattern of glyphosate is more complex than that of dicamba and picloram and that glyphosate does not always follow the assimilate stream. After treatment of one mature leaf of *C. arvense* the radioactivity moved readily via the apoplast to the margins of the treated leaf and via the symplast to the roots and young growing leaves.

In a study with a simplified transport system consisting of a single *C. arvense* shoot attached to a piece of creeping root, with all the leaves removed except for a basal green leaf and the shoot tip with several small leaves (Summers, 1981), it was demonstrated clearly that glyphosate was much more mobile than picloram. Seven days after treatment of a basal leaf, 76% of the ^{14}C-picloram dose had been absorbed but only 2 or 3% was present in the shoot tip. By contrast, 95% of the ^{14}C-glyphosate dose had been absorbed and 15% had been exported to the shoot tip. Similarly, when the herbicides were applied to small leaves at the shoot tip, less than 1% of the picloram dose was exported to the stem after 7 days but 11% of the glyphosate dose was recovered from the stem, most of it from the upper third.

When 0.5 mg glyphosate or picloram was applied to the three largest leaves of an intact shoot and the shoot was severed from the creeping root after different intervals, one day's transport brought enough glyphosate to the root to kill it while for picloram even 3 days was not long enough to kill the root. The greater mobility of glyphosate is indicated although the relative susceptibility of *C. arvense* root tissue to the two herbicides also must be taken into account.

Very small but detectable amounts of radioactivity were present in the roots to 7 days after application of ^{14}C-picloram to the shoot. After application of 48 μg glyphosate to a shoot, glyphosate accumulated in a 20-cm piece of creeping root at an average 0.016 μg/hr, rapidly during the first 60 to 80 hr, then more slowly.

Attempts to relate the degreee of translocation of foliar-applied glyphosate to the stage of growth of Canada thistle and the expected direction and rate of movement of assimilates at these stages of growth have been mostly unsuccessful. The observations that have been made indicate no clear relationship between stage of growth and degree of translocation of glyphosate. On the other hand, there is good evidence that glyphosate controls Canada thistle much more effectively when applied at more advanced stages of growth such as the flowering stage than at relatively early vegetative stages of growth.

Chemical control

C. arvense continues to be a problem for many farmers and, at least in western Canada, shows no signs of being subdued, despite all efforts at control.

One of the main difficulties has been the relative inability to kill the creeping root system. Phenoxy herbicides such as MCPA and 2, 4-D have provided only limited control of Canada thistle, in part because the translocations of these herbicides to the roots is restricted. More recently developed herbicides can be translocated to the roots in larger quantities, and frequently with little or so metabolism in the plants. Most of these herbicides (dicamba, glyphosate, picloram), unfortunately, cannot be used as selective herbicides for the control of Canada thistle in cereal crops and they must be applied during a follow year or before seeding or after harvest. Two experimental herbicides, DOWCO 290 (3, 6-dichloropicolinic acid) and DPX 4189 (chlorsulfuron) have shown real promise for selective Canada thistle control, the former in wheat, barley and rapeseed and the latter in wheat and barley.

We established field trials in which treatments and cropping programs would run for at least 3 years. The treatment programs consisted of herbicide application on fallow followed by barley in succeeding years, or application in crop. In barley after barley the same herbicide treatments were applied in 3 successive years, 1979 to 1981. Most effective treatments on fallow were amitrole, glyphosate, DOWCO 290 and picloram. Dicamba and 2, 4-D were moderately effective. Best results with dicamba were obtained when it was applied at the bud stage while glyphosate was more effective at the bud or flowering stage than at the vegetative stage. DOWCO 290 was equally effective at all three growth stages. Most effective in-crop treatments were those with DOWCO 290 and DPX 4189.

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EVALUATION OF THE ISOPROPYLAMINE SALT OF GLYPHOSATE FOR *IMPERATA CYLINDRICA* (L.) BEAUV. CONTROL IN OIL PALM

WONG PHUL WENG
Product Development Manager, Monsanto (Malaysia) Sdn. Bhd.,
116, Jalan Semangat, Petaling Jaya, Selangor, Malaysia.

ABSTRACT

The use of the isoproylamine salt of glyphosate [N-(phosphonomethyl) glycine] for control of *Imperata cylindrica* (L.) Beauv. in oil palm (*Elæis guineensis)* was evaluated over a four year period under varying shade and other environmental conditions. The results demonstrated that shade has a greater influence on *I. cylindrica* control than do wet or dry season applications. In open conditions, glyphosate 4.4 kg æ ha^{-1} provided over 95% control of *I. cylindrica* for 6 months while in shaded conditions similar control was obtained with 2.2 kg æ ha^{-1} rate. Crop tolerance and yield studies demonstrated that post directed applications of glyphosate did not adversely affect crop yield or frond production. Results of residue studies demonstrated that glyphosate is not readily absorbed by oil palm roots and glyphosate residue were not detectable in either mesocarp or kernel palm oil.

INTRODUCTION

Imperata cylindrica is a serious problem in all stages of oil palm growth due to its highly competitive nature and ability to regenerate from seeds as well as underground rhizomes. If not effectively controlled prior to planting, *I. cylindrica* will severely inhibit or prevent the establishment of oil plam seedlings. In mature oil palms, competition by *I. cylindrica* for soil nutrients as well as moisture results in severely reduced yields. Uncontrolled *I. cylindrica* is also a fire hazard and provides shelter for undesirable insect and animal life on plantations.

Mechanical control practices such as hœing or slashing are extremely labour intensive and do not provide long term control of *I. cylindrica* due to the extensive system of underground rhizomes. Similarly, the majority of currently used chemical control methods require 2 or more applications and provide only partial control of *I. cylindrica*. Some of the chemicals currently being utilized may cause crop injury from spray drift or residual soil activity. Wong (1973) reported results of preliminary *I. cylindrica* control trials with glyphosate under varying environmental conditions. Results of oil palm tolerance, yield and residue studies are also discussed.

MATERIAL AND METHODS

Weed control studies

A total of 131 replicated and non-replicated plot trials (plot size 0.015 to 0.030 ha) were established throughout Peninsular Malaysia over a four years period to evaluate the effect of shade levels and wet versus dry weather conditions on the control of *I. cylindrica* with glyphosate. The glyphosate rates evaluated ranged from 1.1 to 4.4 kg a.i./ha applied in 1125 L/ha of water. At the time of application, the *I. cylindrica* was actively growing and 0.75 to 1.50 m tall. For ease of interpretation, shade categories were divided into 0 to

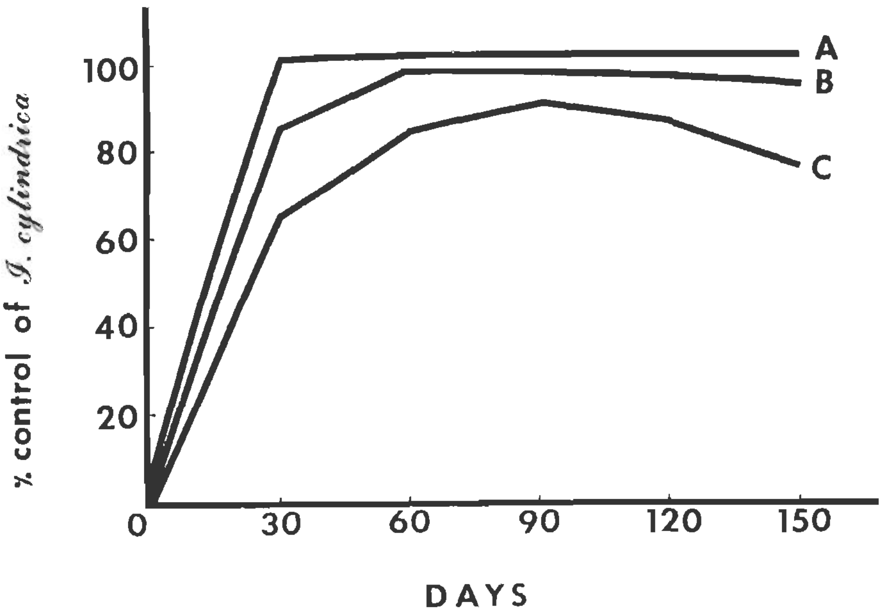

Fig. 1. Control of *Imperata cylindrica* growing in 0 to 30% shade with glyphosate 4.4 kg ae ha^{-1} applied during wet or dry season (A), glyphosate 2.2 kg ae ha^{-1} applied during the dry season (B) and glyphosate 2.2 kg ae ha^{-1} applied during the wet season (C).

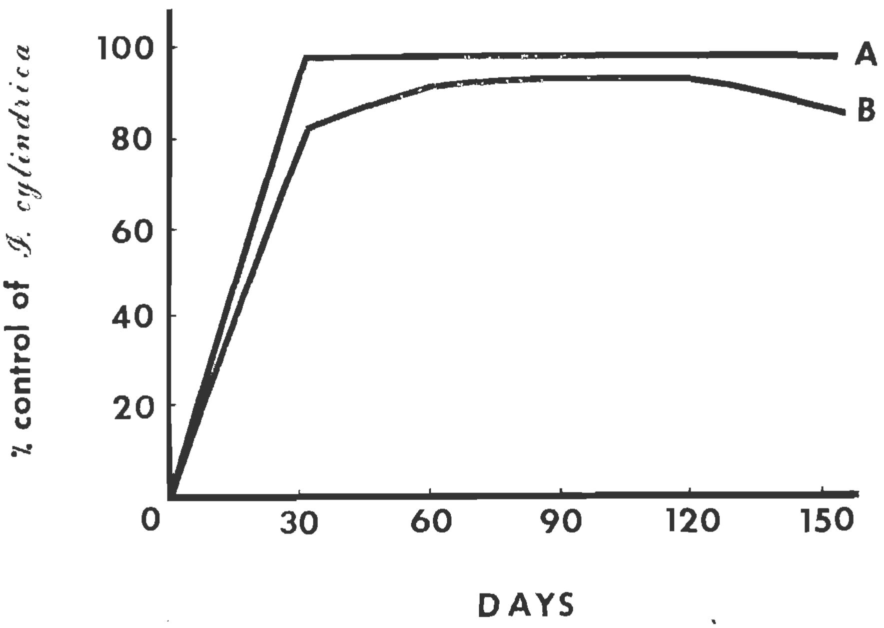

Fig. 2. Control of *Imperata cylindrica* growing in 30% plus shade with glyphosate 2.2 kg ae ha^{-1} (A) versus glyphosate 1.1 kg ae ha^{-1} (B). Data is from applications made during both the wet and dry seasons.

30% shade and 30% plus shade, on a visual basis. Weather conditions were divided into dry season (monthly average precipitation 125 mm) when the weather was generally dry and clear (Jan. to Feb. and May to Oct.) and wet season (monthly average precipitation 300 mm) when the weather was generally rainy and overcast with the onset of the Monsoon rains (Mar. to Apr. and Nov. to Dec.) during and after spraying. At least 30 sets of treatments were applied under each of these four conditions. Percent *I. cylindrica* (vegetative and rhizome) control was determined by visual observations for at least 150 days after application.

Crop tolerance, yield and residue Studies

Three crop tolerance and yield trials were established using a randomized block design with four replications. The plot size was 12 palms per plot and the palms were planted on 9.14 m spacings. The treatments evaluated were glyphosate 0.55, 1.1 and 2.2 kg a.i./ha, a tank mixture of paraquat (1,1'-dimethyl-4, 4'-bipyridinium ion) 0.25 kg + MSMA (monosodium methanearsonate) 1.5 kg + diuron [3 -(3, 4- dichlorophenyl) -1, 1-dimethyurea] 0.25 kg/ha and a handweeded control. The chemical treatments were initially applied every three months and reduced to every four months when the oil palms had been established more than two years and handweeding was done every other month. The treatments were applied as a directed basal spray within the drip line of the oil palms in 445 l /ha of water.

Treatments were continued up to maturity of the palms and yields of all fruit bunches from every harvest were recorded until the trials were terminated. Frond production was measured during the trial.

Four non-replicated trials were established to collect samples for residue analysis. Directed applications of 1.8 and 3.6 kg a.i./ha of glyphosate were applied within the palm circle. Applications were repeated 3 times at 3 month intervals and palm fruit bunches were harvested following the final application. Fruits were extracted separately for mesocarp and kernel oil and glyphosate analysis was performed on the oil samples.

RESULTS AND DISCUSSION

Control of I. cylindrica with glyphosate

In the open condition with 0 to 30% shade, 4.4 kg a.i./ha provided over 95% *I. cylindrica* control 150 days application irregardless of the application season (Fig. 1). *I. cylindrica* control with the 2.2 kg a.i./ha rate was consistently inferior to the 4.4 kg a.i./ha rate and was influenced by the timing of the application. Maximum control observed with this rate during the wet season was 87%, 90 days after application and regrowth was evident 150 days after application while control during the dry season remained approximately 90% after the 60 day observation.

I. cylindrica control in the shaded trials was independent of application season (Fig. 2). Maximum *I. cylindrica* control was observed 30 days after application with the 2.2 kg a.i./ha rate and remained above 95% control throughout the study. Regrowth was noted in the 1.1 kg a.i./ha treatments 120 days after application.

Results of these trials demonstrate that glyphosate provided excellent long term control of *I. cylindrica.* Examination of the treated plants revealed that glyphosate controlled not only the vegetative growth but caused complete dessication of the underground rhizomes. Control was influenced to a greater extent by shade levels than application season and higher glyphosate rates were required to

Table 1: Annual Oil Palm frond production and fruit production as influenced by various weed control programs.

Treatments (Kg/ha)	Frond Production	Fresh Fruit Bunches
	(No./year)	(Kg/ha/year)
Glyphosate 0.55	27.2	11,196
Glyphosate 1.10*	27.4	11,856
Glyphosate 2.20*	26.6	10,764
Paraquat + MSMA* Diuron 0.25 + 1.50 + 0.25	26.6	10,296
Handweeding**	26.8	10,596

*Sprayed every 3 months, then every 4 months after the palms were more than 2 years old.
**Handweeding every 2 months.

control *I. cylindrica* in open conditions than in shaded areas.

Crop tolerance, yield and residue studies

Results of these studies demonstrated that young oil palms were quite tolerant to directed applications of glyphosate (Table 1). Young oil palms treated repeatly with up to 2.2 kg a.i./ha of glyphosate as a directed spray showed no abnormal visual symptoms on the fronds. Frond production for all glyphosate treatments was similar to the handweeded control. Yield of fruit bunches was similarly uneffected by the multiple applications of glyphosate compared to the hand weeded control. The data demonstrates that 19.8 kg a.i./ha of glyphosate, the cumulative dose of maximum rate tested had no residual effect on the oil palm. These data agrees with Upchurch and Baird (1972) who reported negligible herbicidal activity of glyphosate applied to soil. Sprankle *et al.* (1975) reported that the lack of residual soil activity is primarily due to the adsorption of glyphosate on soil particles.

Data further demonstrated that glyphosate is safe for use in oil palm and is not absorbed by the plant roots. Analysis of the mesocarp and kernel oil samples revealed no combined residue levels of glyphosate and its major metabolite, aminomethylphosphonic acid, above the sensitivity level of 0.05 ppm.

CONCLUSION

Control of *I. cylindrica* with glyphosate is influenced to a greater extent by shade conditions than by wet or dry season applications. Applications of 4.4 kg a.i./ha of glyphosate to *I. cylindrica* growing in open conditions or 2.2 kg a.i./ha for shaded areas provides greater than 95% control six months after application. Visual observations and lack of regrowth showed that glyphosate controls both above ground vegetative growth and underground rhizomes. Crop tolerance and yield demonstrated that glyphosate can be safely used as a directed spray around young oil palms and crop residue studies demonstrated that glyphosate residues were not detected in the palm oil.

ACKNOWLEDGEMENTS

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INTRODUCTION AND SPREAD OF *EUPATORIUM ADENOPHORUM* IN CALIFORNIA

T. C. FULLER
California, Dept. of Food and Agriculture
Sacramento, CA 95814, USA.

ABSTRACT

Eupatorium adenophorum is known by the Hawaiian common name of Maui pamakani. This clumped perennial weed was first recorded in southern California in 1908. In the ten years around 1920, Maui pamakani spread rapidly throughout the mountains along the northern side of the Los Angeles Basin. This weed densely occupied the very few areas of year-round water and crowded out the native vegetation in these places. Thus some of the rare and unusual distributions of the native flora were lost. To prevent fires in the native brushlands, some 2,000 acres of hillside were placed under sprinkler irrigation in a park north of Hollywood. Being adapted to the continued source of artificial rain, the Maui pamakani became the dominant herb in more than 2,000 acres. The other distributions in California are along the coast in wet areas until north of San Francisco where the weed grows in full sun on dry soil in the fog belt.

INTRODUCTION

Ageratina adenophora (Spreng.) R. M. King & H. Robinson has been introduced as a weed in Hawaii, the Philippines, Thailand, New Zealand, Australia at Sydney and northwards along the coast, and in India, Nepal and Sikkim (Ferris, 1960; Everist, 1974; Hazelwood & Molher, 1976; Hiroshi, 1976; Lamp & Collet, 1979; Munz, 1974; Parish, 1960). This species, native to Mexico, has been separated along with several others from the *Eupatorium* to the genus *Ageratina*. The introduction and spread of this weed in California is documented by collections in the various herbaria of the state.

There has been a confusion of names in referring to this taxon. Many of the first collections of this weed in California were determined as *E. glandulosum* H.B.K. but this name was used earlier for another taxon, *E. glandulosum* Michx. This duplication of names has led to some confusion in the literature. Most of the records in California have used the *E. glandulosum* Sprengel.

A. adenophora is known in California by its Hawaiian name, Maui pamakani; Maui from being first found on the island of Maui, and pamakani, wind-blown, referring to the dispersal of the many small achenes with their pappus of minute bristles. In Australia, this weed is called Crofton weed *A. adenophora* in California.

The plants are tall herbaceous perennials that become woody at the base. The several stems arise from a taproot that also has short lateral yellowish rootstocks which have a carrot-like odor when broken. The upright stems are somewhat weak and form a tangled mass of the clumps of plants. The stems that touch the ground become rooted, increasing the dense mass of stems and leaves. Under good moisture conditions this mass of the plants may be 3 meters tall.

The first record of *A. adenophora* in California is a collection dated only 1878 (no month or day) from the "clay hills, San Francisco". This collection is a number of years after the immigration into California in the gold rush of 1849, many of whom stopped in Mexico or Central America en route to California.

The next collection of the weed was made on April 20, 1896, and it was assumed to be native, the native flora being poorly known at that time. The name *E. pasadenense* Parish was given to this taxon, the type locality being designated as a canyon south of Pasadena, Los Angeles County. At the present time along the fence of the Pasadena Freeway going from Los Angeles in a canyon south of Pasadena the weed still can be seen clamboring up the freeway fence.

In the decade of the 1920's *A. adenophora* appeared as naturalized populations in widely separated places: above Montecito, Santa Barbara County; coastal edge of the Santa Lucia Mountains south of big Sur, Mounterey County; Berkeley Hills, Alameda County; and north of San Francisco in Marin County.

The biggest damage that this weed has done has been to occupy the few areas of permanent water during the extensive summer dry period found throughout the major portion of California. This dry period is responsible for the success of California's agriculture as the amount of water given crops can be controlled by irrigation practices; any agricultural chemicals as fertilizers and pesticides, can be controlled as to their use, resulting in the production of high quality food and fiber.

The native vegetation has suffered from the invasion of this weed by occupying summer wet areas and taking the places of many of the rare distributions of native plants formerly found in such areas.

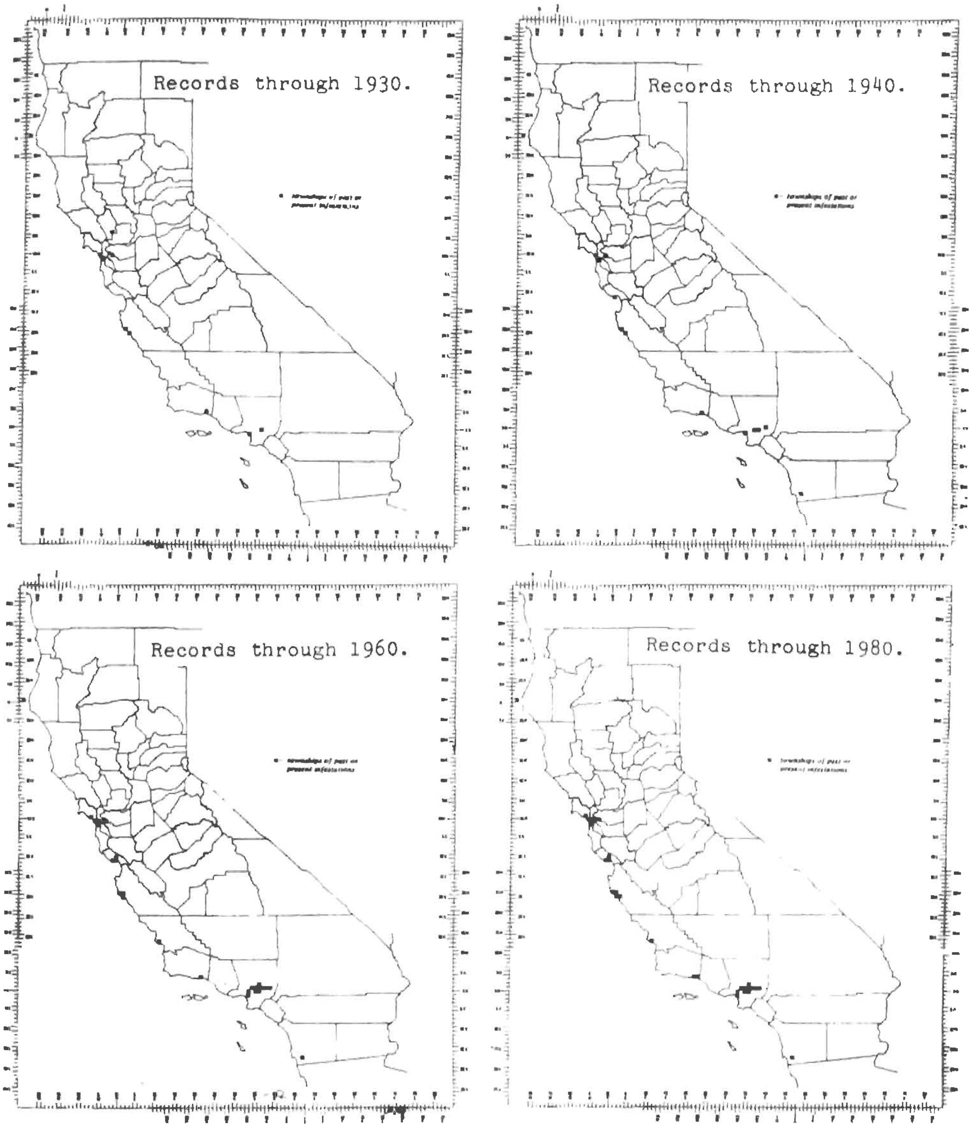
In California, Maui pamakani has not been successful as a weed of agricultural lands. The closest that this species has shown this weedy potential has been on the coast of Marin County, north of San Francisco where the weed is growing in the fog belt on open land. There is no pasturing of this particular area, but several kilometers to the north there are a number of horse pastures where it could become a serious problem.

The toxicity of various species of *Eupatorium* has been well-documented. The toxicity of *A. adenophora* has been suspected for some time. As now understood, the plants are toxic only to horses, producing a dense congestion of the lungs and may result in the death of the animal. The toxin is unknown but there has been a positive test for a form of saponin. Also three steriods and a small amount of pyrrolizidine alkaloid have been found in the pamakani. The poisoning requires ingestion of the weed over a fairly long period of time of several months or more.

In Hawaii, over 10,000 ha of rangeland and pastures have become infested with this weed. Considerable biological control of pamakani has been obtained from the release and build up of populations of the pamakani gall fly from Mexico, *Procecidochares utilis* (Stone). This gall fly in turn is parasitized by the parasite *Opius tryoni* (Cam.) which was introduced into Hawaii for the control of the fruit fly, *Ceratitis capitata* (Wied.). Inspite of this parasitization the pamakani gall fly is producing some effect on the weed. Perhaps further population buildups will produce better reductions of the weed. The pamakani gall fly has also been released in Australia.

In Los Angeles County the largest population of pamakani has exploded under the use of sprinkler irrigation. Above the Greek Theatre in Griffith Park on the northern side of the Los Angeles Basin, the low mountains are covered by cha-

Ageratina adenophora in California.



parral, a dense cover of deciduous and evergreen shrubs that are adapted to fire. To prevent wild fires in this park around the recreation areas, some 8,000 hectares of hillslopes were placed under sprinkler irrigation. This over head moisture, added during what should have been the dry summer season, resulted in over 8,000 ha of the weed, pamakani.

The future of *A. adenophora* as a weed in California remains doubtful. As our young agriculture is developing, more acreage is being placed under irrigation. Because of the cost of levelling the land, more and more areas are being placed under overhead irrigation. This weed is already adapted to such a method of supplying water during the summer. Drip irrigation may become more popular as the costs of labor, water and materials go up for the use of irrigation of crops. Such drip systems would not create the proper environment for the pamakani.

A. adenophora is adapted to become a weed of sprinkler irrigated fields in California, particularly in those warmer areas along the central and south coast. As yet this weed has not become an agricultural pest.

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CONTROL OF *PANICUM REPENS* (L.) IN FIELD CHANNELS

Y. C. PANCHAL
University of Agricultural Sciences, Dharwad, Karnataka India.

ABSTRACT

Panicum repens (L.), torpedo grass or ginger grass, is most commonly noticed along the channels, bunds, water sourses especially in rice fields. Results of four sets of field experiments for controlling this grass have indicated that combinations of bromacil (5-bromo-3-*sec*-butyl-6-methyl -uracil) at 4.0 kg per ha with other herbicides like terbacil (3-*tert*-5-butyl-5-chloro-6-methyluracil) at 4.0 kg per ha or glyphosate [*N*-(phosphonomethyl)-glycine] at 4.01 per ha or dalapon (2, 2-dichloropropionic acid) at 5.0 kg per ha or sequential spray, with paraquat (1, 1'-dimethyl-4, 4'-bipyridinium ion) at 1.01 per ha or dalapon at 5.0 kg per ha plus glyphosate at 4.01 per ha have given effective control of *ginger grass*.

INTRODUCTION

Panicum repens (L.) which is locally known as torpedo grass or ginger grass because of the resemblence of its underground stem which is very thick and hard. It belongs to the family of Poaceæ. Since the grass is palatable and relished by the cattle and because of its soil binding ability and easily propagated by bits of rhizomes, it was popularised to grow along the bunds of the paddy fields, channels and drainage in the ditches in the Tungabhadra Project area in Karnataka. It is stiff, erect grass growing in small clusters to a height of 30 to 60 cm or even more and mostly noticed in water sourses. Aerial branches are covered with pointed scale leaves at the base.

Once it was propagated along the field channels at the Tungabhadra Agricultural Research Station, Siruguppa and in a few years, it started encroaching upon the cultivable lands, it was difficult to control it even by hand digging because of its strong, deep rooted rhizomes. Under such conditions, it was but inevitable to adopt chemical control measures especially when it was known to act as collateral host to rice blast, *Piricularia oryzæ*. Chemical control of *ginger grass* has been reported by several research workers in many countries. Some have used single herbicides (Krechman 1959 and Sze, 1973) reported effective control with several herbicide mixtures.

Studies on the chemical control of *ginger grass* were initiated in 1976-77 at A. R. S., Siruguppa, Karnataka for finding suitable herbicide mixtures and their concentration with maximum effect on this weed.

MATERIAL AND METHODS

During early sixties, bits of rhizomes of *ginger grass* were planted all along the field channels newly opened in the black soil. Within a decade, nearly a kilometre patch of the two metre width on each side of the channel was heavily infested, with this grass thus hindering the water course and eventually causing water logging. Such naturally affected area was divided into small plots of 2.0 × 1.0 m dimensions with a channel of 30 cm around each plot. Before spraying the original volume (percentage ground area covered by grasses multiplied by average height in cm) of the green grass was recorded. Spraying of herbicides was taken up during the first week of September, 1976. Herbicides concentrations mentioned in this article are expressed as active ingredient or acid equivalent only. Before spraying, teepol–a surfactant was added to the spray medium at the rate of 0.05 per cent. The studies were made in four sets of experiments (Tables 1, 2, 3 and 4).

Diuron and its mixture with seven other herbicides (+ one odd treatment of glyphosate alone); Paraquat (as a sequential spray) with seven other herbicides; Bromacil and its mixtures with seven other herbicides and Dalapon and its mixture with nine other herbicides.

Two checks–one of shoot out at ground level and another an untreated check were included for comparison. Paraquat was given as a sequential spray, i.e., eight days after the application of another herbicide. Each set of experiment was conducted in a randomised block design with three replications. Observations at 30 days interval were recorded for a period of 150 days after spraying.

The following herbicides have been used in these experiments:

1. Paraquat (1,1'-dimethyl-4,4'-bipyridinium ion)
2. Diuron [3 - (3, 4 - dichlorophenyl)- 1,1-dimethylurea]
3. Bromacil (5-bromo-3-*sec*-butyl-6-methyluracil)
4. Terbacil (3-*tert*-butyl-5-chloro-6-methyluracil)
5. Simazine [2 - Chloro - 4 - 6 - bis (ethylamino)-1,3,5-triazine]
6. Amitrole-T (3-amino-1,2,4-triazole plus ammonium thiocyanate)
7. Glyphosate [*N* - (phosphonomethyl) glycine]
8. Methazole [2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxidiazolidine-2, 5-dione]
9. Alachlor [2-Chloro -2',6'-diethyl- *N*-(methoxymethyl) acetanilide]
10. Dalapon (2,2 - dichloropropionic acid).

RESULTS AND DISCUSSION

Diuron with other herbicides

Experimental results of the effect of diuron and other herbicide mixtures have shown (Table 1) that compatible mixtures of dalapon with terbacil, bromacil and glyphosate were most effective by reducing the original volume to 5.36, 5.69 and 6.26 per cent respectively as against 21.54 per cent of diuron alone. Use of glyphosate alone was not much effective as spraying with other herbicides. However, Scudder (1975) has reported glyphosate at 2.51 per ha controlled a heavy infestation of ginger grass. Burt and Dudeck (1976) have reported that glyphosate gave excellent control of ginger grass at 2.24 l/ha in turf grass. Higher rates of glyphosate had toxic effects on turf grass, though there was very effective control of this grass and they confirm our experimental results.

Paraquat (sequential spray with other herbicides)

In the second set of experiment, spray of paraquat alone did not control beyond 52.04 per cent of the original volume after 150 days of spraying. Data in Table 2 shows that application of terbacil, bromacil, glyphosate and diuron each at 4.0 l/ha followed by paraquat as sequential spray had reduced the original volume of the ginger grass to 6.43 per cent, 6.92 per cent and 8.65 per cent respectively as against 52.04 per cent of applying paraquat alone. Single hand cutting of grass at

Table 1 : Effect of diuron and herbicide mixture on *Panicum repens* (L) – Percentage of the original value of the grass coverage – Average of 3 replications.

Treatments	Original value before spray, cm²	Days after spraying				Remarks
		30	60	90	120	
Diuron at 4.0 kg/ha	3239	90.90	61.50	40.42	21.54	
Diuron + Simazine 4.0 + 4.0 kg/ha	3400	88.23	54.56	32.35	12.21	
Diuron + Glyphosate 4.0 + 4.0 kg/ha	2112	44.93	64.95	20.95	6.26	
Diuron + Amitrol T. 4.0 + 2.0 kg/ha	2292	71.23	60.34	46.16	20.43	
Diuron + Paraquat 4.0 + 1.0 kg/ha	2965	35.65	32.55	24.10	11.47	Paraquat as sequential spray
Diuron + Dalapon 4.0 + 5.0 kg/ha	2998	55.65	28.65	15.64	10.78	
Diuron + Bromacil 4.0 + 4.0 kg/ha	2723	75.84	44.73	28.24	5.69	
Diuron + Terbacil 4.0 + 4.0 kg/ha	3669	76.02	32.84	22.09	5.36	
Glyphosate alone 4.0 + 4.0 kg/ha	2535	48.67	32.45	21.00	11.44	Odd treatment
Shoot cutting	3080	35.75	67.67	86.04	96.53	
Check	3482	9.99	120.77	132.62	148.47	

Table 2 : Effect of paraquat as sequential spray after the application of some herbicides on *Panicum repens* (L.) – Percentage of the original volume of grass (average of 3 replications).

Treatments	Original value before spray cm²	Days after spraying			
		30	60	90	120
Paraquat alone at 1.0 kg/ha	4419	24.73	37.52	48.85	52.04
*Paraquat and Simazine 4.0 kg/ha	3652	39.73	27.92	21.62	12.95
*Paraquat and Glyphosate 4.0 kg/ha	3820	36.41	32.54	22.09	16.92
Paraquat and Amitrol-T 2.0 kg/ha	3864	32.21	27.38	22.90	12.30
Paraquat and Diuron 4.0 kg/ha	4450	33.84	25.75	14.00	8.65
Paraquat and Dalapon 5.0 kg/ha	4146	35.42	27.52	15.16	9.36
Paraquat and Bromacil 4.0 kg/ha	2947	25.43	21.64	14.59	6.92
Paraquat and Terbacil 4.0 kg/ha	4247	27.78	21.78	11.78	6.43
Shoot cutting	3946	19.50	32.33	56.59	67.41
Check	4634	104.24	107.16	115.15	122.00

* Paraquat at 1.0 kg/ha

Table 3: Effect of bromacil and herbicide mixture on *Panicum repens* (L.) – Percentage of the original volume of the grass (average of 3 replications).

Treatments	Original value before spray cm^2	Days after spraying				Remarks
		30	60	90	120	
Bromacil at 4.0 kg/ha	3316	90.02	64.32	22.10	11.78	
Bromacil + Simazine 4.0 + 4.0 kg/ha	3672	83.42	48.50	25.75	9.71	
Bromacil + Glyphosate 4.0 + 4.0 kg/ha	3532	57.51	43.60	19.42	5.65	
Bromacil + Amitrol T 4.0 + 2.0 kg/ha	3862	69.75	51.50	24.73	8.62	Paraquat as sequential spray
Bromacil + Paraquat 4.0 + 2.0 kg/ha	3275	31.37	23.31	14.09	6.75	
Bromacil + Dalapon 4.0 + 5.0 kg/ha	2784	73.02	34.17	21.54	6.17	
Bromacil + Diuron 4.0 + 4.0 kg/ha	3041	87.57	57.55	22.13	7.76	
Bromacil + Terbacil 4.0 + 4.0 kg/ha	2820	85.50	47.21	29.29	3.05	
Shoot cutting	5280	16.87	27.61	54.01	67.91	
Check	3242	102.41	106.61	120.83	136.77	

Table 4: Effect of dalapon and herbicide mixtures on *Panicum repens* (L.) – Percentage of the original volume of the grass (average of 3 replications).

Treatments	Original value	Days after spraying			
		30	60	90	120
Dalapon 5.0 kg/ha	6815	70.74	65.46	48.91	29.29
Dalapon + Simazine 4.0 kg/ha	4404	69.12	43.62	20.40	13.58
*Dalapon + Glyphosate 4.0 kg/ha	3774	54.17	31.85	17.43	4.71
*Dalapon + Amitrol T. 2.0 kg/ha	4756	74.78	46.94	25.47	17.62
*Dalapon + Paraquat 1.0 kg/ha	4857	31.51	23.58	19.19	12.50
*Dalapon + Bromacil 4.0 kg/ha	3825	74.95	33.85	16.34	6.95
*Dalapon + Diuron 4.0 kg/ha	4468	68.83	43.90	29.55	10.05
*Dalapon + Terbacil 4.0 kg/ha	3116	79.94	44.99	18.02	6.53
*Dalapon + Methazole 4.0 kg/ha	5527	68.52	42.34	30.45	17.11
*Dalapon + Alachlor 2.5 kg/ha	3952	78.29	51.34	43.67	18.47
Shoot cutting	5044	27.82	32.85	50.79	76.28
Check	4372	108.00	115.92	118.31	129.72

*Dalapon at 5.0 kg/ha.

ground level reduced the volume to 67.41 per cent while the untreated check had increased its volume to 122.0 per cent.

Peng (1979) reported application of paraquat 6.01 + dalapon 4.0 kg/ha and paraquat 6.01 + diuron 4.0 kg/ha as directed spray in sugarcane, were effective in controlling *ginger grass* but the later mixture was toxic to cane in Taiwan.

Manipura and Samaraine (1974) reported biweekly application of paraquat at doses of 0.14 to 0.56 kg/ha for a period of three months did greatly reduce the menace of this grass by way of exhausting its food reserves.

Paraquat causes immediate shoot injury because it is a control herbicide and hence it causes rapid desication of the foliage and loss of integrity of the cell membrane. Paraquat application as a sequential spray after the application of other herbicides was more effective than spraying it alone.

The mechanism of paraquat involves the formation of the free radical by reduction of ion and subsequent auto-oxidation to yield the original ion. OH radicle or H_2O_2 formed during auto-oxidation are the primary toxicants (Ashton and Crafts, 1973).

Bromacil with other herbicides

The results (Table 3) have indicated that use of bromacil alone reduced the original volume of the grass to 11.78 per cent as against 3.05 per cent with terbacil (4 kg/ha); 5.65 per cent with glyphosate(4 l/ha); 6.17 per cent with dalapon (5.0 kg/ha); 6.75 per cent with paraquat (2.0 l/ha as sequential spray) while, hand cutting of the shoot at ground level reduced the volume to 67.91 per cent of the original.

Phillips (1971) also reported that application of terbacil at 12 to 16 kg/ha in three application per year gave the initial control of torpedo grass in Florida, USA.

Uracils substituted areas and the triazine compounds cause mortality to the plants by way of inhibiting the photosystem II in the photosynthesis mechanism. These herbicides are often used as pre-emergence herbicides and have high residual toxicity. The effect of these herbicides though slow is sure to cause injury to the weed (Ashton and Crafts, 1973).

Dalapon with other herbicides

One may observe the effect of dalapon alone is not as effective as its combination with other herbicides (Table 4). In this set of experiment, the most effective herbicide mixtures on the control of *Panicum* grass are, in order of merit, dalapon with glyphosate (4.71%), with terbacil (6.53%) and with bromacil (6.95%). Dalapon with other herbicides had reduced the volume from 10.05 to 18.47 against 29.29 per cent of spraying dalapon alone.

Kretchman (1959) has reported that dalapon alone and its combination with 2,4-D/2,4,5-T and methoxy propazine (2-chloro-4,6-bis (isopropylamino)-1,3,5-triazine failed to control *ginger grass* in citrus grasses, whereas, fenuron at 50 kg/ha was effective in controlling this grass for six months. Kretchman (1961) also reported that application of methyl bromide at 1.5 lb or more per 100 sq ft and sealing with plastic sheet was most effective.

Orsenigo (1962) has reported that use of paraquat at 4-6 l/ha and dalapon at 20.0 kg/ha was most effective in controlling torpedo grass.

Peng (1972) found that five to six application with 2,4-D 5.0 kg + dalapon at 5.0 kg/ha at fortnightly interval during fallow was most effective.

Sze (1973) has reported that directed spray of dalapon at 6.0 kg/ha combined with 2,4-D at 4.0 kg/ha gave control of the crapping millet grass *(P. repens)* without injury to sugarcane. Treatments with triazine and uracil compounds was more effective on grasses but proved toxic to sugarcane.

Dalapon like other chlorinated aliphatic acid herbicides cause formative effects, growth inhibition, leaf chlorosis, leaf necrosis and eventually death. They interfere with meristematic activity of root tips and probably apical meristems. Reduced wax formation on leaf surfaces and alteration of all membranes, modifies protein structure, including enzymes, increases toxic levels of ammonia cause change in the membrane degradation and death of tissues.

It may be inferred from the results of these field experiments that *ginger grass* can be effectively controlled by the application of bromacil or terbacil at 4.0 kg/ha with other compatible herbicides like glyphosate at 4.0 l per ha; dalapon at 5.0 kg/ha or with sequential spray of paraquat at 1.0 l /ha. Dalapon at 5.0 kg/ha with glyphosate at 4.0 l/ha was also found to be very effective in controlling this grass. Spraying of the above compatible mixture of herbicides for two to three times at an interval of six months can successfully control *ginger grass.*

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EFFECT OF STRIGA INFESTATION ON SORGHUM

T. K. PRABHAKARA SETTY and M. M. HOSMANI
University of Agricultural Sciences Bangalore-560065, India.

ABSTRACT

The effect of Striga infestation on growth and yield of two sorghum genotypes (cv. Swarna and cv. CSH-1) was studied under potculture conditions. The effect of Striga parasitisation on growth and yield was of similar nature in both the genotypes. Relative water content, free proline and nitrate reductase activity (in both leaf and root) in sorghum were higher with Striga parasitisation, while, chlorophyll content and photosynthetic rate were decreased due to Striga infestation. There was reduction in yield and yield components of sorghum due to Striga infestation in both the genotypes of sorghum. The reduction is grain weight per ear due to Striga infestation was to an extent of 40%.

INTRODUCTION

Striga asiatica (L.) Kuntze is a noxious root parasite having a broad range of hosts including many important graminaceous crops. The crop yield losses due to the infestation of Striga are to the extent of 15 to 75 per cent depending on its severity of the infestation (Hosmani, 1978). The germination of Striga seeds is triggered by a chemical stimulant exuded from the roots of certain host and non-host plants (Parker and Reid, 1979). After germination, the radicle of Striga establishes on host xylem through haustoria and draws water, mineral nutrients and organic compounds. The seedlings will be subterranian for several weeks before it is seen on above ground portion. Infestation of Striga on sorghum has been reported to affect the growth and yield of sorghum (Williams, 1961). The effect of Striga infestation on sorghum studied in detail under potculture conditions in 1979 at Dharwad.

MATERIAL AND METHODS

Sorghum cultivars (Swarna and CSH-1) were grown in cement cisterns of 60 x 75 cm with five plants each. Red loamy soil was filled at the rate of 112 kg/cistern. Before sowing sorghum, 100 mg of *Striga asiatica* seeds were mixed in each cistern by following the procedure of Narasimhamurthy and Sivaramakrishnaiah (1962). The cisterns were brought to field capacity by adding known quantity of water once in 10 days. Emergence of Striga was noticed after 60 days of sowing. Effect of Striga infestation on growth and yield of sorghum was studied by means of several physiological parameters which were compared with sorghum grown in other cisterns free from Striga infestation.

RESULTS

The data on relative water content at 65 days after sowing revealed that infestation of Striga increased the relative water content in both the cultivars. In CSH-1, the parasitised plant recorded 63% of relative water content as against 55% with non-parasitised plant, while in Swarna the parasitised plant recorded 81% relative water content as against 77% with non-parasitised plant (Table 1).

The chlorophyll content and the photosynthetic rate recorded at 60 days after

Table 1 : Effect of Striga infestation onsorghum.

Parameter	CSH–1		Swarna	
	Non-parasitised	Parasitized	Non-parasitised	Parasitized
Relative water content (%)	54.97	63.34	76.65	81.30
Chlorophyll content (mg/g fresh weight)	2.79	2.62	2.98	2.88
Photosynthetic rate [(cpm/g dry weight/hour) in 000's]	223.20	128.80	154.80	114.40
Free proline (mg/g dry weight)	27.40	91.15	29.28	77.72
Nitrate reductase activity (μ NO_2/g fresh weight) Leaf:	169.08	205.13	115.13	215.63
Root:	179.98	255.63	223.93	239.05
Plant height (cm)	57.50	54.50	54.00	49.00
Length of ear (cm)	19.20	13.30	15.90	13.40
No. of raches per ear	33.00	22.00	32.00	23.00
Weight of the ear (g)	18.76	12.14	18.17	10.66
Grain weight (g/ear)	12.24	8.93	11.72	8.45
Grain number per ear	538.00	426.00	529.00	404.00
Thousand grain weight (g)	22.75	20.96	22.16	20.92

to synthetic rate recorded at 60 days after sowing indicated reduction with Striga infestation. The chlorophyll content was higher in non-parasitised plant in both the varieties (2.79 and 2.98 mg/g fresh weight), while with parasitisation the chlorophyll content was reduced to 2.62 and 2.88 mg/g fresh weight in CSH–1 and Swarna respectively. The photosynthetic rate of CSH–1 sorghum (cpm/g) dry weight/hr) was lower in parasitised plant (1,28,800) compared to non-parasitised plant (2,23,200). Similar trend was observed in cv. Swarna also.

Free proline content of sorghum at 60 days after sowing recorded increase with parasitisation in both the varieties. The data on nitrate reductase activity in sorghum leaf and root at 60 days after sowing recorded increase with parasitisation in both the varieties. The extent of increase in NRA was high in Swarna than CSH–1 in leaf while it was vice-versa in root.

There was reduction in plant height, length of the ear, number of bunches per ear and ear weight in both the genotypes with Striga infestation. The grain weight per ear indicated higher reduction in Swarna due to Striga infestation than in CSH-1. The grain number and thousand grain weight per year indicated reduction due to parasitisation of Striga in both the varieties and the reduction being tation was higher in Swarna than in CSH-1.

DISCUSSION

The effect of parasitisation on growth and yield was of similar nature in both the genotypes as both were susceptible for Striga. Chlorophyll content of sorghum decreased with parasitisation. The parasite depends on the host not only for mineral nutrients but also for other organic and growth substances (Yoshikawa *et al.,* 1978). Due to heavy drain on organic substances and other growth regulating substances, there might be some effect on the synthesis of chlorophyll due to parasitisation. The rate of photosynthesis was reduced to an extent of 45 per cent in cv. CSH-1 and by about 25 per cent in cv. Swarna due to Striga infestation which might again be attributed to lower chlorophyll content. Free proline content of sorghum was increased by 2 to 3 times due to Striga infestation. The work of Drennan and EL Hiweris (1979) indicates that Striga parasitisation induces similar effects to that of water stress in host plants and infestation of Striga could also be a stress on the host. The NR activity in both root and leaf of sorghum increased substantially due to parasitisation. It is possible that higher transpiration rates of sorghum and higher relative water content lead to higher uptake of nutrients under favourable moisture and nutrient status of soil (Williams, 1961). Due to higher uptake of nutrients, there might be increased nitrate reductase acivity with Striga parasitisation. There was reduction in yield and yield components of sorghum due to Striga infestation in both the genotypes. There was about 40 per cent reduction in grain weight per ear due to Striga parasitisation.

CONCLUSION

The effect of Striga parasitisation on growth and yield of two sorghum genotypes revealed that there was increase in relative water content, free proline, nitrate reductase activity, chlorophyll content and photosynthetic rate were decreased. The reduction in grain weight per ear due to Striga infestation was to an extent of 40 per cent.

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GROWTH VARIATION OF SOME INDONESIAN ALANG-ALANG CLONES

B. PAUL NAIOLA
Christian University of Satya-Wacana, Salatiga, Indonesia.
Present address: National Biological Institute, Bogor, Indonesia.

ABSTRACT

In Indonesia, alang-alang is mainly considered as one of the noxious weeds, which has received attention as a consequence of its large spreading over many areas.

This experiment was designed to compare the growth characteristics of several Indonesian alang-alang clones derived from different habitats. It was obtained through some observed biological aspects namely the height of mother plants, the amount of tillers and the growing-time of tillers.

The result of this experiment show that under the relatively similar environmental factors, there are some growth variations among clones. These given variations were expressed in certain growth aspects *viz.*, the height of mother plants, the amount of tillers and the growing-time of tillers.

Each alang-alang clone is an ecotype of its original habitat, where the plant body (phenotype) at any given stage is the resultant of the interaction between the external factors of the environment and its inherent potential (hereditary background); so that these clones have been directed to a genotypic selection and the best adaptation to these environmental conditions for a long period of time and two times vegetative propagations, before this experiment was begun. Thus, the observed variations in phenotype may be attributed to differences in hereditary background (genotypic factors).

INTRODUCTION

Imperata cylindrica (L.) Beauv. (alang-alang) is native to tropical areas. In Indonesia, *I. cylindrica* is considered as one of the five main noxious weeds, due to its widespread distribution.

At present, it is estimated that it covers approximately 16 millions ha with its rate of expansion at more or less 150 thousands ha per year (Sœrjani, 1970).

It is a particularly noxious weed due to its high reproductive rate, which allows it spread rapidly and its ability to adapt to minimal conditions. Also, it is reported that *I. cylindrica* has a physio-chemical character of producing an allelopathic substance which causes harmful effects on neighbour plants. These characters give a competitive advantage over plants for common resources like nutrition, water and light.

It is now considered as a serious weed in both traditionally and intensive agricultural systems in Indonesia.

In order to control this weed, basic research is needed. Variation aspects study by Santiago (1974) has shown many variation in morphological features and reaction on environmental changes in *I. cylindrica* var *major* and has led him to conclude gen-ecological clones exist. According to Satyadarma (1977), there is also a high degree of variability in the leaf protein bands in Indonesian *I. cylindrica*.

MATERIAL AND METHODS

This experiment was designed to compare the growth characteristics of fif-

Table 1 : Sources of clones of *I. cylindrica* for this variation study.

Collection No.	Site of source	Remarks Altitude (m)
2	Sumatera Barat	300
5	Riau	100
12	Jawa Barat, about 30 km from Bogor	330
15	Rangkasbitung	100
16	Jawa Barat, about 200 m from south coast	50
17	Pelabuhan Ratu-Lengkong	60
20	Serang	140
22	Merak	-
23	Merak (Florida beach)	10
24	Ragus	–
25	Tangerang	65
26	Parung	120
30	Sindangbarang	300
31	Cibinong	540
32	Bank of Sungai Citarum, about 7 km from coast	Brackish Water

teen Indonesian *I. cylindrica* clones derived from different habitats.

Rhizomes of fifteen *I. cylindrica* clones collected from various sites in Indonesia with different geographical background (Table 1) and planted for a long period in Bogor were used. One-node rhizome cuttings of 2-3 cm long were made. Cuttings with healthy buds were germinated in petridishes containing water (Sœrjani and Sœmarwoto, 1969). After two weeks, small plants of about 5 cm height developed from the cuttings were used for the experiment. These young plants were planted in pots containing a mixture of soil/manure in 1 : 1 ratio in the greenhouse. Experimental design was used with fifteen treatments and six replicates. Each clone was a treatment. After two weeks planting, the height of the mother plant was measured and the number of tillers counted each week until the mother plants died (10th measurement).

RESULTS AND DISCUSSION

The mean height of mother plants and number of tillers in the last measurement are seen in Table 2. Variation in plants was seen and statistically tested by a least standard deviation test. With respect to plant height, the shortest was clone number 30 (43.6 cm height) and the tallest was clone number 17 (90.8 cm). Clones number 25 and 12 were significantly taller than clone number 30. Clones number 20, 32, 26 and 15 were significantly taller than number 30 and 16. Clones number 31 and 2 were significantly taller than number 30, 16, 23 and 22. Clone number 5 was significantly taller than number 30, 16, 23, 22, 24, 25 and 12. Clone number 17 was significantly taller than clones number 30, 16, 23, 22, 24, 25, 12, 20, 32, 26 and 15.

Variation was also seen in the number of tillers produced (Table 2). The lower number of tillers was seen in clone num-

Table 2 : Mean height of mother plants and number of tillers in the first and last measurements and countings (two weeks and eleven weeks after planting).

Collection No.	Height of mother plants (cm)		Number of tillers	
	1st meas	10th meas	1st count	10th count
2	16.5	76.4	0.4	21.6
5	15.4	82.1	0.0	17.7
12	8.7	61.9	0.3	19.8
15	10.5	70.3	0.3	11.3
16	8.2	48.2	0.0	12.0
17	8.2	90.8	0.0	9.6
20	12.0	67.4	0.2	15.5
22	14.7	58.8	0.2	12.7
23	10.0	53.8	0.0	13.0
24	15.0	59.6	0.0	14.3
25	9.2	61.7	0.0	14.7
26	8.9	69.4	0.2	13.2
30	10.6	43.6	0.0	22.2
31	20.5	76.2	0.2	9.3
32	12.0	67.7	0.2	18.0

Table 3 : Ranking of plants on mother plant height and number of tillers.

	Collection number	Height of mother plants (cm)		Collection number	Number of tillers
Most vigorous	17	90.8	greatest	30	22.2
	5	82.1		2	21.6
	2	76.4		12	19.8
	31	76.2		32	18.0
	15	70.3		5	17.7
	26	69.4		20	15.5
	32	67.7		25	14.7
	20	67.4		24	14.3
	12	61.9		26	13.2
	25	61.7		23	13.0
	24	59.6		22	12.7
	22	58.8		16	12.0
	23	53.8		15	11.3
Least	16	48.2		17	9.6
vigorous	30	43.6	lowest	31	9.3

ber 31 (9 tillers) and the greatest number in clone number 30 (22 tillers). Clone number 5 was significantly greater than clones number 31 and 17. Clone number 32 was significantly greater than clones number 31, 17 and 15. Clone number 12 was significantly greater than clones number 31, 17, 15, 16, 22, 23 and 26. Clones number 2 and 30 were significantly greater than the thirteen clones.

According to Turesson (1922), the phenotypic expression of a plant is due to the genotypical response of the plant as an ecospecies in a particular habitat. Clones in this experiment could be considered as ecotypes of their original habitat. Each clone is an ecotype of its habitat, where the phenotype at any given stage is the result of the interaction between the external factors of the environment and its inherent potential (hereditary background). Thus, these clones have a phenotypic expression with the genotypic background controlled by ecological conditions over a relatively long period of time. Before the experiment was held, these clones had been planted in relatively homogenous conditions over a period of time, so that they had undergone some selection and become adapted to the new environmental conditions. Thus, under relatively similar environmental factors, variation in growth between some Indonesian *I. cylindrica* clones was seen in height of mother plants and number of tillers. This observed variation in phenotype may be attributed to interaction between differences in hereditary background (genotypic factors) and environmental factors.

As regards number of tillers, the most productive clone (number 30) was also the shortest (43.6 cm). It is possible that energy was used in tiller formation and not for increasing plant height. The tallest clone number 17 (90.8 cm) produced almost the least number of tillers and was late in tiller production, where the first tillers were produced after 4 weeks indicating that plants do not have sufficient energy for optimal growth in all aspects.

The most vigorous clone can be considered as the one which produced many tillers but was also tall. From the ranking of clones seen in Table 3, clone number 2 fulfills both conditions. *I. cylindrica* is a competitive pioneer species and the ability to produce many tillers rapidly is very important in colonization of new areas. Since it usually grows in exposed areas, plant height is possibly a less important aspect of growth rate for colonization and clone 30 would prove the most efficient as a pioneer.

CONCLUSION

In this comparative study on the growth characteristics of several Indonesian *I. cylindrica* clones, it was seen that phenotypic variation occurs in this species in the height of mother plants and tiller number. This observed variations in phenotype is probably a result of the interaction between environmental factors and genetic potential.

It was seen that no one clone was superior in both aspects tested, but that clones tended either to be prolific in tiller production or produce tall plants. It is suggested that clones with prolific tillering would be most successful in colonization of new environments. It is hoped that the results of this research will help to fill a gap in the information about this important Indonesian weed species.

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PERENNIAL WEED CONTROL IN TEA

V. S. RAO, B. KOTOKY and S. N. SARMAH
Tocklai Experimental Station, Tea Research Association
Jorhat, Assam – 785 008, India.

ABSTRACT

Field experiments were conducted to determine the effect of various herbicides and herbicide combinations on the control of several persistent perennial weeds occurring in tea. They were conducted on established pure stands of each of the weed species grown in the nurseries. Herbicides were applied at postemergence on the foliage of the actively growing weeds. In experiments with the most widely infested perennial grasses *Paspalum conjugatum* and *Axonopus compressus*, neither paraquat nor MSMA or diuron controlled them effectively when applied alone. Paraquat, through its contact action, burnt the above ground weed growth but allowed regrowth within 3 to 4 weeks after spraying. However, synergism was observed when it was applied (0.4 kg/ha) in combination with diuron (0.5 kg/ha) or MSMA (1.0 kg/ha) resulting in delayed regrowth for more than six weeks and better weed control. Glyphosate (0.8 kg/ha) was most effective of all the herbicide treatments against *Paspalum* while paraquat-diuron (0.4 + 1.0 kg/ha) and dalapon-MSMA (3.0 + 1.0 kg/ha) combination gave better control of *Axonopus* than did glyphosate.

Glyphosate (0.8 kg/ha) completely eliminated the infestation of *Cynodon dactylon* against which other herbicide treatments showed only moderate activity. In controlling ferns *Nephridium spp.* and *Pterdidium aquilinum*, glyphosate showed excellent activity (93% control) at 0.8 kg/ha. Asulam was slow in action but the final efficacy (90% control) at 2.0 kg/ha was comparable with that of glyphosate. In experiments with *Imperata cylindrica*, that most persistent rhizomatous perennial grass in young tea, glyphosate gave 97% control of the weed. Paraquat alone had very little lasting effect on this weed. Tank mixing glyphosate with dalapon, MSMA or diuron was not beneficial.

INTRODUCTION

Weed control is the second most expensive input after fertilizers in tea production. This is mostly due to the presence of persistent perennial grass weeds like *Paspalum conjugatum* L., *Axonopus compressus* (SW) Beauv., *Imperata cylindrica* (L.) Beauv., *Cynodon dactylon* (L.) Pers., etc. which occur in pure or mixed stands causing serious problems in tea production. Preemergence herbicides like simazine [2-chloro-4,6-bis (ethylamino) S-triazine] and diuron [3-(3,4-dichlorophenyl)-1, 1-dimethylurea] have very little effect in preventing the establishment of these perennial grasses. Paraquat (1,1'-dimethyl-4,4'-bipyridinium ion), a postemergence contact herbicide, is widely used against these grasses. Paraquat, through its contact action, kills the above-ground weed growth, leaving the underground propagules unaffected or less affected. These propagules can regenerate and strike new growth thus precluding the possibility of achieving complete control. This necessitates repeat applications two to four times at different intervals in a year to keep weed growth under check. Complete control of these weeds is seldom achieved. Dalapon (2,2-dichloropropionic acid) is used against *I. cylindrica* in mature tea in rotation with paraquat and this gives only partial effect. Thus, there is a need to select newer herbicides or herbicide combinations which can provide more effective control of these perennial grasses in tea.

In the recent years, infestation by ferns like *Pteridium aquilinum, Nephridium spp.* etc. is on the increase in tea and these weeds are expected to pose a serious problem in the years ahead. Thus, a search for herbicides to control these weeds is warranted.

With these objectives in view, a number of field experiments have been conducted to determine the effect of various herbicides and herbicide combinations which can effectively control these perennial weeds in tea.

MATERIAL AND METHODS

All the experiments have been conducted in the field on pure stands of individual weed species grown in weed nurseries at the Borbhetta Experimental Estate of Tocklai Experimental Station from 1978 to 1980. The infestation of each of the weed species has been very uniform. The plot size varied between 3 m^2 to 10 m^2, depending on the weed species under investigation. Each experiment has been conducted two times in a year between April and September and continued for two years.

Herbicides have been applied using the hand-operated Holder Harriden, 1.5 l capacity sprayer. The spray volume in all the experiments has been maintained at 500 l/ha.

The effect of herbicide treatments in weed species has been assessed qualitatively by scoring visually in the scale of 0 to 10 (0 for no control and 10 for complete control) and the scores have been converted to corresponding percentage figures.

RESULTS

Control of Axonopus compressus

In this trial the effect of paraquat was compared with combinations of paraquat-diuron, paraquat-MSMA, (monosodium methanearsonate), and dalapon-MSMA, as well as glyphosate [N-(phosphonomethyl) glycine] alone. The data showed that paraquat-diuron was more effective than paraquat alone (Table 1.) At 0.4 + 1.0 kg/ha paraquat+diuron combination showed greater persistence of activity. Similar results were also obtained with paraquat+MSMA combination at 0.4 + 1.0 kg/ha. But complete elimination of *A. compressus* was observed in dalapon-MSMA (3.0 + 1.0 kg/ha) combination treatment. Glyphosate alone at 0.8 kg/ha showed excellent activity by eliminating 90% of the infestation.

Table 1: Effect of paraquat-diuron, paraquat-MSMA, and dalapon-MSMA combinations and glyphosat on the control of *Axonopus* compressus.

Herbicides	Rate (kg a.i./ha)	Control of *A. compressus* (%) 1 wk	3 wk	6 wk
Paraquat	0.4	80	38	13
Diuron	0.5	5	21	8
Diuron	1.0	10	26	13
Paraquat + diuron	0.4 + 0.5	88	76	62
Paraquat + diuron	0.4 + 1.0	93	88	83
MSMA	1.0	26	51	43
Paraquat + MSMA	0.4 + 0.5	86	66	32
Paraquat + MSMA	0.4 + 1.0	96	83	80
Dalapon + MSMA	3.0 + 1.0	78	91	100
Glyphosate	0.8	11	68	80

Control of Paspalum conjugatum

As in the case of *A. compressus*, paraquat-diuron (0.4 + 0.5 or 1.0 kg/ha), paraquat-MSMA (0.4 + 1.0 kg/ha), and dalapon-MSMA (3.0 + 1.0 kg/ha) combinations showed greater activity on *P. conjugatum* than paraquat alone. At 0.8 kg/ha glyphosate, however, controlled this pe-

Table 2: Effect of paraquat-diuron, paraquat-MSMA, and dalapon-MSMA combinations and glyphosate on the control of *Paspalum conjugatum*.

Herbicides	Rate (kg a.i./ha)	Control of *P. Conjugatum* (%) 1 wk	3 wk	6 wk
Paraquat	0.4	78	33	11
Diuron	0.5	8	26	6
Diuron	1.0	21	33	21
Paraquat + diuron	0.4 + 0.5	80	60	55
Paraquat + diuron	0.4 + 1.0	83	70	68
MSMA	1.0	40	46	35
Paraquat + MSMA	0.4 + 0.5	75	45	36
Paraquat + MSMA	0.4 + 1.0	85	71	68
Dalapon + MSMA	3.0 + 1.0	60	63	62
Glyphosate	0.8	16	83	81

Table 3: Effect of paraquat, paraquat-MSMA combinations and glyphosate on the control of *Cynodon dactylon*.

Herbicides	Rate (kg a.i./ha)	Control of *C. dactylon* (%) 1 wk	3 wk	5 wk
Paraquat	0.4	70	53	28
MSMA	1.0	15	12	5
Paraquat + MSMA	0.4 + 0.5	74	59	32
Paraquat + MSMA	0.4 + 1.0	76	63	45
Glyphosate	0.4	21	40	62
Glyphosate	0.8	41	100	100

rennial grass more effectively than any of the herbicide treatments tested (Table 2).

Control of Cynodon dactylon

In another trial, the effect of paraquat on *C. dactylon* was compared with paraquat-MSMA combination and glyphosate alone. The results indicated that paraquat-MSMA (0.4 + 1.0 kg/ha) combination was slightly more effective than paraquat. However, glyphosate completely controlled this weed at 0.8 kg/ha in three weeks after application (Table 3).

Control of Imperata cylindrica

In our earlier experiments (Rao *et al* 1977; Rao and Rahman, 1978) it was found that glyphosate was extremely effective in controlling *I. cylindrica*, the most persistent of the perennial grases in tea. In the present investigation, the effect of diuron, MSMA, paraquat and dalapon on the herbicidal activity of glyphosate when applied as tank mixtures was studied. The results showed that contact herbicides, paraquat and MSMA, reduced glyphosate activity. Translocated herbicides, diuron and dalapon, caused no change on glyphosate efficacy (Table 4).

Table 4: Effect of glyphosate applied alone and in combinations with paraquat, diuron, MSMA and dalapon on the control of *Imperata cylindrica*.

Herbicides	Rate (kg a.i./ha)	Control of *I. Cylindrica* (%) 2 wk	4 wk	5 wk
Glyphosate	0.4	38	62	70
Glyphosate	0.8	68	87	97
Diuron	0.5	0	0	0
MSMA	0.5	0	0	0
Paraquat	0.5	52	10	5
Dalapon	1.5	22	18	15
Dalapon	3.0	52	40	32
Glyphosate + diuron	0.4 + 0.5	43	68	75
Glyphosate + diuron	0.8 + 0.5	68	85	89
Glyphosate + MSMA	0.4 + 0.5	32	23	28
Glyphosate + MSMA	0.8 + 0.5	43	53	52
Glyphosate + paraquat	0.4 + 0.5	55	18	10
Glyphosate + paraquat	0.8 + 0.5	56	20	15
Glyphosate + dalapon	0.4 + 1.5	78	70	73
Glyphosate + dalapon	0.8 + 1.5	80	90	90

Table 5 :Effect of glyphosate and asulam on the control of ferns (*Pteridium aquilinum* and *Nephridium spp.*)

Herbicides	Rate (kg a.i./ha)	Control of ferns (%) 2 wk	5 wk	9 wk	14 wk
Glyphosate	0.4	41	60	68	70
Glyphosate	0.8	68	83	93	93
Asulam	0.8	5	8	40	57
Asulam	1.2	5	18	50	67
Asulam	1.6	5	21	53	77
Asulam	2.0	5	20	63	90

Glyphosate-dalapon combination was found to have greater effect initially, but the final effect on *I. cylindrica* was similar to that when glyphosate was applied alone.

Control of Ferns

The ferns grown in weed nursery consisted mostly of *Pteridium aquilinum* and *Nephridium spp.* The effect of glyphosate and asulam on the control of these ferns was studied in the present investigation (Table 5).

The data show that at 0.8 kg/ha glyphosate had almost eradicated ferns. Asulam was slow in showing its effect. It required 9 weeks to show moderate activity. At 2.0 kg/ha it controlled 90% of the infestation by the 14th week after application.

DISCUSSION

For controlling perennial grasses like *Paspalum conjugatum* and *Axonopus compressus,* one application of paraquat cannot prevent regeneration of the underground plant propagules. This necessitates several repeat applications in the same year and for many years to keep them under check and to slowly exhaust food reserves of the propagules and eliminate their infestation gradually. The results presented in this paper indicate that paraquat-diuron combination is far more effective than paraquat alone. In the combination, diuron delayed the regrowth, resulting in more effective weed control than when either of them was applied alone. Similar synergistic interaction was reported by Horowitz (1971) when paraquat was combined with triazines or phenylureas in the control of *Portulaca oleracea.*

Paraquat-MSMA and dalapon-MSMA combinations showed increased activity on *A. compressus* and *P. conjugatum* than when paraquat, dalapon, or MSMA was applied alone.

In a tank mix, glyphosate activity on *Imperata cylindrica* was found to be reduced by paraquat and MSMA possibly because of the rapid destruction of the leaf tissue by these contact herbicides and consequent prevention of uptake and movement of glyphosate. Tank mixing of translocated herbicides, dalapon or diuron with glyphosate showed no benefit over glyphosate applied alone. These results indicated that glyphosate must be applied alone to control *I. cylindrica.*

The various experiments reported in this paper showed that glyphosate was very effective in controlling the perennial grasses, *A. compressus, P. Conjugatum, C. dactylon* and *I. cylindrica.* It also showed excellent activity on ferns.

Asulam showed a delayed but effective control of ferns at 2 kg/ha. Martin (1977) reported 70 to 100% reduction in frond numbers of *P. aquilinum* at 4 to 8 kg/ha. The delayed effect could be due to differences in asulam translocation as affected by frond maturity. Veerasekaran and Kirkwood (1972) found that asulam is acropetally translocated in completely unfurled fronds of *P aquilinum.* It is possible that asulam could cause immediate effect if it is applied on mature fronds, as much of the herbicide could be translocated to active frond buds and rhizome apices (Martin, 1977). Further investgations are required to study the relationship of maturity of fronds and asulam activity.

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TIME-OF-DAY EFFECTS IN HERBICIDE APPLICATION

ROBERT N. ANDERSEN and WILLARD L. KOUKKARI
Research Agronomist, U.S.D.A., Science and Education Administration
Agricultural Research, Department of Agronomy and Plant Genetics, and
Professor, Department of Botany, University of Minnesota
St. Paul, Minnesota, 55108, U.S.A.

ABSTRACT

The time of day when post-emergence herbicide treatments are applied may sometimes be important in determining the degree of weed control obtained. In this paper, research that has been done on, time-of-day effects associated with diurnal leaf movements is reviewed. It suggests that, with some herbicides and some weed species, the time of day when herbicide applications are made can be of practical importance. Weed species that exhibit large diurnal changes in leaf position are the ones most likely to show important differences in control due to time of herbicide applications. Plants with leaves in the night position have less surface area exposed to an overtop spray than do plants with leaves in the day position; hence, plants with leaves in the night position may be less readily controlled.

INTRODUCTION

Post-emergence herbicide treatments may be more effective if applied at one time of day than at another. Weaver and Nylund (1965) first pointed out the importance of investigating variation in tolerance of weeds and crop plants to herbicides applied at different times of day. Weaver and Nylund (1963) found that *Pisum sativum* L., peas, were injured more by applications of MCPA ([(4-chloro-*o*-tolyl) oxy] acetic acid) at 1200 or 1600 hr than at earlier or later times of the day. A greater carbohydrate content at the time of spraying was associated with greater susceptibility of *P. sativum*. Weaver and Nylund (1965) found only minor diurnal variation in tolerance to MCPA among the weed species they studied.

Bovey *et al.* (1972) found that late evening applications of mixtures of picloram (4-amino-3, 5, 6-trichloropicolinic acid) and 2, 4, 5-T [(2, 4, 5-trichlorophenoxy) acetic acid] sometimes were more effective in controlling *Acacia farnesiana* (L.) Willd., huisache, and *Rosa bracteata* Wendl., Macartney rose, than were applications made earlier in the day. Putnam and Ries (1968) found that evening applications of paraquat (1, 1'-dimethyl-4, 4'-bipyridinium ion) were slightly more effective in controlling *Agropyron repens* (L.) Beauv., quackgrass, than were mid-day applications.

Schuster (1970) hypothesized that *Opuntia polyacantha* Haw., plains prickly pear, should be better controlled by night application of herbicide because of more herbicide entry through stomata, which are open at night in this species. In field tests, 2, 4, 5-T in diesel oil applied at night was considerably more effective than when applied during the day. Hence, the results fit the hypothesis, but stomatal opening may or may not have been involved. Bukovac (1976) states that herbicides applied in organic solvents or in oils may penetrate via stomatal pores, sprays with commonly used surfactants appears minimal.

Norris and Lardelli (1976) reported that injury to *Beta vulgaris* L., sugarbeets, treated with phenmedipham (methyl *m*-hydroxycarbanilate *m*-methylcarbanilate) and desmedipham [ethyl *m*-hydroxycarbanilate carbanilate (ester)] was greater when treatments were made in the early morning than when made in the late afternoon. Bethlenfalvay and Norris (1977) were able to reproduce this phenomenon in growth chambers, using desmedipham, if light and temperature conditions were programmed to approximate out-of-doors daily cyclic conditions. They state that the time-of-day effect with desmedipham "can be explained in relation to the rapid inhibition of photosynthesis, and associated effects, in high light intensity, followed by detoxification in the dark". Some growers of *B. vulgaris* are now using this time-of-day effect by spraying desmedipham in the late afternoon or evening to obtain increased crop tolerance or spraying in the early morning (but at reduced rates) to obtain more efficient weed control.

Gosselink and Standifer (1967a, 1967b) were the first to suggest a relationship between sensitivity of plants to herbicides and, so called, "sleep movements" of leaves. They found that seedlings of *Gossypium hirsutum* L., cotton, were more susceptible to injury by several herbicides applied when the leaves were at the high-est position in their nyctinastic rhythm (at or soon after daybreak). Least injury occurred from applications soon after dark on the descending slope of the nyctinastic leaf rhythm. Although the "sleep movements" of leaves were associated with a diurnal rhythm in herbicide sensitivity, leaf movements were not implicted as a cause of the rhythmic sensitivity. Our work, which we will review later, does in some cases implicate leaf movement as a direct cause of rhythmic sensitivity to herbicides.

Brief history of diurnal leaf movements studies:

The leaves of many plants move rhythmically back and forth between a night-time orientation and a day-time orientation. This phenomenon of "sleep" movements of leaves was recorded as early as the time of Alexander the Great (Cumming and Wagner, 1968). Linnaeus was fascinated by plant movements and published an essay entitled *Somnus Plantarum,* which described many plants that "sleep" (Darwin and Darwin, 1897). Pfeffer made extensive studies on the rhythmic movement of leaves. The salient points of Pfeffer's findings, along with references to his original publications, have been summarized by Bünning and Chandrashekaran (1975).

Darwin and Darwin (1897) saw an evolutionary advantage in the sleep movement of leaves; the nocturnal position being adopted to lessen radiant heat loss-thereby reducing the chance of frost damage at night. More recently, this view has been supported by the studies of Smith (1974). There are instances, however, as in *Glycine max* (L.) Merr., soybeans, where nyctinastic movements may not reduce the frost damage (Schwintzer 1971).

Bünning (1969), when discussing the subject of leaf movements, humorously stated, "I used to believe they were only an expression of the plants' kindness toward botanists, in allowing them to discover and record circadian rhythms within the plant". On a serious note, Bünning followed this statement by presenting data to support his belief that, "Darwin was correct in his view that leaf movements have an adaptive value".

Bünning, however, saw the adaptive value differently: "The movements allow a precise perception of the photoperiodically decisive twilight intervals. They also prevent disturbing effect of moonlight. And, finally, the circadian oscillation of leaf positions apparently yields optimum gravitational conditions for flower formation".

Doran and Andersen (1976) sprayed bentazon [3-isopropyl-1*H*-2, 1, 3-benzothiadiazin-4 (3*H*)-one 2, 2-dioxide] on *Abutilon theophrasti* Medic., velvetleaf and *Xanthium pensylvanicum* Wallr., common cocklebur, at various times of day in both field and growth chamber studies. Diurnal variation in herbicide response was observed for both species in field studies, leading to the conclusion that, with *A. theophrasti* and *X. pensylvanicum*, "the time of day when bentazon is applied can be of practical importance. Poor control might occur following application in late evening, night or early morning". Doran and Andersen, (1976) found the same diurnal variation in the response of *A. theophrasti* to bentazon in growth chambers, kept at constant temperature and humidity during the light and dark cycles. With *X. pensylvanicum*, however, we found little or no diurnal variation in response to bentazon under these growth chamber conditions. We speculated that nyctitropic leaf movements (the leaves drooping at night) might explain our results with *A. theophrasti*, because drooping leaves might intercept and retain less spray than leaves in the day-time position. *X. pensylvanicum* did not show dramatic changes in leaf orientation from day to night. In the field, poor control of *X. pensylvanicum* appeared to occur when dew was present at time of treatment, and particularly when dew continued to form after treatment.

The initial findings of Doran and Andersen (1976) were generally confirmed in another field study by Andersen (1976). In this study bentazon was applied to *A. theophrasti* and *X. pensylvanicum* at 4-hr intervals throughout a 48-hr period. *A. theophrasti* showed a relatively small diurnal variation in herbicide response during the first 24-hr of the study, but a striking diurnal variation during the second 24-hr of the study. *X. pensylvanicum* showed a dramatic diurnal variation in herbicide response during both 24-hr periods of the study.

Andersen and Koukkari (1978) demonstrated the involvement of leaf movements in the diurnal variation in response of *A. theophrasti* to bentazon. In these studies, *A. theophrasti* plants were grown in growth chambers under constant temperature and humidity conditions, with a 16 hr light span and an 8 hr dark span. The pattern of leaf movement was charted by measuring the angle the leaves formed relative to the horizontal. Leaves moved rhythmically from a nearly horizontal day-position to a nearly vertical night-position with the tip of the blade pointed downward. This rhythmic pattern of movement continued even if plants were then exposed to continuous light. This indicated that the leaf movements of *A. theophrasti* were under the control of an endogenous circadian rhythm. We sprayed *A. theophrasti* plants with 1.12 kg/ha of bentazon, a rate that gave virtually complete control of plants with leaves in the near horizontal daytime position. Applications were made at 4-hr intervals throughout a 3-day span. During the first day the plants were exposed to the light and dark span, but during the last 2 days they were exposed to continuous light. The leaves of some plants in this study were supported so that they could not move downward into the night position. Bentazon gave a high degree of control of all plants with leaves thus supported, regardless of the time of spraying throughout the 3-day period. Plants in which leaves were allowed to move in the normal diurnal rhythm had a high degree of control by bentazon applied during those times when the leaves were nearly horizontal (the day-position), but control dramatically decreased when applications were made when leaves were in the night-position. These results suggested that leaf movements determined bentazon's effectiveness by changing the leaf surface area that would be exposed to an overtop spray. More spray per plant would be intercepted and retained when leaves were in day positions than when in the night position. This was confirmed by determining the amount of spray retained per unit leaf area of *A. theophrasti* from applications at different times in the light and dark span. The amount of spray retained was greatest from applications when leaves were in the day-position. The amount of spray retained was directly related to leaf angles and to the degree of control by bentazon. We concluded that "a major cause of the time-of-day effect with bentazon treatments on velvetleaf *(A. theophrasti)* is variation in the amount of spray intercepted and retained as a function of varying leaf angles". Fuhrman and Koukkari (1981) have presented both functional and anatomical evidence of the presence of a pulvinus that functions in circadian leaf movements of *A. theophrasti*. Koukkari and Johnson (1979) have demonstrated another rhythmic response in leaf injury of *A. theophrasti* by bentazon. In these studies, bentazon was applied in droplets to leaves so that the differential retention due to varying leaf angle was not a factor as it was in our previous studies. With this technique, a rhythmic pattern of leaf injury was observed in *A. theophrasti* plants. In this case, leaf injury was greatest from applications made during the dark span. This rhythmic pattern was best demonstrated with plants under stress of low soil moisture and low relative humidity.

Anderson and Koukkari (1979) have charted the rhythmic leaf movements in seedlings of some common annual weeds. No clearly defined pattern of leaf movement was found in *Brassica kaber* (DC.) L.C. Wheeler var. *pinnatifida* (Stokes) L.C. Wheeler, wild mustard. Daily rhythmic leaf movements that did not appear to be endogenously controlled were found in *Amaranthus retroflexus* L., redroot pigweed, and *Solanum nigrum* L., black nightshade. Circadian rhythmic leaf movements that appeared to be under endogenous control were found in *Datura stramonium* L., jimsonweed; *Chenopodium album* L., common lambsquarters; *X. pensylvanicum; Sida spinosa* L., prickly sida; *Cassia obtusifolia* L., sicklepod; and *Cassia occidentalis* L., coffee senna. The magnitude of leaf movements of some species, particularly *C. obtusifolia* and *C. occidentalis*, were such that they might be expected to cause time-of-day effects in response to herbicide applications. *C. obtusifolia* was selected for further studies (Kraatz and Andersen, 1980b).

The leaf movements of *C. obtusifolia* are complex (Andersen and Koukkari, 1979) and measuring leaf angles would not give an indication of the amount of leaf surface exposed to an overtop spray, as was the case with *A. theophrasti* (Andersen and Koukkari, 1978). Therefore, to quantify the diurnal changes in leaf surface area of *C. obtusifolia* that would be exposed to a herbicide spray, a photographic technique was developed (Kraatz and Andersen, 1980a). Using this technique, Kraatz and Andersen (1980b) showed dramatic diurnal changes in the leaf area that was exposed to an overtop herbicide spray. The leaf area of *C. obtusifolia* thus exposed varied more than seven-fold throughout 24-hr periods, being greatest during the day and least at night. Control of *C. obtusifolia* with linuron [3-(3, 4-dichlorophenyl)-1-methoxyl-1-methylurea] applied post-emergence at intervals throughout 24 hr periods was greater from day time applications than from late evening, night, and early morning applications. Per cent control was highly correlated with the amount of leaf surface exposed to the spray, suggesting that rhythmic leaf movements and the resulting change in exposed leaf area could be an important factor in determining the efficacy of post-emergence herbicide applications on *C. obtusifolia*.

CONCLUSION

This review suggests that the time of day when post-emergence applications of herbicides is made can be important. The reasons for these time-of-day effects can be complex and the degree of weed control or the amount of crop injury at any given time will be the result of the interaction of many factors. These factors may often be working in opposition to each other. For example, during the day the temperature may be high, perhaps increasing herbicidal activity, but the relative humidity may be low, perhaps decreasing herbicidal activity; at night, the situation may be reversed, with temperature low and relative humidity high. The presence or absence of dew is usually a function of time of day. Behrens (1977) has shown that dew can be a significant factor in determining the performance of post-emergence herbicide treatments. He found that dew may increase, decrease or have no effect on herbicidal activity, depending on the specific herbicide, herbicide formulation and plant species involved. Thus, dew may be an important factor in time-of-day effects. Light intensity and the length of the light period following application may be important in determining time-of-day effects with some herbicides as demonstrated by Bethlenfalvay and Norris (1977).

Our own work has implicated diurnal leaf movements, with resultant changes in the leaf surface area exposed to spray, as an important factor in time-of-day effects with herbicides. One would expect leaf movements to be most important for those species having dramatic diurnal changes in leaf orientation.

Whatever the cause, time-of-day effects on herbicide applications deserve continuing attention by weed scientists.

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GROWTH RESPONSE OF FIVE SPECIES OF JAPANESE ARROWHEAD WEEDS TO THE LEVELS OF LIGHT INTENSITY

K. ITOH and T. KUSANAGI
Central Agricultural Experiment Station, 1227, Konosu
Saitama, 365, Japan.

ABSTRACT

In Japan, rapid rampancy of *Sagittaria trifolia, S. pygmæa* and *Alisma canaliculatum* (Alismataceæ) occurred in the transplanting rice fields and these species are considered to be the most troublesome perennial weeds. While *S. aginashi* and *A. plantago-aquatica* var. *orientale* are not the rampant weeds among those species of perennial Alismataceæ.

The growth of five Alismataceæ species was compared under five different levels of light intensity (100%, 75%, 50%, 25%, 4%). In order to produce the next generation, each stage of the plant growth was recorded, and percentage allocation and crude reproductive efficiency were calculated. Pot trials were carried out from 1977 to 1980.

This paper describes the results of the experiment and the reproductive strategy of species. *S. trifolia* grew better and produced the tuber and seed under a lower light intensity (25%). The shoots of *S. pygmæa* developed well and the dry matter was increased under a medium level (50%). *S. aginashi* was poor in the production of maximum dry matter and flowering stem. *A. canaliculatum* showed high percentage allocation of seed and flowering stem. The number of flowering stems of *A. plantago-aquatica* gradually declined as the light intensity got lower.

From these results it was learned that above three serious weeds produced much propagules under the lower light intensity levels.

INTRODUCTION

Such perennial Alismatacæa weeds as *Sagittaria pygmeæ, S. trifolia* and *Alisma canaliculatum* are widely distributed throughout Japan and are troublesome in rice culture. Harada *et al.* (1979) reported that *S. pygmæa* plants were adaptable to diminishing light intensity, and Hiroi and Monsi, 1964) also studied shade tolerance of the plants in relation to photosynthesis, but effects of shading on the formation of propagules have not been reported so far.

In this paper, an attempt was made to compare the percentage allocation of total dry weight (Harper and Ogden, 1970), percentage allocation of propagules and crude reproductive efficiency of the plants grown under different shading conditions among five Alismataceae species.

MATERIAL AND METHODS

All species studied were collected from paddy fields in central parts of Japan. The same size of ramets were used in the case of *S. pygmæa, S. trifolia* and *S. aginashi*. Seeds were used in the case of *A. canaliculatum* and *A. plantago-aquatica* var. *orientale*.

Tubers of *S. pygmæa* were planted on May 15 and July 15, 1979. With respect to the other species, propagules were planted in plastic trays on June 3, and after establishment, the plants were then transplanted on June 21. A plant per pot was grown in paddy soil. Plants of *S. pygmæa* were multiplied in concrete pots, one sq.m and 75 cm deep, sunk in the ground. The other species of plants were grown in Wagner pots of 1/20 m^2. The pots were kept submerged at a 2-4 cm depth from June 19 to November 9.

Four levels of light intensity (25%, 50%, 75% and 96% shade), which were adjusted by using different "kuremona" salan nets, and full sunlight were imposed from June 9 to November 20. At harvest, each plant was divided into roots, leaves, scapes, tubers (corms), basal parts of leaves (stocks) and achens, and these were separately weighed after oven-drying. All vegetative propagules were collected from soil samples with a 2 mm mesh sieve under running water. Mature achenes of all species which were completely collected except those of *S. pygmæa*.

RESULTS

When shading was 96%, all the plants did not survive at 40 days after transplanting. Thus, no data were obtained for this treatment.

Total dry weight per plant

The seasonal changes of total dry weight of each individual plant was related to the shading intensity in which it was grown (Fig. 1). The most notable decrease in dry weight was obtained when

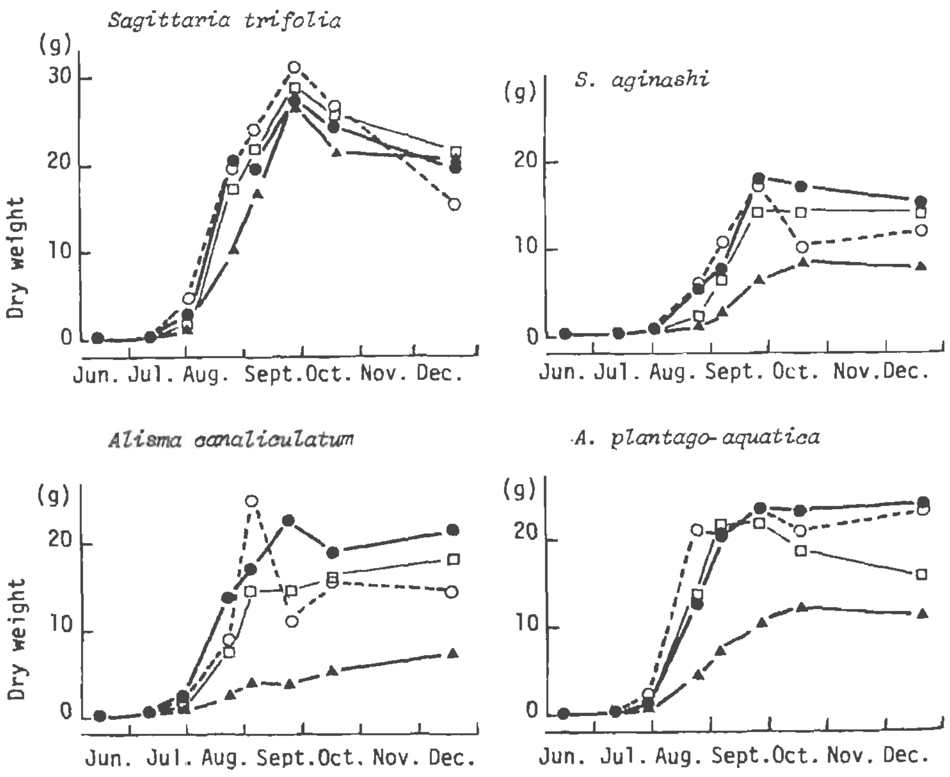

Fig. 1: Seasonal change of total dry weight per plant
O---O: 0% Shade, ●---●: 25% □_□: 50% Shade, ▲_▲: 75% Shade

Table 1: Dry weight and shoot number of *Sagittaria pygmaea* produced at 4 months after planting.

Characteristics	Planting date	Shading intensities			
		0 %	25 %	50 %	75 %
Number of shoots	May 15	1,004.0	940.0	913.0	408.0
	July 15	428.0	399.0	138.0	87.0
Dry weight* (g)	May 15	46.0	70.6	50.7	13.3
	July 15	7.0	7.2	4.3	2.7

* Dry weight of top parts except roots, tubers and stolons.

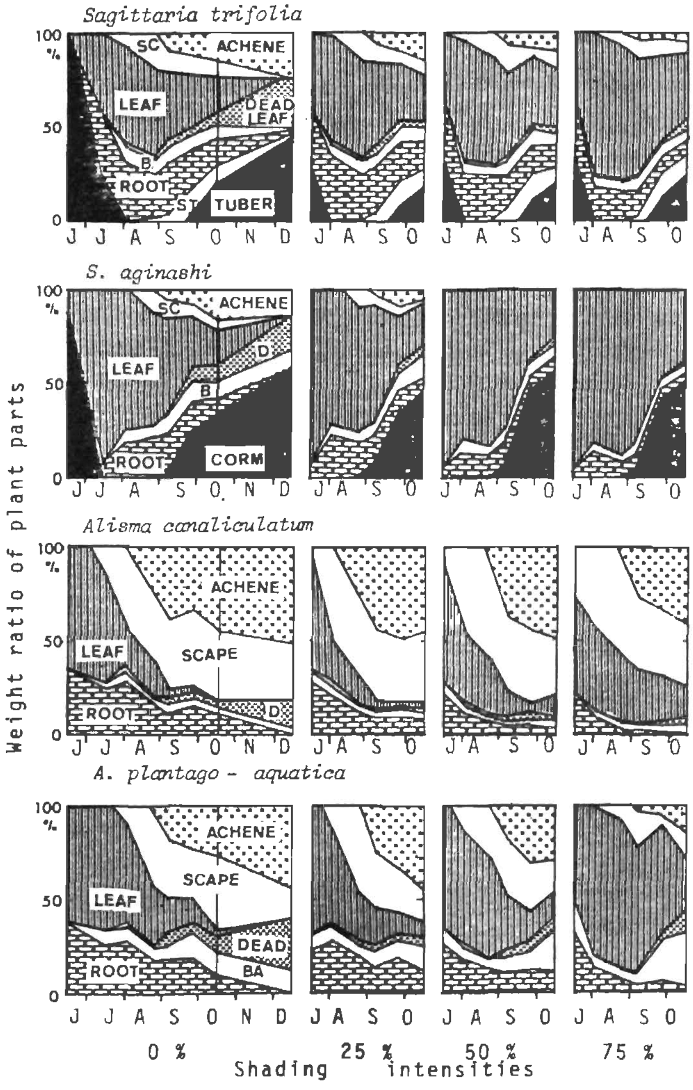

Fig. 2: Seasonal change in percentage allocation of dry matter of various plant parts under four shading intensities

BA: Basal part (s) of leaves and stock (s) in autumn.

the shading was 75% in three species, but *S. trifolia* did not follow this trend. The dry matter production of *S. aginashi* was the least of the five species.

As shown (Table 1) in the case of *S. pygmæa* 25% shading gave the highest dry matter production, followed by 50%, full sunlight and 75% in decreasing order. The maximum shoot number during the growing period decreased with increasing shading.

Percentage allocation of dry matter of various plant parts

Fig. 2 shows seasonal changes in percentage allocation of dry matter of various plant parts throughout the life phases of plants grown under the different shading conditions.

It was found in all species examined that leaf and vegetative propagule parts increased with increasing shading, and root and achene parts showed an opposite trend. Only minor differences were noted in propagule (achenes) production of *S. trifolia* and *A. canaliculatum* resulting from the various shading treatments, whereas in the case of *S. aginashi* and *A. plantago-aquatica*, propagule (scapes) production decreased markedly as the shading increased.

Percentage of reproductive organs

The percentage of weight of each propagule is shown in Fig. 3.

In the case of *S. aginashi*, production of achenes did not occur when shading was 50% and 75%, and production of the corms increased relatively with increasing shading. The percentage of stocks (vegetative reproductive organs overwintered) to total weight in plants grown under 75% shading increased by 70% in *A. canaliculatum*. Tuber formation in *S. trifolia* increased slightly, and the weight of stocks in *S. aginashi* decreased with increasing shading (Table 2). The amount of production of achenes was smaller in the case of *A. canaliculatum* than in *A. plantago-aquatica* under full sunlight, but similar amounts were produced by both under 50% shading.

DISCUSSION

The relative light intensity in rice fields changes remarkably from the top of

Table 2 : The number of propagules per plant under different shading intensities.

Weeds	Characteristics		Shading intensities			
			0%	25%	50%	75%
S. pygmæa	No. of tubers*	May 15	173.00	170.00	183.00	178.00
		July 15	103.0	111.0	83.0	41.0
S. trifolia	No. of achenes	(x 10^3)	6.12	6.92	4.72	1.91
	No. of tubers	(x 10^2)	1.81	1.66	2.10	2.31
S. aginashi	No. of achenes	(x 10^3)	2.15	–	0.00	0.00
	No. of corms	(x 10^3)	1.10	1.34	1.57	0.83
	No. of stocks		5.00	5.00	2.50	1.00
A. canaliculatum	No. of achenes	(x 10^3)	16.30	28.20	19.80	6.40
	No. of stocks		1.00	1.00	1.00	.00
A. plantago-aquatica	No. of achenes	(x 10^3)	551.40	40.00	20.90	6.30
	No. of stocks		1.00	1.00	1.00	1.00

* Sampling size of *S. pygmaea* is a soil block (25 x 25 x 15 cm) with the mother shoot at the center.

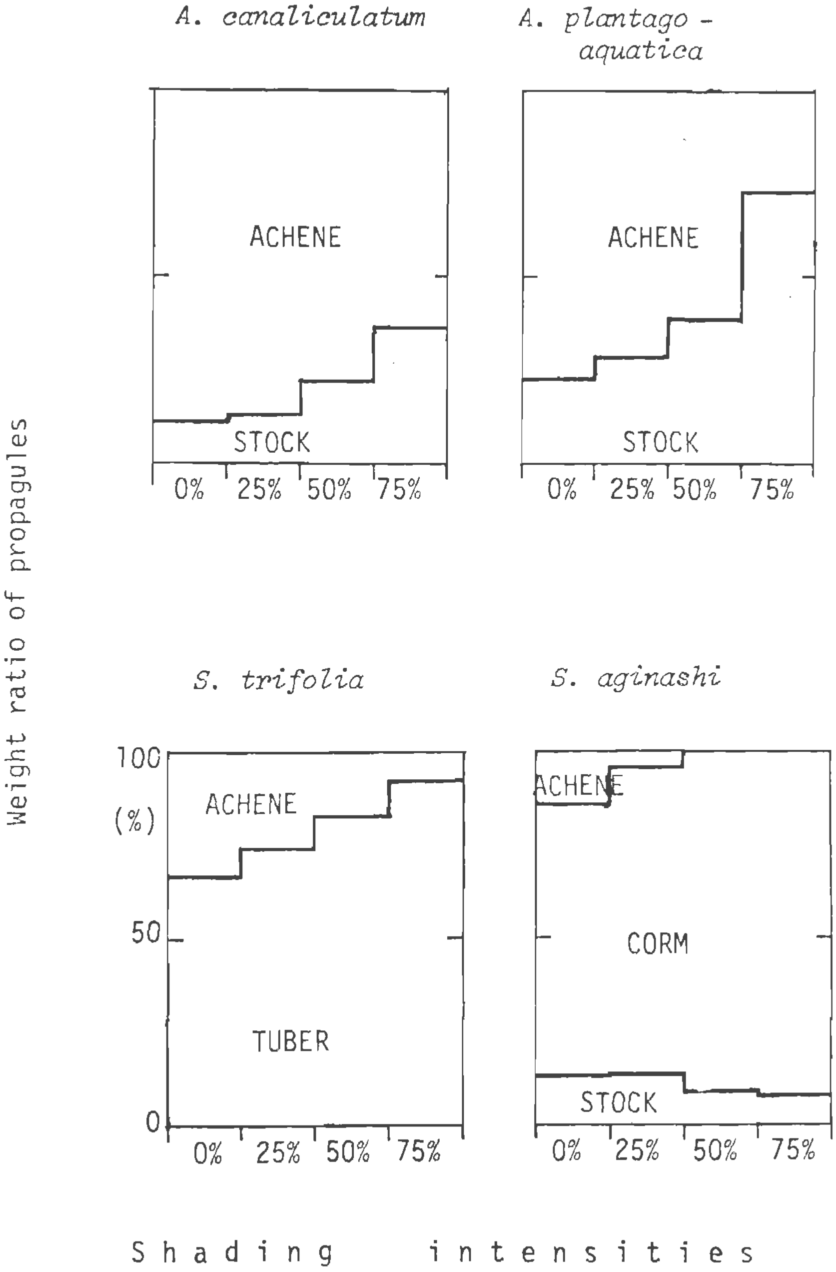

Fig. 3 : Percentage distribution of dry weight of sexual and vegetative propagules per plant under four shading intensities

Table 3 : Crude reproductive efficiency (CRE) of the four species of Alismataceae under four shading intensities.

Weeds	Shading intensities			
	0%	25 %	50 %	75 %
S. trifolia	34.6	49.6	47.9	48.3
S. aginashi	57.1	66.5	77.4	73.4
A. canaliculatum	31.0	58.7	56.5	55.5
A. plantago-aquatica	55.5	60.4	40.2	45.4

CRE is the weight ratio of achenes plus vegetative propagules to the maximum total dry matter during the growth period.

the rice plants to the ground level (Itoh *et al.,* 1979). The five species studied are shorter than rice in plant height, so that they are generally grown under the rice canopy.

In the following discussion, special attention is paid to the production of reproduction organs. Crude reproductive efficiency (CRE), which is defined by Harper and Ogden (1970) as a harvest index, is calculated for four species and shown in Table 3. The CRE values under 25% and 50% shaings were relatively high in the four species, but they decreased remarkably under full sunlight in the case of *S. trifolia* and *A. canaliculatum.* In the case of *S. aginashi,* it is noticeable that the value of CRE was relatively high in spite of poor dry matter production.

Sarukhan and Harper (1973) studied population flux and survivorship in fields and analysed factors which may cause an increase or decrease in population. It may be quite all right to judge the adaptability of weeds in paddy field conditions from the growth response of weeds under the shading experiment. As mentioned above, in the case of *S. trifolia* the total dry weight did not decrease under low light intensities. On the other hand, that of *A. canaliculatum* decreased under the same conditions. In these species, however, the percentage allocation of achenes and scapes decreased slightly, and those of tubers or stocks decreased slightly.

In paddy fields, *S. trifolia* and *A. canaliculatum* predominate as weedy species on the contrary, in spite of belonging to the same genera, *S. aginashi* and *A. plantago-aquatica* occur only in small amounts. The results would suggest that the main factor contributing to the predominance of the former species is due to the unchangeable weight ratio of their propagules to the gross production under low light conditions.

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COMPARATIVE EVALUATION OF PARTHENIN FROM *PARTHENIUM HYSTEROPHORUS* L. AS A GROWTH INHIBITOR

KULDEEP SINGH, S. N. KHOSLA and S. N. SOBTI
Regional Research Laboratory (C.S.I.R.), Canal Road, Jammu-Tawi-180 001, India.

ABSTRACT

The utilization aspect of *Parthenium hysterophorus* L. if commercially exploited is one of the ways of getting its spread checked in addition to mechanical and chemical control measures in view of its health hazards and agricultural importance. Parthenin, the principal component of this weed has been reported as a growth inhibitor. To determine its growth inhibiting potential from its utilization point of view, a comparative study of parthenin with 2, 4-D (2, 4-dichlorophenoxy acetic acid), CFL (chlorflurenol, EMD-7301 W) and MH (maleic hydrazide 30%) was conducted. Thirty seeds each of *Secale cereale* in three replicates, 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 above chemicals along with a blank-water control treatment. Thereafter, they were washed and placed on moist filter paper discs in tap water, kept in 15 cm petridishes. Observations with regard to germination were made at an interval of 24 hr and linear growth of shoot and root after 72 hr.

The germination was delayed and also decreased at higher concentrations of all treatments and occurred after 24 hr at 0.5-1.0 mg/ml of 2, 4-D followed by parthenin and CFL at 1.0-2.5 and 2.5-5.0 mg/ml respectively except MH treatment. Parthenin affected germination more than MH but at 0.5 mg/ml it was at par with CFL. At 2.5 mg/ml parthenin was stronger germination inhibitor than CFL even and at 5.0 mg/ml it became phytotoxic only next to 2, 4-D. The shoot and root growth decrease at 0.025-1.0 mg/ml of parthenin was much less but stronger at 2.5 mg/ml as compared to both MH and CFL treatments.

INTRODUCTION

Parthenin from *Parthenium hysterophorus* L. has been variously reported as a growth inhibitor (Lakshmi Rajan, 1973; Sukhada, 1975; Khosla and Sobti, 1981; Khosla *et al.*, 1980; Singh *et al.*, 1980 and Rodriguez *et al.*, 1976). To determine its growth inhibiting potential from its utilization point of view a comparative evaluation of parthenin with other growth regulators like 2,4-D(2,4-dichlorophenoxy acetic acid), CFL [Chloroflurenol (EMD 7301-A)] and MH-30 (maleic hydrazide 30%) was undertaken in the present study.

MATERIAL AND METHODS

Thirty seeds each of *Secale cereale* L. (rye) in three replicates 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 parthenin, 2, 4-D, MH and CFL along with a water treatment (control). Thereafter, they were washed and placed on moist filter paper discs in tap water in 15 cm petridishes. Observations on germination and growth were made.

RESULTS AND DISCUSSION

Germination percentage in 2, 4-D, parthenin and CFL treatments decreased progressively with increases in concentrations and time. A similar effect with MH was observed at 1.0-5.0 mg/ml concentrations but in lower concentrations MH did not exhibit any definite pattern.

Table 1 : Influence of parthenin and some growth regulators on the linear growth (mm) and germination (%) of *Secale cereale.*

Concentrations (mg/ml)	Germination				Root length				Shoot Length			
	P	2,4-D	MH	CFL	P	2,4-D	MH	CFL	P	2,4-D	MH	CFL
C		84.8				30.0				25.2		
0.025	82.2	75.6	86.6	86.8	21.6*	7.4*	17.7*	13.7	25.0	15.1	15.7*	21.2*
0.05	78.1	69.3*	80.1	84.4	21.4*	6.0*	16.0*	11.0*	25.6	16.3*	16.2*	21.6*
0.1	77.9	71.0*	77.4	75.8	18.4*	4.0*	15.8*	9.0*	22.3	15.2*	13.1*	17.6*
0.5	71.3*	69.0*	80.1	73.5*	18.0*	2.7*	6.6*	9.6*	17.5*	8.4*	11.1*	15.3*
1.0	73.3*	24.4*	75.8	66.6*	12.4*	2.7*	4.8*	7.7*	12.5*	4.2	8.2*	12.0*
2.5	39.9*	–	72.9*	53.3*	3.7*	–	4.8*	6.2*	5.0*	–	8.6*	5.5*
5.0	–	–	62.1*	46.6*	–	–	4.0*	4.6*	–	–	6.5*	4.7*

C – control, P, 2,4-D, MH and CFL denote parthenin, 2,4 dichlorophenoxy acetic acid, maleichydrazide and chlorflurenol respectively and bar (–) represents lethal concentration. Each figure is a mean value of three replications and figures marked with asterisk (*) differ significantly from control value at 5% level.

Whereas, in control most of the seeds (80.0%) germinated within one day and maximum germination (84.4%) occurred within two days.

At control and all the concentrations of MH as well as at the lower concentrations 0.025-0.1, 0.025-0.5 and 0.025-1.0 mg/ml of 2, 4-D, parthenin and CFL respectively, the germination was simultaneous. But at 0.5-1.0, 1.0-2.5 and 2.5-5.0 mg/ml of 2, 4-D, parthenin and CFL respectively germination was delayed by one day and it increased as the time lapsed. Complete cessation of germination was found only with 2, 4-D at 2.5 and parthenin at 5.0 mg/ml concentrations. Higher concentrations of 2, 4-D and parthenin gradually decreased the seed germination (Table 1). This decrease compared to control became significant at 0.05-1.0 and 0.1-2.5 mg/ml concentrations of 2, 4-D and parthenin respectively.

Partial or complete cessation of germination with 2, 4-D and parthenin has been reported by several workers. (Khosla and Sobti, 1981; Lakshmi Rajan, 1973; Khosla *et al.* 1980) and Singh *et al.* (1980) further confirmed parthenin as a germination inhibitor. They reported that inhibition of germination caused by parthenin was partly counteracted by gibberellic acid.

Chlorflurenol at 0.025 mg/ml concentration caused 2.0% increase in germination over control. At 0.05 mg/ml concentration, germination was at par with control and at higher concentrations it progressively decreased. This decrease became significant at 0.5 mg/ml, the same concentration as that of parthenin treatment. Morphactins have been reported as germination inhibitors because of their interference with various mobilizing systems. The inhibition of germination process is only the concentration dependent delay which can be overcome partly by GA_3 (Sankhla and Sankhla 1968 and Harda, 1967) and completely by cytokinin (Sankhla and Sankhla, 1968).

Like CFL, MH also caused little increase (1.8%) in germination of seeds at 0.025 mg/ml and at its higher concentrations the germination percentage decreased. At 0.05-1.0 mg/ml the germination percentage did not exhibit any definite pattern but at higher concentrations the germination decreased significantly. Dhyansagar and Khosla (1968) have found similar results and elaborated that beyond 5400 ppm MH failed to check the germination and at higher concentrations the chemical recrystallizes after 24 hr.

Germination was inhibited by 2, 4-D and MH was the least effective in this regard compared to other treatments. Although significant reduction of germination in parthenin and CFL started at the same concentration but next to 2, 4-D only parthenin could be lethal to germination.

The results reveal that parthenin is a growth inhibitor. In comparison to 2, 4-D, CFL and MH, parthenin ranks next to 2, 4-D as a growth inhibitor only at higher concentrations.

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ALLELOPATHIC EFFECT OF PURPLE NUTSEDGE ON THE GROWTH OF PEARL MILLET

M. LALL and H. O. SAVONGDY
Central Plant Protection Training Institute, Hyderabad-500 030, India.

ABSTRACT

Studies were conducted to find out the magnitude of plant growth inhibition by the leachates of purple nutsedge (*Cyperus rotundus* L.) on pearl millet (*Pennisetum typhoideum* L.). Pearl millet was grown in association with purple nutsedge and its plant residues and the effect of root exudates and plant residue leachates were studied. Observations on plant growth and dry matter production were recorded. No adverse effect of root exudates or leachates of purple nutsedge was recorded on the germination of pearl millet seeds but tillering, stem girth, plant height and dry matter production were affected. Root exudates of growing plants and leachates of plant residues of purple nutsedge caused significant reduction in plant height and dry matter production of pearl millet.

INTRODUCTION

Weeds are known to cause reduction in the growth of crop plants for they compete with these for moisture, nutrients, light etc. Besides direct competition, some of the weeds exert chemical stress on some crops by their phytotoxic root exudates and plant leachates secreted or excreted into the soil. Due to these phytotoxic substances other plants growing in proximity are adversely affected.

Presence of plant debris of *Circium arvense* L., canada thistle, in soil was found to have inhibitory effect on other plant species (Wilson and Hardlie, 1978; Stachan and Zimdahal, 1980). Toai and Linscott (1979) found that dried leaves and rhizomes of *Agropyron repens* L., quackgrass, inhibit lucerne seedling development, and Carnahan and Hull (1962) found that dried plants and plant leachates of *Madia glomerata* Hook, clusterweed, inhibit the germination of *Angropyron intermedium* (Host.) P. Beauv., intermediate wheatgrass and induced abnormal seedling development.

Aqueous extract of leaf, stem and root of *Celosia argentea* L., white cock's comb, inhibited the growth of *Pennisetum typhoideum* L., pearl millet. Total inhibition (non germination) of *Sesamum indicum* L., sesame, occured, when *C. argentea* plants were buried in the soil (Ashraf and Sen, 1978). Rao *et al.* (1977) observed the inhibitory effect of *Parthenium hysterophorus* L., on *Triticum aestivum* L., wheat, and *Cicer arietinum*, chickpea, and found that extract from leaves was more inhibitory than extract from stem and roots.

Extract of plant debris and root debris of *Cyperus esculentus* L., yellow nutsedge, has been found to reduce the growth of *Zea mays* L., corn, and *Glycine max* Meer, soybean. Foliar and tuber residues of the weed reduced the height and fresh and dry weight of the foliage and roots (Drost and Doll, 1980) whereas the extract of nuts of *Cyperus rotundus* L., purple nutsedge, was reported to have caused significant reduction in root development and dry matter production of *T. aestivum, C. arietinum* and *Vigna senensis*

Savi., cowpea (Krishnamacharyulu and Lall, 1978). Meissner *et al.* (1970) also observed appreciable reduction in root and shoot growth of barley, cucumber and tomato when grown in the soil previously grown with *C. rotundus* and attributed the reductions due to the biologically active substances contained in the underground parts of the weed.

With a view to find out the magnitude of plant growth inhibition by the root exudates and plant leachates of *Cyperus rotundus* L., the studies were conducted.

MATERIAL AND METHODS

Studies were conducted at Central Plant Protection Training Institute, Hyderabad, during the *kharif* 1979 and 1980. In these studies *Pennisetum typhoideum* L., pearl millet, was taken as test species. The plastic pots were placed on stilt, in two tiers.

Two holes were drilled in the bottom of the each pot. Polythene tubes were fitted into the holes of the pots placed on the upper tier and were connected to the pots placed on the lower tier. This was done with a view to facilitate the drainage of root exudates and plant leachates alongwith the water from the upper pots to the lower pots. The treatments included were: T_1 – Pearl millet watered through the pots grown with *C. rotundus*, T_2 – Pearl millet grown with *C. rotundus*, T_3 – Pearl millet grown with dried plants of *C. rotundus* and T_4 – Pearl millet grown alone. All the treatments were repeated five times.

First the nuts of the *C. rotundus* were planted and the dried plants were incorporated into the soil. After the sprouting of the nuts, seeds of pearl millet were sown. Each pot was sown with 50 seeds of pearl millet in 1979 and with 10 seeds in 1980. As per treatments the pots placed on the upper tier were planted with *C. rotundus*, *C. rotundus* plus *P. typhoideum*, dried plants of *C. rotundus* plus *P. typhoideum* and *P. typhoideum* alone, respectively. The corresponding pots on the lower tier were planted with *P. typhoideum*, *P. typhoideum* plus *C. rotundus*, *P. typhoideum* plus dried plants of *C. rotundus* and *P. typhoideum* alone. Water was given only to the upper pots which also infiltrated down to the lower pots through the connecting tubes. The infiltrate of lower pots was collected in separate containers and recirculated except in first treatment, where it was added to the lower pots. The arrangement of pots in this fashion permitted the individual treatment to get the root exudates of *C. rotundus*, root exudates of *C. rotundus* and *P. typhoideum*, plant leachates of *C. rotundus* and root exudates of *P. typhoideum*, respectively.

Observations on germination, tillering, stem thickness, plant height and dry matter accumulation of *P. typhoideum* were recorded. After germination count, only 6 plants of *P. typhoideum* were left in each pot and rest were uprooted. For taking dry matter only aerial portion was taken and the plants were dried in hot air oven. The recorded data were analysed statistically for interpreting the results.

RESULTS

There was no adverse effect of root exudates and plant leachates of *C. rotundus* on the germination of *P. typhoideum* seeds but the tillering was affected. *C. rotundus* grown in association with *P. typhoideum* root exudates and plant leachates caused significant reduction in tillering. The reduction was maximum when *P. typhoideum* and *C. rotundus* were grown together followed by root exudates and plant leachates (Table 1).

Association of *C. rotundus*, its root

Table 1 : Effect of root exudates and plant leachates of *C. rotundus* on the growth of *P. typhoideum*.

Treatment	No. of tillers/plant		Plant height, cm		Dry matter production g/plant	
	1979	1980	1979	1980	1979	1980
T_1	1.84	1.92	47.62	51.76	27.82	31.51
T_2	1.24	1.60	44.19	43.32	16.76	18.34
T_3	1.72	1.94	48.96	51.33	31.74	34.66
T_4	2.36	2.68	52.20	61.08	35.64	47.12
Level of significance	*	***	***	***	***	***

exudates and plant leachates affected the height of *P. typhoideum* plants significantly. *C. rotundus* when grown alongwith the *P. typhoideum* caused maximum reduction in plant height followed by root exudates in first year and plant leachates in second year. However, there was no significant difference between these two treatments. The average reductions in plant height were: 22.75 per cent in association with *C. rotundus*, 12.27 per cent with root exudate and 11.47 per cent with the plant leachates of *C. rotundus*.

The adverse effect of *C. rotundus* on the dry matter production was significant. The presence of *C. rotundus* with pearl millet caused 57.59 per cent reduction in dry matter accumulation followed by 34.46 per cent with root exudates and 19.77 per cent with plant leachates.

DISCUSSION

In the studies conducted, the root exudate and plant leachates of *C. rotundus* were not found to cause any adverse effect on the germination of pearl millet seeds. Regarding this it could be said that either the root exudates and plant leachates had no adverse effect on germination or the concentration of phytotoxic substances did not reach to that critical level which causes any appreciable damage.

The association of *C. rotundus* with pearl millet caused significant reduction in tillering, plant height and dry matter production of pearl millet. The adverse effect of *C. rotundus* might have been due to the presence of one or more phytotoxic substances in its root exudates and plant leachates.

More deleterious effect on tillering, plant height and dry matter production in pearl millet in the presence of *C. rotundus* might have been due to the fact that it competed for moisture, nutrients, light etc., and also exerted chemical stress by releasing phytotoxic substance(s) into the root zone. In other treatments, comparatively less adverse effect observed, may be either due to the root exudates or plant leachates and there was no direct competition for the resources.

Results of the study indicate the possibility of severe yield reductions of pearl millet and other susceptible crops, if any, under *C. rotundus* infestation. As crops affected by the allelopathic action of *C. rotundus* has not been identified there is need to pursue the studies further.

CONCLUSION

Studies were conducted to find out the magnitude of plant growth inhibition by leachates of purple nutsedge (*Cyperus rotundus* L.) on pearl millet (*P. typihoideum* L.). Pearl millet was grown in association with purple nutsedge and its dried plants. The effect of root exudates and plant leachates were studied. Observations on plant growth and dry matter production were recorded. No adverse effect of root exudate and leachates of purple nutsedge was recorded on the germination of pearl millet seeds but tillering, plant height and dry matter production were affected. Root exudate of growing plants and leachates of dried plants of purple nutsedge caused significant reduction in plant height and dry matter production of pearl millet.

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ECOTYPIC RESPONSES IN *CYPERUS SEROTINUS* ROTTB. RELATING TO THE EFFECT OF HERBICIDE ON TUBER FORMATIONS

KYOJIRO NAKAGAWA
Division of Weed Science, Institute for Agricultural and Biological Sciences, Okayama University, Kurashiki 710, Japan.

ABSTRACT

The strains of water nutsedge (*Cyperus serotinus* Rottb.) collected from various parts of Japan were compared in respects of morphological characters and growth habits. At higher latitude habitats the tubers formation was earlier.

The five strains with different habits were offered to the test of herbicidal effect with the combined application of 2, 4-D and amitrole. The effects of herbicides were compared among the three application times.

The first application on fourteenth of September was most effective. It suppressed completely the tuber formation of strain collected from the region of low latitude. The second application on twenty-eight of September obtained very variant results among strains. The strain from the region of high latitude was not so effective, but numbers of tuber of the strains from the region of middle latitude decreased to half or so. And tubers were scarcely formed on the strain from the region of low latitude. At the time of third application on twelfth of October almost all tubers had been already formed and the control effect was little on any strain.

INTRODUCTION

Cyperus serotinus Rottb. (water nutsedge) is the very noxious perennial weed of rice fields in Japan and Korea. Its ecological characteristics and methods of ecological or chemical control were studied (Nakagawa *et al.* 1973; Nakagawa, 1977; Kim and Kang, 1977; Yamagishi, 1979). The effects of herbicide sprayed after rice harvest on water nutsedges were not necessarily the same with each experimental station. On the other hand shape and growth characters differed among strain collected from a wide range of sites (Nakagawa, 1977).

It is the purpose of this paper to point out that effects of herbicide differed with strains according to times of their tuber formation.

MATERIAL AND METHODS

Plants of 14 strains of water nutsedge were collected from a wide range of sites, the southernmost site situated in latitude 32 degrees north and the northernmost site in 39 degrees north. They were grown in growth cabinets under three lengths of daytime (13.5, 13 and 12.5 hr) and in experimental pots in the open air (natural daylength) at Kurashiki.

Five strains of them were offered for the experiment of herbicidal effect on tuber formation of water nutsedge. Three seedlings were transplanted on 10 August into a pot with 15.9 cm diameter. 2, 4-D (2, 4-dichlorophenoxy acetic acid) and amitrole (3-amino-s-triazole) were mixed-sprayed on water nutsedge with an air-compressor. 2, 4-D and amitrole were both sprayed at rate of 20 g ai/a on 14

Table 1: Differences of times of heading and tuber formation among the strains.

Code of strains	Days of delayed heading(1)	Days until heading	Index of tuber formation(2)	Latitude of sites	Mean temp. of September at sites
A	4.3	37.0	48.6	39.40	19.4
YN	7.8	38.0	45.4	38.15	19.5
NB	0.7	30.5	26.1	37.56	21.4
NC	3.2	34.8	30.6	37.56	21.4
ND	3.3	35.5	19.9	37.29	21.4
TY	8.7	38.0	25.6	36.38	21.5
SL	6.2	37.0	25.2	36.04	21.7
SS	10.2	39.0	25.0	36.04	21.7
CM	14.8	43.0	18.9	35.27	22.8
O	12.5	43.5	5.9	34.41	22.7
TK	7.7	39.5	17.4	34.07	23.5
K	19.5	43.0	6.9	33.37	23.9
I	7.5	40.5	16.1	33.45	22.7
M	24.8	46.5	3.0	32.01	24.1

(1) Days of delayed heading: number of days from heading date in 13.5 hr to heading date in 13 hr of day length
(2) Index of tuber formation: evaluated by tuber appearances.

Table 2: Correlation coefficients among factors related to the times of heading and tuber formation.

	1	2	3	4
Days of delayed heading (1)				
Days until heading (2)	0.915**			
Index of tuber formation (3)	-0.655*	-0.628*		
Latitude of site (4)	-0.770**	-0.781**	0.897**	
Mean temperature of September (5)	0.690**	0.652*	-0.938**	-0.940**

September, 28 September and 12 October with three replications.

RESULTS

1. Photoperiodic responses of heading and tuber formation

As shown in Table 1, heading times were delayed when the daily exposure to light increased more than 13.5 hr and degrees of delay differed with strains. It was recognised that strains from northern sites came early into ears and their degrees of delay between 13 hr and 13.5 hr of daylength were smaller than strains from southern sites.

Tuber formations of strains from sites at high latitude progressed early and it was clarified that the tuber formation was also regulated by daylength.

Correlation coefficients between characters related to time of heading or tuber formation and latitudes or mean air temperatures at sites of collection of each strain are shown in Table 2. Correlation coefficients between the latitudes or temperatures of sites with the index of tuber formation were higher than with the characters of heading time.

2. Effects of herbicide on tuber formation

As shown in Table 3, number of shoot

Table 3 : Differences of increasing of shoot number among strains before tuber formation or in its early stage.

Date	Strain				
	Y	N	SL	SS	M
7 September (a)	11.2	8.1	7.8	9.3	10.2
13 September (b)	22.0	16.6	17.0	18.3	17.6
27 September (c)	28.9	25.3	26.1	32.2	31.4
Increasing rate (b/a)	1.96	2.05	2.18	1.97	1.73
Increasing rate (c/b)	1.32	1.52	1.51	1.76	1.78

Table 4 : Differences of numbers of tuber formed in five strain plots among three treated times of herbicide (ratio to the non-treated plot).

Time of treatment	Strain				
	Y	N	SL	SS	M
14 September	8.9	5.6	0.1	1.2	0.0
28 September	76.5	34.3	37.5	31.4	8.5
12 October	100.7	74.7	84.8	76.4	73.4

increased rapidly in September, but increasing rates for two weeks from 13 September were inferior to rates for a week from 7th September. Especially the rate of strain Y with earliest time of tuber formation was most inferior, but the rates of strain SS and M with late times of tuber formation did not decrease.

Number of tubers are shown in Table 4 as ratios to the non-treated plots. The herbicide treated on 14 September suppressed tuber formations and almost perfectly inhibited formating tuber on strains SL, SS and M. Effects of treatments on 28 September differed with strains; it was very large on strain M and not so large on strains N, SL and SS. Numbers of tuber of them were 34, 38, 31 per cent of the untreated plot respectively. But it did not affect very much the strain Y. Treatments on 12 October were not so effective on every strains.

DISCUSSION

It was already clarified that effects of herbicide on tuber formations of water nutsedge varied with treating times. Herbicide treatments in early autumn were very effective but treatments later than times of tuber formation could not control the reproduction by tubers (Nakagawa and Miyahara, 1967). Results in this paper show that variations of herbicide effects differed with strains. Therefore an optimum time of treatment should be decided for each strain.

2, 4-D is effective to suppress the tuber formation and amitrole is very effective to supress the germination of tuber. And in this experiment we did not yet conduct the test of tuber germination. So the results reported in this paper are mainly in respect of the effect of 2, 4-D.

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ALLELOPATHIC EFFECT OF AQUEOUS EXTRACTS OF SOME WEEDS ON TWO WHEAT CULTIVARS

G. L. BANSAL, S. C. MODGAL and K. K. SINGH
Department of Agronomy and Agrometeorology, Himachal Pradesh Agricultural University, Palampur 176 062, India.

ABSTRACT

The inhibitory effect of aqueous unboiled and boiled extracts of weeds like crab grass, bill goat weed, fall panic grass, yellow nut sedge grass and dallis grass was tested on the germination of two wheat cultivars viz., VL-421 and S-308. It was found that both the varieties of wheat were affected by the weed extracts, while root tip burning from the top and lowering of the same from the base was noticed in respect of yellow nut sedge, dallis grass and panic grass respectively. The action may be attributed to some allelopathic effect. The inhibitory effect of all the weeds on root growth increased with an increase in concenstration of weed extract and remained in the order dallis grass > bill goat weed > yellow nut sedge > crab grass > panic grass.

INTRODUCTION

Thousands of weed seeds and inflorescences get shattered each season, which remain dormant in soil till the conditions become favourable or may decay within a few weeks (Harborne, 1964; Hennis *et al.* 1964; Rice, 1974; Klingman and Ashton, 1975). Under both the instances, the leachate-chemicals escaping from seeds into the soil may have an allelopathic influence on the germination and growth of a subsequent crop. Naqvi and Muller (1975) reported that leachates of Italian ryegrass in soil, and its decomposing residues were toxic to seedling growth of oats, lettuce and *Trifolium sp.* A considerable amount of literature on the allelopathic effects of weeds on crop plants has piled up in recent years (Rice, 1979). No systematic attempt has, however, been directed towards the different aspects of allelopathy. A preliminary experiment was, therefore, conducted to evaluate the effect of aqueous extracts of inflorescence and seeds of five serious weeds of *kharif* season (wet season) of Palampur on the germination and seedling growth of wheat, the most important *rabi* crop (winter season) which constitutes the subject matter of this paper.

MATERIAL AND METHODS

Twenty seeds each of the two wheat cultivars namely, VL-421 and S-308 were tested for germination on filter papers lined in petri dishes. The papers were moistened with water (control), 5.0 and 10.0 per cent (dry wt/vol.) aqueous unboiled and boiled-autoclaved extracts each of five weeds namely *Digitaris sanguinalis* Scop. (crab grass), *Ageratum conyzoides* L. (bill goat weed), *Panicum dichotomiflorum* (fall panic grass), *Cyperus esculentus* L. (yellow nut sedge) and *Paspallum dilatatum* Poir. (dallis grass). The assays were conducted in triplicate and the germination data was recorded daily while the final root and sheet length was recorded after seven days. The results were statistically analysed and the per-

Table 1: Effect of aqueous unboiled and boiled-autoclaved extracts of some weed inflorescences and seeds of *kharif* season on the germination and seedling growth of two cultivars of wheat (VL-421 and S-308). The data represents the percentage inhibition or promotion (+) in root and shoot growth.

Name of Weed	%	Root length				Shoot length			
		VL-421		S-308		VL-421		S-308	
		unboiled	boiled	unboiled	boiled	unboiled	boiled	unboiled	boiled
Digitaria	50	15.32	+14.30	46.46	5.58	+ 5.41	+13.27	22.70	19.58
sanguinalis	100	49.50	22.51	47.25	31.42	+ 2.21	+17.81	5.73	18.78
Panicum	50	0.74	2.85	25.76	21.60	+ 4.67	+16.58	6.93	2.51
dichatomiflorum	100	34.23	31.19**	45.58**	35.58**	+ 6.63	0.25	4.92	25.60
Cyperus	50	51.03*	54.34*	43.72*	28.85	8.23	2.95	26.51	23.69
esculentus	100	70.21*	66.70*	57.44*	66.20*	15.85	21.99	20.28	37.25
Ageratum	50	68.16*	54.80	23.28	17.97	29.12	17.69	7.63	12.85
conyzoides	100	81.55*	79.89*	76.20*	56.64*	68.80	63.51	61.35	34.74
Paspalum	50	29.06	56.19	58.85	51.22	+10.57	+17.57	40.86	8.03
dilatatum	100	83.12*	83.22*	83.19*	79.65*	2.21	24.69	22.19	37.15

*Root tip burning occurred in most cases **Root base burning occurred in most cases.

centage growth inhibition or promotion was calculated, which has been presented in Table 1.

RESULTS

All the weeds inhibited root growth of both the wheat cultivars with unboiled as well as boiled-autoclaved extracts (Table 1). In both the cultivars, the effect become more evident with high concentration. Amongst the weeds, the highest effect was observed with *Paspalum* followed by *Ageratum*, *Cyperus*, *Digitaria* and *Panicum* in the descending order. It was interesting to note that in *Digitaria*, the boiled extract at lower concentration had promotary effect on root growth. It may be noted that while both concentrations of *Cyperus* and higher concentrations of *Ageratum* and *Paspalum* caused root tip burning in both the cultivars of wheat, the higher concentration of *Panicum* caused the burning of roots from their bases.

While both the concentrations of boiled and unboiled extracts of *Digitaria* in case of VL-421 and lower concentrations of *Panicum* and *Paspalum* in this cultivar promoted the shoot growth, in all other cases, both the concentrations inhibited shoot growth; the effect being more pronounced with boiled than unboiled extracts. Further, shoot growth inhibition was apparently more in S-308 than in VL-421 and the highest with *Ageratum*, moderate in *Paspalum* and *Cyperus*, and least with *Panicum* and *Digitaria*. It may, however, be noted that aqueous extracts of these weeds did not affect the percentage of seed germination although it was slightly delayed in almost all cases.

DISCUSSION

Growth and yield reductions in crops by severe infestations of weeds in the same season due to allelopathic effects have been well documented (Schreiber and Williams, 1967; Rice, 1974, 79). But the reports on such effects in the following season are scanty. The results presented here, however, clearly demonstrate the inhibitory effect of aqueous extracts of inflorescences and seeds of five weeds of *kharif* season (wet season) on the germination and seedling growth of both the wheat cultivars which happens to be the major crop of the following season.

Interestingly, the inhibitory effect on root growth which did not differ significantly in case of *Cyperus, Ageratum* and *Paspalum,* was more with unboiled than boiled-autoclaved extracts in case of *Digitaria* and *Panicum.* It would appear that in the latter cases, there may be some volatile components which may either escape or there is a decomposition of the active allelopathic principal at higher temperature and pressure. This assumption is supported by the fact that there was promotion in shoot growth with boiled-autoclaved extracts in the latter case.

The most significant point that emerges from these studies is that both the concentrations of *Cyperus* and higher concentrations of *Ageratum* and *Paspallum,* caused root tip burning in both the cultivars of wheat.The higher concentration of *Panicum* caused the burning of roots from the points of their origin. This would be still more detrimental because the dead base root cells ultimately may shed off entire roots.

CONCLUSION

The aqueous extracts of all the weeds inhibited root and shoot growth and interestingly those of *Cyperus, Ageratum* and *Paspalum* caused the root tip burning while with *Panicum,* root tip burning started from their bases in both the cultivars of wheat. It appears that the harmful effect of these weeds on root and shoot growth is due to the presence of some allelopathic agent in the aqueous extracts. However, much more information is needed on the rates of production of allelopathic compounds, rates of escape into the environment, rates of decomposition and cycling of these compounds back into plants. Work on these lines under field conditions (currently in progress) may lead to a better understanding in this field of allelopathy.

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MINERAL ACCUMULATION BY TWO SUBMERGED AQUATIC WEEDS OF LAKE KONDAKARLA

V. SESHAVATHARAM and P. VENU
Department of Botany, Andhra University, Waltair-530 003, India.

ABSTRACT

Information on the absorption, accumulation and seasonal variation of nitrogen, phosphorus, calcium and magnesium by two submerged aquatic weeds, *viz.*, *Najas graminea* Del. and *Hydrilla verticillata* (L. Fil.) Royle in the lake Kondakarla has been presented. The data were based on these mineral composition and dry matter production of these aquatic weeds during the period of study. The accumulation of these nutrients was in the order of N > Ca > Mg > P with a seasonal maximum occurring during September-December. The possible role of these weeds in the control of eutrophication was suggested.

INTRODUCTION

In recent years increasing efforts have been made in the study of chemical composition of aquatic macrophytes. Investigations of Misra (1938), Allen and Pearsall (1963), Boyd (1969a, b; 1970a, b) and Howard Williams and Junk (1977) provided valuable information to our knowledge on the nutrient uptake of the various aquatic macrophytes.

MATERIAL AND METHODS

The lake Kondakarla stretches between latitudes 17° 35′ 02″ N, longitudes 82° 59′ 27″ and 83° 01′ 0″ E and is situated at about 50 km Southwest of Visakhapatnam of Andhra Pradesh. The lake receives considerable amount of nutrients in the form of agricultural run-offs. So far no information is available on the nutrient uptake by the aquatic macrophytes in this lake and hence the present study.

The macrophytes selected are *Najas graminea* and *Hydrilla verticillata*. These plants were collected during 1979 and 80 from the lake. Monthly samples of these plants were analysed for nitrogen, calcium, magnesium and phosphorus following the methods of Jackson (1967).

RESULTS AND DISCUSSION

The data revealed a wide range in the accumulation of the four elements which showed seasonal variation (*see* Fig. 1 and Table 1).

Nitrogen: The widest amplitude of fluctuations were noticed in *Najas graminea* with a range from 19.6 mg g^{-1} DM to 30.4 mg g^{-1} DM while in *Hydrilla verticillata*, it varied from 18.4 to 27.3 mg g^{-1} DM.

Phosphorus: The concentration of phosphorus was found higher in *Najas graminea* with values ranging between 5.4 and 8.8 mg g^{-1}DM, while lower values were obtained with a variation from 2.1 to 2.8 mg g^{-1}DM in *Hydrilla verticillata*.

Calcium: Higher values of calcium concentration are obtained for *Najas gra-*

Table 1 : Nutrient accumulation by the two sub-merged macrophytes *Najas graminea* and *Hydrilla verticillata* in lake Kondakarla during "1979/80" (gm^{-2}).

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Najas graminea												
Nitrogen	–	·7.18	8.10	6.55	8.61	–	12.92	16.33	21.36	–	24.89	28.32
	21.21	11.79	8.91	6.27	9.89	11.23	15.81	15.47	17.64	20.96	19.16	16.09
Phosphorus	–	2.30	2.05	2.26	2.57	–	2.86	4.30	5.73	–	6.86	8.04
	3.95	3.68	2.59	1.88	2.74	3.01	4.25	4.52	5.21	5.86	4.37	3.74
Calcium	–	5.45	5.74	7.46	8.01	–	10.52	12.69	18.11	–	22.31	23.85
	10.72	10.58	8.16	6.15	6.69	7.27	8.40	6.37	12.74	15.58	13.54	13.93
Magnesium	–	4.68	3.02	1.99	3.30	–	2.26	3.80	4.54	–	7.63	7.55
	6.44	3.58	2.78	2.06	1.27	3.14	3.21	3.66	3.20	3.72	4.03	3.45
Hydrilla verticillata												
Nitrogen	–	1.35	1.22	2.38	3.13	–	3.40	3.52	5.84	–	5.19	2.87
	1.72	0.97	0.97	1.21	1.95	2.21	4.01	5.57	5.75	5.78	5.12	3.61
Phosphorus	–	0.18	0.12	0.21	0.36	–	0.42	0.38	0.65	–	0.47	0.36
	0.18	0.13	0.12	0.13	0.22	0.16	0.45	0.46	0.68	0.78	0.62	0.49
Calcium	–	1.15	0.89	1.91	2.23	–	2.89	2.93	5.40	–	4.26	2.31
	1.44	0.83	0.85	0.95	1.48	1.69	3.04	4.06	4.57	4.26	3.39	2.58
Magnesium	–	0.46	0.41	0.59	1.13	–	0.87	0.97	1.56	–	1.11	0.83
	0.56	0.33	0.24	0.26	0.53	0.43	0.82	1.04	1.43	1.50	1.30	0.93

minea with values ranging from 15.1 to 26 mg g^{-1}DM while in case of *Hydrilla verticillata* the values varied from 14.2 to 19.9 mg g^{-1}DM.

Magnesium : Variations in the accumulation of magnesium by the two macrophytes are not much and the maximum values obtained in *Najas graminea* range between 6.1 and 13.61 mg g^{-1} DM. Lower concentrations were recorded for *Hydrilla verticillata,* varying from 4.9 to 7.1 mg g^{-1}DM.

Highest concentration of nitrogen was locked up in the month of December, the major contributor being *Najas graminea* (28.32 g m^{-2}) followed by *Hydrilla verticillata,* varying from 4.9 to 7.1 mg g^{-1}DM.

Highest concentration of nitrogen was locked up in the month of December, the major contributor being *Najas graminea* (28.32 g m^{-2}) followed by *Hydrilla verticillata* (2.87 g m^{-2}). In the year 1980, comparatively lower amounts of nitrogen was locked up per square meter by the two species.

Similarly, phosphorus was accumulated in the month of December, the major contributor being *Najas graminea* (8.04 g m^{-2}) followed by *Hydrilla verticillata* (0.36 g m^{-2}).

Calcium was locked up in maximum concentrations in the month of November by these species, the major contributor being *Najas graminea* (22.3 g m^{-2}) followed by *Hydrilla verticillata* (4.3 g m^{-2}).

The maximum accumulation of magnesium occurred in the month of November, the major contributor being *Najas graminea* (7.6 g m^{-2}) followed by

Hydrilla verticillata (1.1 g m^{-2}). In the year 1980, a maximum accumulation of 4.6 g m^{-2} was recorded by these species during the month of September.

The values for nitrogen obtained in the present investigation are much higher when compared to the values reported earlier by Misra (1938) and Gorham (1953). According to Boyd (1968), plants in general contain 3.4 per cent (34 mg g^{-1} DM) of nitrogen while emergent and marginal vegetation contain less than 2.5 per cent (25 mg g^{-1} DM). The phosphorus levels according to Boyd (1968) range from 0.1 to 0.6 (1 to 6 mg g^{-1} DM). The data obtained in the present study is in agreement with the statement of Boyd (1968). However, Kaul *et al.* (1980) reported a range of 0.95 to 3.02 per cent (9.5 to 30.2 mg g^{-1} DM) for nitrogen and 0.014 to 0.262 per cent (0.14 to 2.62 mg g^{-1} DM) for phosphorus. Though nitrogen values are in agreement with the statement of Boyd, data of Kaul *et al.* (1980) show a much lower value of phosphorus than that suggested by Boyd (1968).

The ratios between phosphorus and nitrogen observed in the present study are 1 : 4 in case of *Najas graminea* and 1 : 8 in case of *Hydrilla verticillata*. Earlier reports on the ratio between phosphorus and nitrogen reported by Kaul *et al.* (1980) ranged from 1 : 11 to 1 : 38. Regarding the accumulation of calcium by the various macrophytes, Kaul *et al.* (1980) reported a value of 19.5 to 20.3 mg g^{-1} DM for *Najas graminea* and 24.2 to 25.4 mg g^{-1} DM for *Hydrilla verticillata* while for magnesium the values are in the range of 5.5 to 5.9 mg g^{-1} DM for *Najas graminea* and 4.8 to 6.6 mg g^{-1} DM for *Hydrilla verticillata*. Kaul's observation that rooted floating types have lower concentration of calcium compared to submerged ones is in agreement with the present record. However, in lake Kondakarla, the concentration of calcium in *Najas graminea* and *Hydrilla verticillata* is approximately twice that of *Nymphaea nouchali* a rooted floating type (Venu, 1981).

In lake Kondakarla, the submerged life forms dominating the ecosystem, were recorded to have higher percentage of minerals with values of 28.32 g DM m^{-2} for nitrogen, 23.85 g Dm m^{-2} for calcium in *Nahas graminea* followed by *Hydrilla verticillata*. It should be remembered that the nutrient uptake vary with the species and its standing crop which again varies with season. One of the aims for estimating the nutrient removal capacity of the different aquatic plants has been to recognise the most efficient nutrient removing species in controlling eutrophication. Howard Williams and Junk (1977) have shown that the aquatics accumulate eight times more of potassium, four times more of phosphorus, three times more nitrogen than the same area of water. Kaul *et al.* (1980) also emphasized the importance of macrophytes in pollution abatement in aquatic ecosystem. The present study suggests that *Najas graminea* is a useful aquatic weed for controlling eutrophication in aquatic systems which are less polluted and where a luxuriant growth of the submerged weed is possible.

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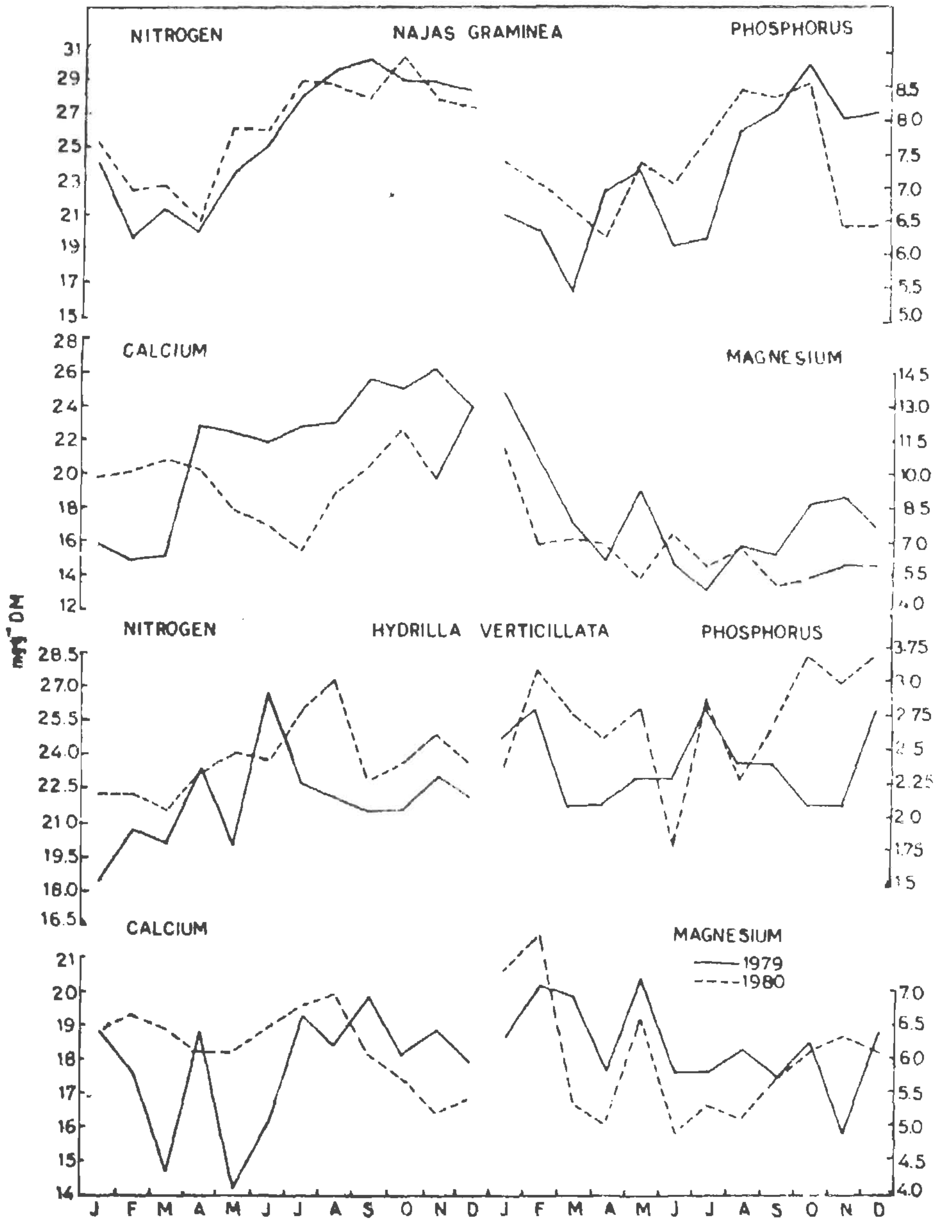

Fig. 1 : Seasonal variation in the nutrient accumulation (mg g^{-1} DM) of two submerged aquatic macrophytes of lake Kondakarla.

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KAOLIN AND AMMONIUM SULPHATE AS ADDITIVES TO INCREASE THE HERBICIDAL EFFICACY OF GLYPHOSATE

V. S. SHARMA and K. R. SUNDAR
Botany Division, UPASI Tea Research Institute, Cinchona 642 106, India.

ABSTRACT

The additive effect of medicinal grade kaolin at 1.5, 2.5 and 3.5 kg and ammonium sulphate at 1.25 kg, with the herbicide N-(phosphonomethyl) glycine (glyphosate) at 0.42, 0.84 and 1.26 kg in 450 l of water, per hectare, was investigated against *Panicum repens* L. While the addition of ammonium sulphate to glyphosate at the two lower rates, enhanced the biological efficacy, no such effect was observed at the highest rate of glyphosate. In the case of kaolin, a positive synergistic ratio evolved between the additive and the herbicide; glyphosate at 0.84 kg with kaolin at 2.5 kg proved to be significantly superior to glyphosate at the same rate without the additive and was comparable to glyphosate at the highest rate tested, with or without additive.

INTRODUCTION

Glyphosate (N-phosphonomethyl glycine) was found to be effective against a spectrum of perennial grass weeds occurring in tea fields at 1.12 and 1.68 kg (Sharma *et al.,* 1973, 78). *Panicum repens* L., one of the most troublesome weeds for which there were no satisfactory control measures, was found to be controlled effectively by glyphosate at the higher rate (Sharma *et al.,* 1978). A positive interaction between glyphosate and ammonium sulphate was established by Suwunnamek and Parker (1975) in the control of *Cyperus rotundus* L. and by Blair (1975) in the control of *Agropyron repens* (L.) Beauv. Eveling and Eisa (1976) reported an increased necrosis of leaves of certain plant species by some herbicides when kaolin was added to the latter. Sharma *et al.* (1980) reported positive activation of lower doses of glyphosate by ammonium sulphate at 1.25 kg and depression of herbicidal effect at higher rates; kaolin exhibited additive effect. The study also indicated the existence of a possible ratio between the herbicide and the additives. In the current investigation, it was hoped to find an appropriate additive and its ratio with glyphosate which would enhance the activity and thus economise on the amount of herbicide required.

This paper reports the results of the experiment which examined the effect of ammonium sulphate and kaolin on glyphosate against *P. repens.*

MATERIAL AND METHODS

Panicum repens L. was established in plots in the UPASI Tea Research Institute's Experimental Farm at Cinchona, by transplanting bits of rhizome 1 cm deep and rearing them for about 12 weeks before commencing the experiment. The experiment was of split-plot design with four replicates. The main plots, in which different levels of herbicide were sprayed, were 6 by 1 m and the sub-plots, in which additives were imposed, were 1 m^2, with 0.25 m wide paths on all sides. In the centre of each sub-plot, a quadrat of 900 cm^2 was fixed permanently to take shoot counts. At the end of 12 weeks from planting, the grass, 20-25 cm tall, was sprayed with the herbicide through a small hand-held, single nozzle sprayer specially designed for applications to small plots; all treatments were imposed in 450 l/ha water. An isopropylamine salt formulation of glyphosate was used in the experiment. Ammonium sulphate and kaolin used were of 'Analar' and medicinal grade, respectively.

Herbicidal effect was assessed by counting shoots of *P. repens* in the 900 cm^2 quadrats at the end of 4, 8, 12 and 16 weeks from imposing the treatments and expressed as percentages of number of shoots prior to imposing the treatments; the data were subjected to statistical analysis. The quantitative relationship between the rates of glyphosate application and the per cent weed control achieved was studied by plotting them in graphs and determining the regressions. From the smoothened curves and the regressions, the rates of glyphosate required for 90% kill, with and without additives, were calculated. The synergic ratio was estimated as the ratio of glyphosate required without additive to that required with additive, both to achieve 90% kill.

RESULTS

The results (Table 1) indicate a strong interaction between glyphosate at 0.84 kg/ha and ammonium sulphate; ammonium sulphate did not activate glyphosate at 0.42 and 1.26 kg/ha. Some reduction in the number of shoots was noticed in the plots treated with kaolin alone at the rates of 1.5, 2.5 and 3.5 kg/ha. The herbicidal efficacy of glyphosate at 0.42 kg/ha was significantly enhanced by the addition of kaolin at 1.5 and 2.5 kg/ha the latter being superior; the mixture of kaolin 1.5 kg/ha and glyphosate 0.42 kg/ha was comparable to glyphosate alone at 0.84 kg/ha. Addition of kaolin at 3.5 kg/ha did not activate glyphosate at 0.42 kg/ha while kaolin at 2.5 kg/ha produced the maximum effect and was superior to glyphosate alone at 0.84 kg/ha and comparable to its mixture with ammonium sulphate. A strong interaction was noticed between glyphosate at 0.84 kg/ha and the three rates of kaolin and the effect was comparable to glyphosate alone at 1.26 kg/ha; no significant differences in shoot numbers between the plots treated with kaolin at the three rates in mixture with glyphosate at 0.84 kg/ha were noticed. Kaolin, at the three rates tried, did not activate glyphosate at 1.26 kg/ha. The effect of additive was pronounced only when added to the dose of glyphosate required to give about 50% and less reduction in the numbers of shoots. A critical examination of synergism between the additives and glyphosate was possible only by working out the regressions and plotting them (Fig. 1). The efficacy of glyphosate at a particular dose was enhanced by the addition of either of the additives at the rates tried in the experiment. Kaolin at 2.5 and 3.5 kg/ha being nearly comparable, exhibited the highest synergism, followed by kaolin at 1.5 kg/ha and ammonium sulphate. The synergic effect in all the treatments declined with the increase in the dose of glyphosate.

Synergic ratios calculated at the end of 4, 8, 12 and 16 weeks are given in Table 2. It is evident from the data that in all the treatments, the synergic effect was most pronounced at the end of eight weeks and then onwards it started declining. In the case of ammonium sulphate and kaolin at 1.5 kg/ha no synergism was noticed in the first observation while it could be seen from the beginning with kaolin at 2.5 and 3.5 kg/ha; kaolin at 3.5 kg/ha produced the maximum synergism

Table 1 : Effect of glyphosate with additives on shoot numbers of *P. repens*.

Glyphosate kg/ha	No additive	Amm. sulph. kg/ha	Kaolin kg/ha		
		1.25	1.5	2.5	3.5
0	113	130	86	97	84
0.42	78	71	52	30	69
0.84	51	30	13	2	5
1.26	8	10	11	2	5
CD (P = 0.05) = 13					

Planted 1 March 1979; Sprayed 29 May; shoot numbers recorded 29 September.

Table 2 : *Synergic ratio of glyphosate with additives

Additives in kg/ha		Weeks after spraying			
		4	8	12	16
Ammonium sulphate	1.25	0.85	1.42	1.20	1.06
Kaolin	1.50	0.92	2.00	1.50	1.40
Kaolin	2.50	1.57	2.40	2.00	2.03
Kaolin	3.50	1.83	2.73	2.40	1.89

$$\text{*Synergic ratio} = \frac{\text{Glyphosate required for 90\% kill without additive}}{\text{Glyphosate required for 90\% kill with additive}}$$

Estimated dose of glyphosate required for 90% kill without additive is 1.32 kg/ha.

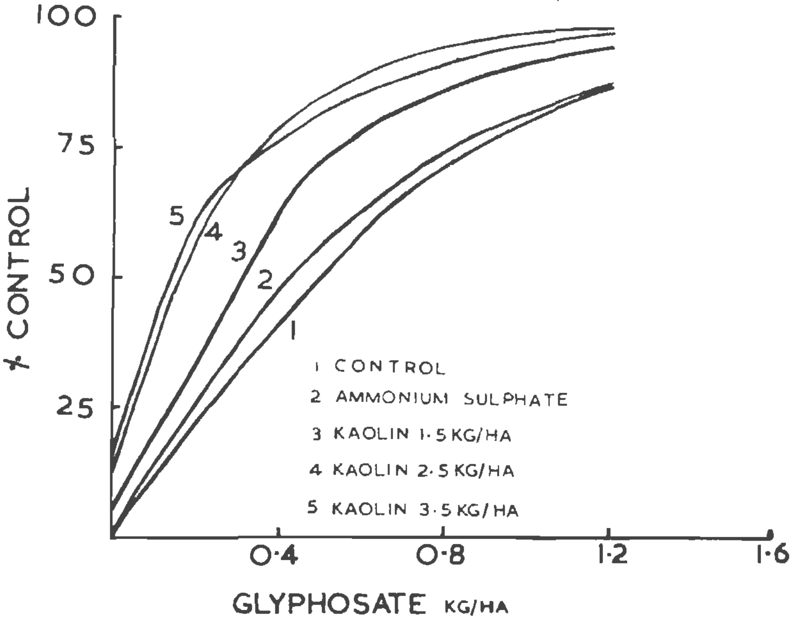

Fig. 1 : Effect of additives on the efficiency of glyphosate. Log (100-y) = m–kx where 'y' is percent control and 'x' glyphosate rate per ha; control : y = 2.09-0.79x with R^2 x 100 = 78*; AS : y = 2.02-0.75x with R^2 x 100 = 86**; Kaolin 1.5 kg : y = 1.95-1.00 x with R^2 x 100 = 90**; Kaolin 2.5 kg : y = 1.89-1.40 x with R^2 x 100 = 87**; Kaolin 3.5 kg : y = 1.82-1.09 x with R^2 x 100 = 98**. *Significant at P = 0.05; ** Significant at P = 0.01.

at the end of 8 weeks, but the effect tailed off by the end of 16 weeks and was marginally inferior to kaolin at 2.5 kg/ha. Thus it could be seen that the active effect of kaolin at 25 kg/ha had a prolonged persistence.

DISCUSSION

The statistical analysis of the data indicated a strong interaction between glyphosate and the two additives. Since quantitative expression of synergism could not be discerned from the analysis of variance, regressions were worked out between dose of glyphosate and per cent control, with and without additives. The correlations between log (100-y) and 'x', where 'y' was percent control and 'x' the dose of glyphosate, were highly significant, giving a quantitative expression of the efficacy of glyphosate with and without additives. Synergism between glyphosate and the additives at different doses was thus established. The exponential nature of the curve indicates the declining trend in synergism with increase in glyphosate levels and confirms the results of Suwunnamek and Parker (1975) and Sharma *et al.* (1980), with regard to ammonium sulphate.

Kaolin at the three doses tried in the experiment proved to be superior to ammonium sulphate as additive to glyphosate. The synergic effect of kaolin at 2.5 and 3.5 kg/ha were nearly comparable and superior to kaolin at 1.5 kg/ha. The synergism at a higher efficiency was persistent up to the end of 16 weeks in the case of kaolin, particularly at the dose of 2.5 kg/ha.

The synergic mechanism of ammonium sulphate with glyphosate is little understood. Blaïr (1975) suggested increased penetration or translocation of the herbicide by the addition of ammonium sulphate; Suwunnamek and Parker (1975) felt that there is some activation within the plant and that a greater translocation reduced the ability of regrowth. Kaolin particles were reported to damage the cuticle in certain plant species (Eveling and Eisa, 1976), which facilitates better penetration of glyphosate. However, the authors cited Eveling's (1967) observation that kaolin had no effect on cuticular permeability of some weed species tested by him. Absorption of glyphosate by soils, in the same way as that of phosphates, is already documented (Hance, 1976). The absorption, retention and slow release of glyphosate from the anionic exchange sites of kaolin may be indicative of a possible explanation to the prolonged persistence of synergism between kaolin and glyphosate. High degree of synergism observed between glyphosate and kaolin may be due to either one or both the factors discussed afore.

CONCLUSION

A high degree of synergism was established between glyphosate and the two additives tried in the experiment, which declined with increased doses of glyphosate; kaolin proved to be a superior additive to ammonium sulphate. Kaolin at 2.5 kg/ha appears to be the optimum dose to achieve the maximum economy in the dose of glyphosate.

ACKNOWLEDGEMENTS

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TRANSLOCATION OF FOLIAGE APPLIED GLYPHOSATE INTO THE RHIZOMES OF CATTAIL

R. S. BALYAN, V. M. BHAN, R. K. KAMBOJ and S. P. SINGH
Department of Agronomy, Haryana Agricultural University, Hissar, (India).

ABSTRACT

Established cattail (*Typha angustata* Bory and Chaub) in ditches was subjected to 0, 0.2, 0.4 and 0.6 per cent concentration of glyphosate [N-(phosphonomethyl) glycine] to find out the translocation of foliage applied glyphosate into the rhizomes to influence its sprouting capacity. The treated stems were cut close to the ground level after 12, 24, 48, 72 and 96 hr of glyphosate application. Regrowth of cattail was significantly reduced with the increase in concentration of glyphosate from 0.2-0.4 per cent. At 0.2 per cent concentration, regrowth of rhizomes decreased with the increase in the cutting interval indicating that translocation of glyphosate from leaves to rhizomes continued to 96 hr. The translocation was maximum within 72 hr of spray. Data recorded at 90 days after treatment application revealed that for the complete control of cattail with 0.2 0.4 and 0.6 per cent concentration the minimum period for herbicide translocation required was 96, 24 and 12 hr respectively. Reducing, non-reducing and total sugar content of rhizomes decreased with the increase in herbicides concentration and the time interval for stem cutting.

INTRODUCTION

Cattail, a perennial and emergent type of aquatic weed, usually infests low lying fields, drainage ditches and irrigation canals. It spreads and multiplies both by seeds and underground rhizomes. Due to the extensive and deep rhizome system, it is very difficult to eliminate this weed by mechanical means.

Effective control of cattail has been obtained with dalapon, amitrole and paraquat (Singh, 1979; Dutta and Prasad, 1971). Glyphosate has been shown to be more effective against many perennial weeds including cattail (Nir, 1976; Mueller and Lembi, 1975). Glyphosate is a foliar applied, translocated herbicide which accumulates in areas of high meristematic and metabolic activity (Wyrill and Burnside, 1976). Translocation of glyphosate following foliar treatment into the roots and rhizomes has been found to increase significantly with the extended period of exposure from 3-6 days in johnson grass (Kells and Rieck, 1979) and from 1-2 days in quack grass (Claus and Behrens, 1976).

Present experiment was conducted to investigate the influence of rate and time interval after treatment on the translocation of foliage applied glyphosate into the rhizomes and its effect on mortality and regrowth.

MATERIAL AND METHODS

The experiment was carried out at the Weed Control Research Area of Haryana Agricultural University, Hissar. Cattail plants were fully established from single slips in 3 m-diameter ditches before treatment application. Glyphosate at 0, 0.2, 0.4 and 0.6 per cent concentration was applied as foliar spray on cattail plants of approximately one meter height.

Following gylphosate treatment, the treated stems were cut close to the

Table 1 : Emergence of new shoots (Per cent Control) at 30, 60 and 90 days after glyphosate spray.

Glyphosate Concentration (Per cent)	Time interval for the removal of treated foliage after spray					
	12 hr	24 hr	48 hr	72 hr	96 hr	Av.
			30 Days			
0 (Untreated)	100	100	100	100	100	100
0.2	28.3	16.7	8.3	3.3	0.3	11.4
0.4	5.0	1.7	0.0	0.0	0.0	1.3
0.6	0.3	3.3	4.0	0.0	0.0	1.5
Mean	33.4	30.4	28.1	25.8	25.1	0.0
C. D. at 5%	Concentration (C) = 11.80, Time (T) = NS, CxT = NS					
			60 Days			
0 (Untreated)	100	100	100	100	100	100
0.2	21.7	18.3	5.3	0.0	0.0	9.1
0.4	2.0	0.7	0.0	0.0	0.0	0.5
0.6	0.0	0.0	0.0	0.0	0.0	0.0
Mean	30.9	29.7	26.3	25.0	25.0	0.0
C. D. at 5%	Concentration = 1.01, Time = 1.13, CxT = 2.26					
			90 Days			
0 (Untreated)	100	100	100	100	100	100
0.2	20.0	13.3	2.3	2.0	0.0	7.5
0.4	0.3	0.0	0.0	0.0	0.0	0.1
0.6	0.0	0.0	0.0	0.0	0.0	0.0
Mean	30.1	28.3	25.6	25.5	25.0	0.0
C. D. at 5%	Concentration = 0.72, Time = 0.81, CxT = 1.62					

ground level after 12, 24, 48, 72 and 96 hr of spraying. Emergence and mortality of new shoots was recorded at 30, 60 and 90 days after herbicide application to assess the extent of translocation of glyphosate in the cattail rhizomes. At the 90th day of herbicide treatment, rhizomes samples were collected and analysed for reducing, non-reducing and total sugars.

RESULTS AND DISCUSSION

Emergence of cattail shoots: Data recorded on emergence of shoots from cattain rhizomes (Table 1) revealed that glyphosate was very effective in controlling the regrowth. At 30th day of glyphosate treatment, regeneration was found to decrease progressively with the increase in the time interval for the cutting of shoots treated with 0.2 per cent concentration of glyphosate. Regrowth was drastically reduced at 0.4 and 0.6 per cent concentration and it was completely checked if the treated shoots were removed after 48 and 72 hr of treatment respectively. At 60 days after glyphosate application, control of regeneration in general was further improved. Shoot cutting after 72 hr or more of 0.2 per cent glyphosate application resulted in complete control of regrowth. At 0.6 per cent concentration, new shoots did not emerge at all even when the treated foliage was removed at the shortest interval of 12 hr while in case of 0.4 per cent concentration, only 2.0 and 0.7 per cent regrowth was observed with 12 and 24 hr interval respec-

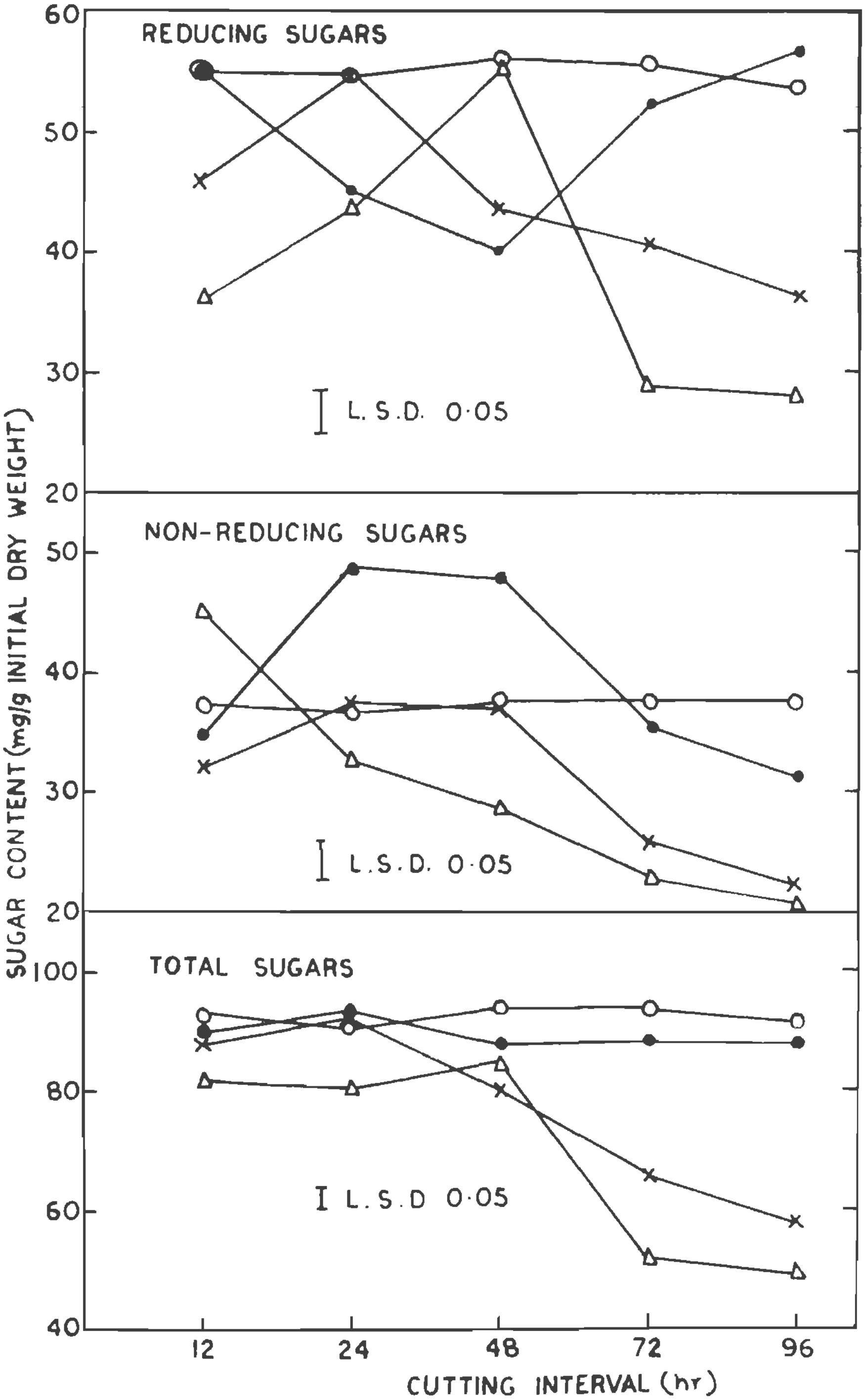

Fig. 1 : Effect of shoot cutting at different time intervals after glyphosate spray 0 (o_o) 0.2 (●_●) 0.4 (x_x) and 0.6 (Δ_Δ) per cent concentration on sugar content in cattail rhizomes.

tively. Further delay in cutting of the treated shoots resulted in no regeneration of shoots. Observation taken at 90 days after glyphosate application revealed that emergence of shoots was almost completely controlled by 0.4 and 0.6 per cent glyphosate even in case of 12 hr cutting interval. However, glyphosate at 0.2 per cent concentration depicted a similar decreasing trend in growth with the delay in shoot cutting.

It is apparent from the observation on regrowth that glyphosate translocation from treated foliage to the rhizomes continued up to 96 hr of treatment. As a consequence, there was a progressive decrease in regeneration of shoots with the increase in the period allowed for herbicide movement. At higher concentrations of glyphosate, killing of rhizomes and inhibition of regrowth was comparatively more, which shows that more herbicide was translocated and accumulated in the rhizomes at higher concentrations. Therefore, to wipe off the weed completely with low concentration of glyphosate comparatively longer period for translocation is required. The results are in agreement with the findings of Rious *et al.* (1974); Claus and Behrens (1976) and Parochetti *et al.* (1975). Similarly, cutting of shoots without any chemical or cultural treatment did not control regrowth in cattail. This has been proved earlier also (Singh and Moolani, 1973a).

Sugar content of rhizomes

Sugar analysis of cattail rhizomes revealed that reducing sugar content was reduced by glyphosate treatment (Fig. 1). The effects were more prominent in case of glyphosate application at 0.6 per cent concentration with 72 and 96 hr incubation period. Increase in the concentration of glyphosate revealed a decreasing trend in reducing sugar content of rhizomes. Non-reducing sugar content of rhizomes was significantly more than untreated control in 24 and 48 hr cutting interval with 0.2 per cent concentration and 12 hr interval in case of 0.6 per cent concentration. In rest of the treatments, the non-reducing sugar content was less than control. Decreasing trend in non-reducing sugar content was noticed with the increase in time interval for shoot cutting from 24 to 96 hr at all the concentration. Significant reduction in total sugars content was noted in rhizomes of plants treated with 0.2-0.4 per cent glyphosate and harvested after 48 hr or more. While in case of 0.6 per cent concentration significant reduction in total sugars was observed in all the cutting intervals over treated control. Depletion of sugar content of rhizomes of cattail killed as a result of chemical or cutural treatments has also been reported by Singh and Moolani (1973a, 1973b).

CONCLUSION

The data indicate that translocation of glyphosate from treated foliage continued up to 96 hr of treatment. Complete kill of rhizomes and total inhibition of regrowth requires at least 96 hr for the translocation of the chemical applied at 0.2 per cent concentration, while at 0.4 and 0.6 per cent concentration even 12 hr translocation period was sufficient to obtain similar results.

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TOXIC EFFECT OF *PARTHENIUM HYSTEROPHORUS* IN THE DIET OF RAT

T. K. DAS and K. KRISHNAMURTHY
University of Agricultural Sciences, Bangalore – 560 024, India.

ABSTRACT

Parthenium hysterophorus has been reported earlier to cause contact dermatitis mostly to male human beings. This work was conducted to observe the nutrient composition of *P. hysterophorus* and the degree of toxicity caused by its toxic principle to the general physiology of male rats after feeding at 0% (control), 10% and 30% levels and of female rats after feeding it at 10% level with their normal diet. Incorporation of 10% parthenium in the diet was lethal for male rats within four weeks, but it was not in respect of the females even after 9th week. Diet with 30% parthenium was lethal for male rats within one week. All the animals fe.'. n diet containing 10% and 30% parthenium were showing reduced growth rate compared to those fed on diet with 0% parthenium. The female rats failed to conceive indicating that their impaired fertilizing capacity which did not regenerate even after ten weeks of rehabilitation with normal diet.

INTRODUCTION

The first report was given by French (1930) in the USA that contact dermatitis was associated with *Parthenium hysterophorus*. Subsequently, many workers reported similar clinical findings which were seasonal in nature (Khan and Grothaus, 1936; Ogden, 1957; Lonker and Jog, 1972; Lonker *et al.* 1974). Krishnamurthy *et al.* (1975) suggested to control this weed by chemical spray. But none of these studies had been conducted on the laboratory animals under controlled condition. This work was therefore undertaken to observe the toxicological effect on young rats after incorporating the dried powdered plants in their normal diet.

Table 1 : Composition of concentrate mixture.

Ingredients	Parts
Groundnut cake	30
Yellow maize	30
Rice polish	25
Fish meal	5
Mineral mixture	3
Gingelly oil	2
Molasses	2
Common salt	1
Shell grit (fine)	1
Ferrous sulphate	0.50
Vitamin mixture	0.25
TM-5	0.25
Total	100.00

MATERIAL AND METHODS

Preparation of parthenium plants for dietary incorporation: Whole parthenium plants at flowering stage (without roots) were chopped, sun dried and finally powdered. This was incorporated in the ration of rats at different levels (0%, 10% and 30%) on dry matter basis of normal cooked food. No incorporation (0%) served as control.

Ration: A standard concentrate mixture was prepared and the composition of it has been given in the Table 1. This was incorporated at the rate of 100 g/group in the normal cooked human food. This was just to ensure that the rats did not suffer from any nutritional deficiencies.

Table 2: Composition of experimental ratio.

Materials	T_1 (Control)	T_2 & T_4 (g)	T_3 (g)
Cooked human food (as fed)	1000	1000	1000
Cooked human food (dry matter)	300	300	300
Sun dried parthenium powder	0	30	30
Percentage of parthenium in the feed on dry matter basis	0	10	30
Concentrate mixture incorporation	100	100	100

Feed and feeding: The feed consisting of concentrate mixture and parthenium was not palatable enough for rats to take voluntarily. It was made palatable by adding equal proportion of cooked human food consisting of rice and other ingredients obtained from the University Student's Hostels. One kg of such food (containing 300 g of dry matter) was mixed with 0 g, 30 g and 90 g of dried and finely powdered parthenium. These were finally mixed with 100 g of concentrate mixture and marked as T_1 T_2 and T_3 respectively (Table 2).

These feeds were prepared weekly thrice and stored at 18° C. Each day's feed was thawed and brought to room temperature before being fed. Feed was given twice daily *ad libitum* and unused amount was discarded. Plenty of clean fresh water was supplied.

Animals: Thirty male albine weanling littermate rats of comparable body weights (average 30 g) from five mothers were equally divided into three groups according to the litter and body weight. Each group of ten rats was kept on 0, 10 and 30% parthenium diet mixed with concentrate mixture. Four female littermate rats of same age as the males and similar body weights were kept in another cage. These animals were given the diet of T_2. For the sake of convenience, this group will be referred to as T_4.

Management: Dietary intake and physiological status of all the animals were examined everyday. Body weight of each

Table 3: Percentage composition of sun-dried powdered parthenium plant (except roots) compared to berseem (Punjab), lucerne (Bangalore) and cotton seed cake (Anand).

Nutrients	Parthenium (Present work)	Berseem (Punjab) *	Lucerne (Bangalore) *	Cotton seed cake (Anand) *
Dry matter	88.78	–	–	–
Moisture	11.22	–	–	–
		ON DRY MATTER BASIS		
Crude protein	16.00	17.35	20.24	22.32
Ether extract	2.83	1.89	2.32	6.09
Crude fibre	18.58	25.91	30.13	23.28
Total ash	16.02	14.16	10.69	4.78
Acid insoluble ash	1.66	2.16	0.62	–
Acid (HCl) soluble ash	14.36	12.00	10.07	–
Nitrogen-free extract	46.57	40.69	36.62	43.53
Calcium	1.95	1.92	1.24	–
Phosphorus	0.06	0.28	0.35	–

* After Sen and Ray, 1971.

animal was taken at weekly intervals. Mortality and psychological behaviour of the animals were noted. Postmortem examination of some of these animals were conducted. After completion of the 8th week, two female rats were kept separately and each was given one male rat from the control group. These two pairs were given control diet and kept for another ten weeks. The remaining two female rats were sacrificed on the day making pairs i.e., eighth week. At the end of sixteen weeks of experimental period i.e., after keeping the two female rats (in different cages with male rat) on rehabilitation diet for ten weeks they were sacrificed and the postmortem examination was made.

RESULTS AND DISCUSSION

Composition of parthenium: The chemical composition of parthenium is quite comparable with highly nutritious leguminous plants like berseem or lucerne and also with cotton seed cake (Table 3). As far as major nutrients were concerned there were no gross deficiencies in their contents. The analytical figures showed that leaf protein concentrates (LPC) could be extracted if technology is available to eliminate the toxic principles. Recently, Savangikar and Joshi (1978) reported that edible portion could be extracted from parthenium. This needs more detailed study. The amount of toxic principle, parthenium (sesquiterpene lactone) present in the plant was not analysed in this experiment since work has already been done in this direction (Herz, 1968; Herz *et al.* 1962).

Body weight: While the control group (T_1) gained weight from 37 g to 85 g and 109 g at the end of 8th and 9th week respectively. The T_2 group reached only up to 67 g and 87 g during the same period. The T_3 group was also gaining weight slowly but at the same time they were dying from the first week (Table 4). Prior to death, the individual animal was losing weight and at eighth week the animal which fairely survived had to be sacrificed just before death for carcass analysis, while the T_4 group (female rats on 10% parthenium) reached body weight up to 79 g and 99 g at the end of 8th and 9th week respectively starting from 35 g without any mortality. These showed that the toxic effect was highest on T_3 group and lowest on T_4 groups. Compared to T_2 group consuming the same diet, T_4 group was less affected. There are evidences that the degree of toxicity differs with sex. Lonker and Jog (1972) and Lonkar *et al.* (1974) observed that the dermatitis of the exposed skin surfaces in adult males employed in agricultural work was 10 times more than the females. The present result similarly

Table 4: Weekly body weight of rats (g) as influenced by feeding of different proportions of parthenium.

	Male			Female
	T_1	T_2	T_3	T_4
No. of animals (initial)	10	10	10	4
Week		Body weight, g		
0	37	37	37	35
1	50	44	52	45
2	54	45	41	52
3	56	48	47	54
4	60	53	50	58
5	63	61	49	60
6	70	65	51	65
7	78	66	48	70
8	85	67	45	79
No. of animals survived at 8th week	10	7	1	4
Body weight at 9th week	109	87	–	99

showed that the female rats' growth rate was less affected. This aspect of sex difference needs detailed study in future. It could be mentioned here that the voluntary feed intake by rats in T_3 group was reduced in comparison to that of T_1. It was not practicable in this experiment to take exact weight of feed intake because of the nature of materials and the contamination with urine and faeces. It was also not possible to force feed the animals. However, the T_2 group of animals were also eating slightly less and their growth rate was also less. The T_4 group appeared to consume food normally. Any way, the reduction of growth rate could not be just due to lowered feed intake alone as it was seen that the animals were dying right from the first week. However, the reduced appetite might also be due to a toxic effect although the diet was made palatable enough by adding cooked human food and concentrate mixture.

Mortality rate: Animals succumbed at the first week on 30% parthenium diet (Table 5), at the end of eighth week, only one surviving. It was so weak and emaciated that it could have died any moment. Therefore, it was sacrificed just prior to its natural death. Animals on T_2 diet started to die from fourth week onwards and seven animals survived at the end of this period. There was no mortality amongst T_1 and T_4 groups. Since the number of female rats were less (4 only) statistical analysis was not made to verify the significancy between males and females. However, it supported the observation of Lonker and Jog (1972) that the females were 10% amongst the affected population suffering from dermatitis. This aspect of hormonal interaction, detoxification and toxic threshold need to be investigated in future. The results showed that the T_3 groups consumed

Table 5: Weekly mortality rate and survival of animals as influenced by feeding of different proportions of parthenium.

		Male			Female
		T_1	T_2	T_3	T_4
Initial No of animals		10	10	10	4
	Week				
Mortality	0	0	0	0	0
	1	0	0	1	0
	2	0	0	1	0
	3	0	0	2	0
	4	0	1	2	0
	5	0	1	2	0
	6	0	1	1	0
	7	0	0	0	0
	8	0	0	0	0
Survival	8	10	7	1	4
	9	10	7	x	4

X = Sacrificed

lethal dose within the first week and this dose was consumed by T_2 animals during three weeks period and therefore the mortality started at the beginning of fourth week. It further revealed that the toxicity was cumulative and detoxification, excretion and elimination were slow or nil.

General health and behaviour: There was wide variation of general health and behaviour. The control animals were calm, normal and friendly. The male animals on T_2 were vicious looking and biting the attender all through from a few days after the start of the experiment and at the sixth week cannibolism was noticed in this group, whereas the female rats kept on the same diet did not behave badly till fifth or sixth week, after they started to show irritation. The T_3 animals were very irritated and aggressive at the second day and continued to show such behaviour till second or third week after

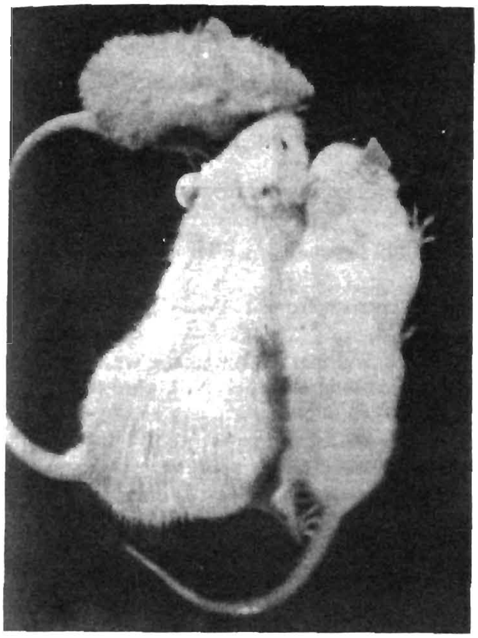

Fig. 1. Toxic effect of Parthenium on growth and appearance of male rats.

when they started to lose physical strength, looked marasmic and collapsed although they were eating food. No cannibolism was noticed in this group. No group showed clear sign of œdematus kwashiorkor. The photograph was taken during the 7th week of the experiment whereby it could be seen that the big, medium and small rough coated animals were from T_1, T_2 and T_3 groups respectively (Fig. 1). The marasmic rats looked almost similar to what Waterlow (1969) described in his review article and these male rats on both T_2 and T_3 diets really looked abnormal.

Postmortem examination: Two females from the T_4 and two males from the T_1 were chosen for making pairs. The two pairs were kept in separate cages from 9th week onwards and allowed them for mating. They were given control diet *ad libitum* and kept for another 9 weeks. At the end of this period, they were sacrificed and post-mortum examination was conducted. After post-mortum examination it was revealed that the female rats were not pregnant. All the internal organs of control animals were heavier than any other groups. Except the control group, all other animals skin and subcutaneous tissue were cyanotic. Since both the female rats were not pregnant, it was tempting to presume that probably the female rat's ability to conceive was impaired at 10% parthenium feed and the capacity of fertilization did not regenerate even after rehabilitation of feeding control diet for another 10 weeks. No earlier reports on this aspect are available. It will be interesting to pursue further work on these lines taking larger number of animals to see whether two evils can be eliminated together or parthenium contains a pharmacological principles which may be useful to antagonise female sex harmones action or secretion useful for the control of rats population.

It can be concluded that parthenium plants have all the major nutrients required for animal feed but the plants contain toxic principles which can be lethal to male rats even at 10% level in the diet. The female rats are less affected as far as general mortality is concerned, but their fertilisation capacity can be impaired at 10% incorporation of parthenium in the diet. Further study will be necessary to ascertain whether it can also be used for beneficial purposes such as application as feeding stuff or fertility control.

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DISTRIBUTION OF PROPANIL HYDROLYZING ENZYME (RICE ARYLACYLAMIDASE I) IN *ORYZA* GENUS

SHOOICHI MATSUNAKA and YOSHINORI AOYAMA
Faculty of Agriculture, Kobe University, Nada-ku, Kobe 657, Japan.

ABSTRACT

Usual rice plants *(Oryza sativa)* contain a hydrolyzing enzyme of propanil (3', 4'-dichloropropionanilide) and are very tolerant to this herbicide which are detoxified by the enzyme. However organophosphorus or carbamate insecticides inhibit the enzyme, when the herbicide may show severe damage on the rice plants. On the other hand, swep (methyl *N*-3, 4-dichlorophenylcarbamate) is also detoxified by the same enzyme. In *Oryza sativa* cv. Norin No. 8, the control of biosynthesis of the enzyme by a single gene was found by one of author.

In this report, the distribution of the enzyme in *Oryza* genus, including *Oryza graberrima* and wild rice species, was surveyed by measurement of the propanil-hydrolyzing activity of leaf homogenates from each rice plant. Following rice species can hydrolyze propanil: *Oryza sativa* (AA), *O. sativa* f. *spontanea* (AA), *O. graberrima* (A^gA^g), *O. breviligulata* (A^gA^g), *O. punctata* (BB or BBCC), *O. minuta* (BBCC), *O. eichingeri* (CC), *O. officinalis* (CC), *O. latifolia* (CCDD), *O. alta* (CCDD), *O. grandiglumis* (CCDD). Although *O. australiensis* belongs to *Oryzæ* section, it showed no activity of the enzyme. It has EE genome. *O. brachyantha* (FF) and *O. perrier* (??) also lacked the enzyme. Both species belong to *Ridleyanæ* section. *O. tesseranti* which also belongs to *Ridleyanæ* section showed very low activity of the enzyme.

As a conclusion, rice species having genomes relating to A, B, C and D have the activity of propanil-hydrolyzing enzyme and are supposed to be tolerant to the herbicide. On the other hand, those having genomes E and F lacked the activity and then may be susceptible to propanil. *Rhynchoryza subulata* which at once called *Oryza sublata* showed the enzyme activity, which fact should be studied more in future.

INTRODUCTION

As shown in the previous papers (Matsunaka, 1969, 1974 and 1979), propanil (3', 4'-dichloropropionanilide) shows a high selectivity between rice plants *(Oryza sativa)* and paddy weeds, and the tolerance of rice plants can be explained by the existence of an enzyme in the plants which can hydrolyze the herbicide to non-phytotoxic compound, 3, 4-dichloroaniline, and is called aryl acylamidase I (Yiah *et al.* 1968; Akatsuka, 1979). The distribution of the enzyme is limited to rice plants, and the selectivity is a very strict one to this crop plant. Matsunaka (1974) found that the biosynthesis of the enzyme was genetically controlled in *O. sativa* with crossing experiments of a mutant which lacked the enzyme.

On the other hand, *Oryza* genus contained a lot of species, among which only *O. sativa* is being cultivated in wide area in the world and *O. graberrima* in western Africa. Other plants which belong to *Oryza* genus are assumed to be the weeds against cultivated rice plants and showing troublesome competition with the latter (Parker and Dean, 1976). Some of them are tolerant to propanil.

In this preliminary report, the distribution of aryl acylamidase I in *Oryza* genus was surveyed to prepare a fundamental information to the genetical systematics of rice plants and the origin of cultivated ones.

Table 1 : Distribution of aryl acylamidase I (propanil hydrolyzing enzyme) in *Oryza* genus.

Genus, section and species	n	Genome	Aryl acylamidase I
Oryza genus			
Oryzae section			
Oryza sativa	12	AA	++
O. sativa f. *spontanea*	12	AA	+
O. rufipogon	12	AA	
O. barthii	12	A^bA^b	
O. graberrima	12	A^gA^g	+
O. breviligulata	12	A^gA^g	++
O. australiensis	12	EE	–
O. eichingeri	12	CC	+
O. punctata	12	BB	+
	24	BBCC	+
O. officinalis	12	CC	+
O. minuta	24	BBCC	+
O. latifolia	24	CCDD	+
O. alta	24	CCDD	+
O. grandiglumis	24	CCDD	+
Ridleyanae section			
O. ridleyi	24	????	(±)
O. longiglumis	24	????	
O. brachyantha	12	FF	–
O. angustifolia	12	??	
O. perrieri	12	??	–
O. tisseranti	12	??	(±)
Granulatae section			
O. meyeriana	12	??	
Schlechterianae section			
O. schlechteri	?	?	
Rhynchoryza genus			
Rhynchoryza subulata			
(C. subulata)	?	?	+

++ : activity as strong as *O. sativa*, + : less than *O. sativa*, (±) slight or almost no activity, and – : no activity.

RESULTS

The seeds of the wild rices were collected by Dr. Oka's group of National Institute of Genetics and kindly supplied to the authors.

The activity of the enzyme was assayed as follows: Leaf homogenates from rice plants were incubated with propanil (as substrate) at pH 7.0, 40°C for 30 min. After protein and pigments were removed by trichloroacetic acid treatment and centrifugation, 3, 4-dichloroaniline, a product of propanil hydrolysis, was assayed by a diazo-coupling colorimetric method with *p*-dimethylaminocinnamaldehyde.

Table 1 shows the distribution of aryl acylamidase I activity in *Oryza* genus which classified by a proposal by Tateoka (1964).

Following rice species can hydrolyze propanil, letters in parenthesis showing the genome of the species: *O. sativa* (AA), *O. sativa* f. *spontanea* (AA), *O. graberrima* (A^gA^g), *O. breviligulata* (A^gA^g), *O. punctata* (BB or BBCC), *O. minuta* (BBCC), *O. eichingeri* (CC), *O. officinalis* (CC), *O. latifolia* (CCDD), *O. alta* (CCDD), and *O. grandiglumis* (CCDD). Although *O. australiensis* (EE) belongs to *Oryzae* section, it showed no activity of the enzyme.

Both species belonging to *Ridleyanae* section, *O. brachyantha* (FF) and *O. perrieri*, also lacked the enzyme. And other two *Ridleyanae* species, *O. ridleyi* and *O. tisseranti*, showed a very low activity of the enzyme.

Rhynchoryza subulata once called *Oryza subulata* also showed the enzyme activity.

DISCUSSION

Because the plant types and growth stages of rice plants used in this experiment were rather different from each other, the absolute enzyme activities can not be compared quantitatively. However, it is clear that rice species having genomes A or A^g including cultivated rice have high activity of the enzyme and are supposed to be tolerant to the herbicide, propanil. Those having genomes relating to B, C and D were also found to have the enzyme. The enzyme activity among rice species having BC or CD (n = 24) and having B or C (n = 12) may be supposed to have some quantitative relationships with each other. Which genome may control these relationship should be clarified in future with some crossing experiments too. And these species are also supposed to be tolerant to propanil.

Rice species having genomes E or F, (EE) and *O. brachyantha* (FF) were found to have no such enzyme and supposed to be susceptible to propanil. These facts confirmed the research results of genome analysis.

In rice species which genomes have not been determined yet, *O. ridleyi* and *O. tesseranti* showed very low activity and *O. perrieri* lacked the enzyme activity. These three species belong to *Ridleyanæ* section with *O. brachyantha* described above, and the obtained result may contribute to the genome analysis to some extent.

Although the fact that *Rhynchoryza subulata* has the enzyme activity should be studied in detail, it is an interesting information from a standpoint of the systematics of rice plants.

The relationships between the existence or absence of aryl acylamidase I and tolerance and susceptibility to the herbicide, propanil, will be surveyed in future and reported as a full paper.

CONCLUSION

Rice species having genomes relating to A, B, C and D have the activity of aryl acylamidase I and are supposed to be tolerant to the herbicide. On the other hand, those having genomes E or F lacked the activity and then may be susceptible to propanil. Four species belonging to *Ridleyanæ* section showed very low or no activity of the enzyme. *Rhynchoryza subulata*, which at once called *Oryza subulata*, showed the enzyme activity.

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INVESTIGATION ON WEED SUPPRESSING ABILITY OF SMOTHER CROPPING SYSTEMS IN RELATION TO CANOPY DEVELOPMENT AND LIGHT INTERCEPTION

A. N. RAO* and S. V. R. SHETTY
Farming Systems Research Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru 502 324, A. P., India.
*Present Address is: Dr. A. Narayana Rao, Plant Physiologist, Oil Seeds Section Agricultural Research Institute, Rajendranagar, Hyderabad – 500 030, India.

ABSTRACT

A weed suppressing 'smother' cropping system was developed at ICRISAT which involved inclusion of quick growing, early maturing and good canopy structured crops like cowpea (*Vigna unguiculata* (L.) Walp) and mungbean (*Vigna radiata* (L.) Wilczek) in betwen the rows of main crop – sorghum 6(*Sorghum bicolor* (L.) Moench). This inclusion of an additional 'smother' crop not only resulted in better weed suppression but also resulted in additional 'smother' crop yields. In the present investigation a detailed analysis of canopy development and pattern of light interception was conducted to understand the eco-physiological mechanisms behind the observed advantage of sorghum/mungbean smother cropping systems.

The weed biomass accumulation in sorghum/cowpea and sorghum/mungbean 'smother' cropping systems with one hand weeding was observed to be less than that observed in sorghum sole situation with two hand weedings. Light interception pattern and leaf area index (LAI) observations revealed that inclusion of 'smother' crop *viz.*, cowpea and mungbean resulted in quicker and earlier attenuation of maximum LAI and maximum percentage of light interception by component crops. Significant positive correlation was observed between LAI and percentage light interception. Significant negative correlation was observed between percentage light interception by component crops and weed biomass accumulation. The growth and resource use by different cropping systems are analysed and the net productivity with different systems are computed.

INTRODUCTION

Earlier studies on weed management at ICRISAT revealed that many biological and cultural factors like crop species, varieties and row arrangements etc., influence the nature and extent of weed growth in cropping systems (Shetty and Rao, 1977; Rao, 1980). Intercropping was proved to be superior to component crops in its weed suppressing ability (Bantilan and Harwood, 1973; Shetty and Rao, 1977; Shetty and Rao, 1979) and thus it provided an opportunity to utilize crops themselves as tools of weed management. At ICRISAT a concept of Smother cropping system was developed which involves the inclusion of rapid growing early maturing and good canopy structured crops like cowpea and mungbean in between the rows of main crops (ICRISAT, 1977 and 78). The ability of 'smother' cropping system in suppressing the weed growth without reducing the total productivity was also demonstrated.

The advantage with 'smother' cropping system or with other intercrop situation referred earlier was attributed to less weed growth in such systems. The need for ecophysiological studies to better understand the resource utilization and the causes of weed suppression in intercrop and smother cropping systems was stressed earlier (Moody and Shetty, 1979, Shetty and Rao, 1979). Such ecophysiological studies also provide a basis for further yield improvement through shifting the crop weed balance more in favour of crops rather than weeds, besides indicating how weed suppressing ability of smother crop systems and the grain yield advantage are likely to be affected by different growing conditions. The present study was therefore conducted to examine the physiological mechanism of observed advantage of sorghum/cowpea and sorghum/mungbean 'smother' cropping systems through a detailed analysis of canopy development and pattern of light interception by different systems.

MATERIAL AND METHODS

The experiment was conducted on Alfisols of ICRISAT – with available water of about 100 mm in the top of 90 cm of the profile. The experiment was conducted during the monsoon season of 1979. Even though the total rainfall during the year was about normal (631 mm), there was a brief dry spell during flowering stages which necessitated two irrigations.

Sorghum both with and without the inclusion of 'smother crop' (cowpea or mungbean) was grown at 45 cm row width. The sorghum population was maintained at 180,000 plants/ha. A basal fertilizer application of 50 kg/ha of P_2O_5 was applied to all plots and soghum was top dressed at a rate of 80 kg/ha in two split doses. Cultivars grown were CSH-6 sorghum, local cowpea and H8 mungbean. The experiment was Randomised Block Design with the following treatments replicated thrice: (*a*) sorghum sole system, one hand weeding; (*b*) sorghum sole system, two hand weedings; (*c*) sorghum/cowpea 'smother' cropping system, one hand weeding; (*d*) sorghum/mungbean 'smother' cropping system, one hand weeding; (*e*) sorghum sole system – kept weed free (*f*) sorghum/cowpea system – kept weed free; (g) sorghum/mungbean system – kept weed free.

Samples areas of two 1.0 m^2, one from each end of each of the replicated plots were harvested for the estimation of dry matter and the area of green lamina at 10 day intervals starting from 15th day of planting. From the same area the weed biomass was recorded at the time of first hand weeding, second hand weeding, 'smother' crop harvest and at sorghum harvest.

For final estimation of total dry matter and grain yield, harvest area of approximately 40 m^2 were taken.

Light interception was measured at 10 day intervals with 90 cm tube solarimeters sensitive to all solar radiation wave lengths. (Szeicz *et al.* 1964). Solarimeters were placed at ground level and the difference between these and a control solarimeter recording total incident light was measured. Using solarimeters light interception readings were taken thrice *viz.*, morning (8-30 to 9-30 a.m.), afternoon (12-30 to 1-30 p.m.) and evening (4 to 6 p.m.) at five different spots of each replicated plot and the average value was taken as percent total light interception.

RESULTS AND DISCUSSION

Leaf Area Index

Leaf area index pattern of component crops under different treatments was studied – until 75th day (Fig. 1).

Peak values of leaf area index attained by sorghum/cowpea and sorghum/mungbean smother cropping systems given one hand weeding were found to be higher than the peaks observed by all sorghum sole situations including weed free sole sorghum. Among the two smother cropping systems, when given one hand weeding maximum leaf area index was observed – in sorghum/cowpea system which was nearly 66%, 44% and 29% higher than peak leaf area index attained by sorghum sole sorghum given one hand weeding, two hand weedings and weed free situations respectively. The leaf area index of sorghum/mungbean given one hand weeding was 63%, 41%, 26.5% higher than that observed in above compared systems. However, the leaf area index of sorghum alone under both the smother cropping systems was lesser than that observed in sorghum given two hand weedings and sorghum weed free system.

Even under weed free situation, inclusion of 'smother' crop resulted in attenuation of higher leaf area index within first 35 days only, the implications of which are discussed later in relation to associated weed growth.

Light interception

The pattern of leaf area development in turn affects the light interception pattern. In comparison to the light interception peak attained by sorghum sole with one hand weeding, the peak percentage light interception by sorghum/cowpea and sorghum/mungbean smother cropping systems were 34.9% and 29.8% higher when given same weed management (Fig. 2*a*, *b*). Even on 35th day the percentage light interception by sorghum/cowpea and sorghum/mungbean systems given one hand weeding were 48% and 40% higher than sorghum sole given one hand weeding. Thus the introduction of 'smother' crops resulted in quicker attenuation of maximum percentage of light interception than sole sorghum system. After smother crops harvest sharp decline in percentage light interception occurred. Light intercepted under sorghum/cowpea and sorghum/mungbean systems after smother harvest was less than that observed with sorghum given two hand weedings but was higher than intercepted by sorghum given one hand weeding.

Weed growth

Weed growth was maximum in association with sole sorghum given one hand weeding. At smother crop harvest, the weed biomass observed in sorghum/mungbean, sorghum/cowpea 'smother' cropping systems given one hand weeding was less than that in sorghum given two hand weedings. After 'smother' crop harvest a trend of increase in weed dry matter was observed under both the 'smother' cropping systems (Fig. 3).

Grain yield and net monitor returns

Grain yield reduction of 43% occurred when only one hand weeding was given to sole sorghum as compared to sorghum sole weed free system. However, the inclusion of cowpea and mungbean as 'smother' crop in addition to one hand weeding resulted in a reduction of only 23.6% and 22.7% respectively. Under two hand weeding situation the sole sorghum yield reduction was about 18% when compared to weed free sorghum yields.

Under weed free situation also the inclusion of cowpea and mungbean resulted in some reduction of sorghum grain yields. The grain yields of cowpea and mungbean were 36.1% and 38% lesser under one hand weeding situation when compared to weed free situation.

Net monitory returns from sorghum/cowpea (Rs. 3,869) and sorghum/mungbean (Rs. 3,784) given one hand weeding were cosiderably higher than the sorghum sole system given one hand weeding (2398) or two hand wee-

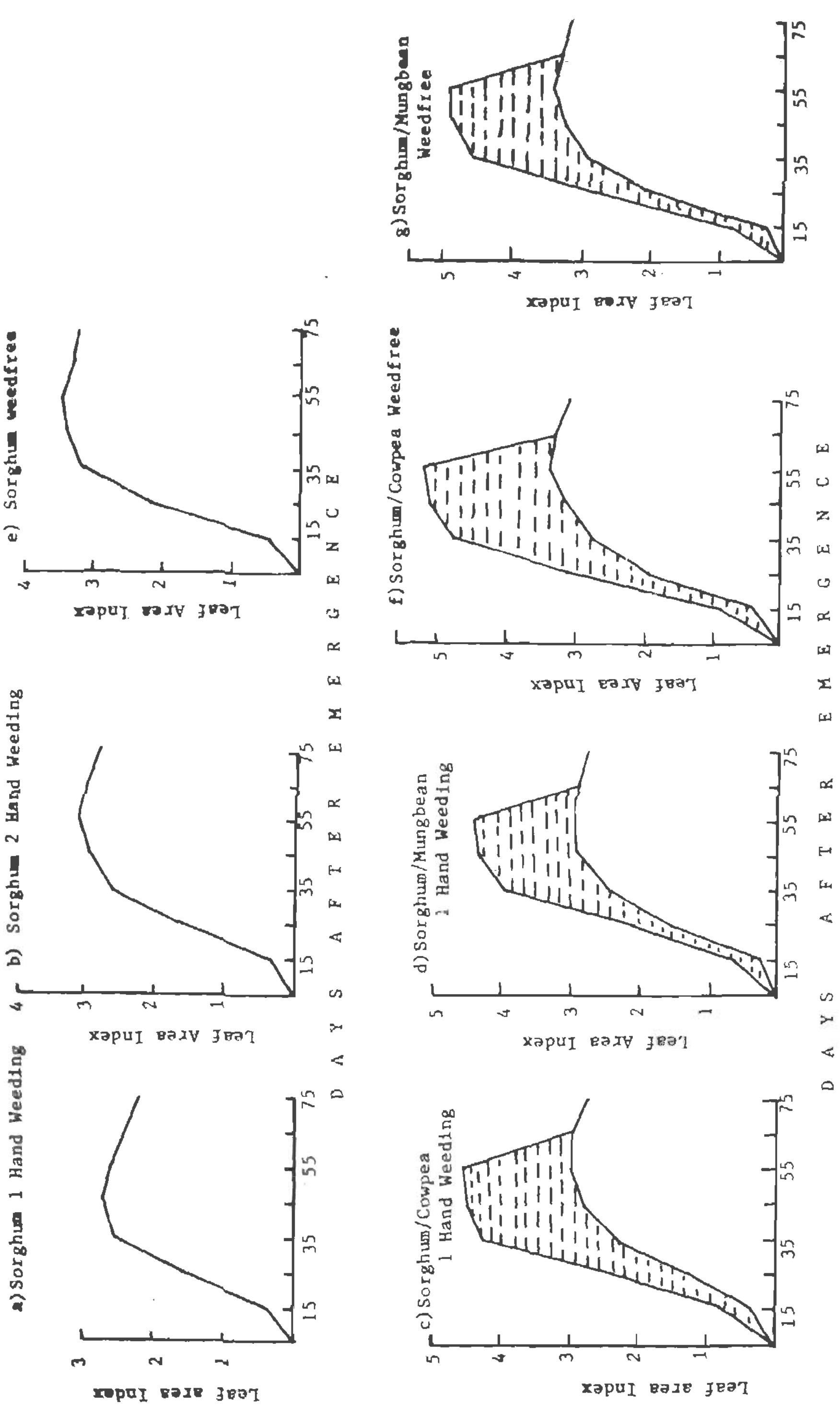


Fig. 1. Leaf area index of component crops in different cropping systems

Table 1 : Effect of smother cropping system on grain yield of sorghum and smother crop and on net production in terms of grain products monetary value.*

	Sorghum Grain yield kg/ha	Sorghum Stover yield kg/ha	Cowpea kg/ha	Mungbean kg/ha	Weed dry matter at harvest g/m^2	Total production (Rs/ha)	Net production (Rs/ha)
Sorghum 1 HW	3652	4660.0	–	–	78.71	2518.50	2398.50
Sorghum 2 HW	5264	6598.0	–	–	16.97	3629.40	3389.40
Sorghum/Cowpea 1 Hand Weeding	4895	6083.0	223.81	–	8.30	4049.00	3869.00
Sorghum/mungbean 1 Hand Weeding	4952	6136.0	–	173.10	14.70	3936.18	3784.00
Sorghum Weed free	6408	7637	–	–	–	4416.00	3936.00
Sorghum/cowpea Weed free	6142	7237.0	350.20	–	–	5286.60	4866.60
Sorghum/mungbean Weed free	6183	7360.0	–	281.10	–	5104.20	4712.20
LSD at 5%	391	534.2	–	–	7.72	–	.

*Considered monetary values :Sorghum 1 q = Rs. 69, Cowpea 1 q = Rs. 300, Mungbean 1 q = Rs. 300.

**Net production = Total production – Hand Weeding Cost (Rs. 120/each Weeding) and 'Smother crop seed cost (Cowpea Rs. 60/ha., Mungbean Rs. 32/ha).

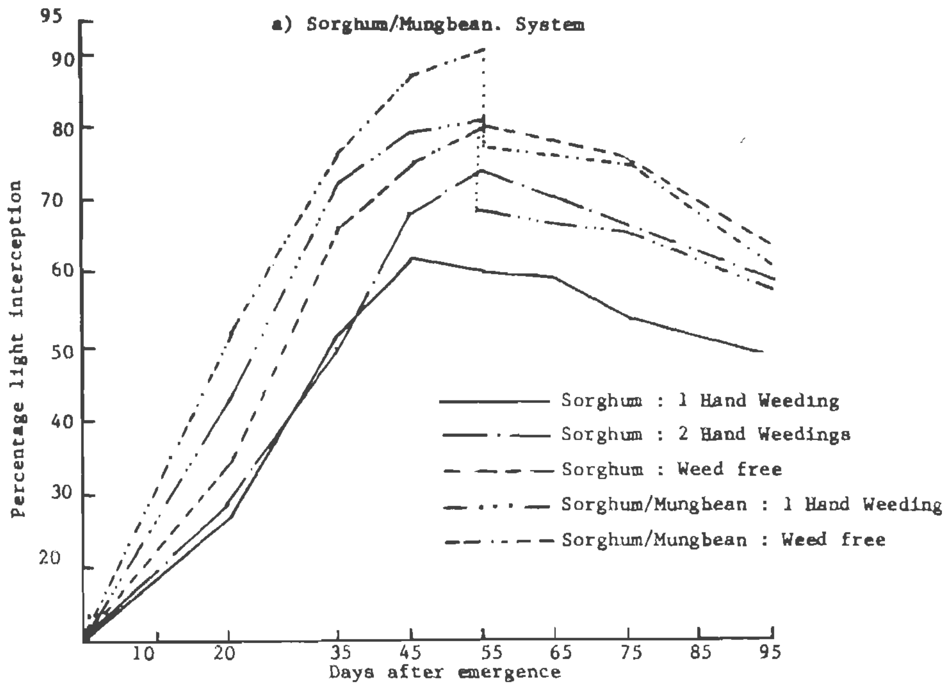
dings (3389). Under weed free situation inclusion of smother crop resulted in even higher net monitory returns (Table 1).

CONCLUSION

Poor competitive ability of sorghum especially during seedling stage due to relatively small and weak seedlings is well known (Shetty, 1978; Rao, 1978). Abundant moisture availability, weak crop seedlings and greater space and light availability together resulted in immediate germination and rapid growth of weeds offering severe competition against the associated crop after first hand weeding. Inclusion of additional 'smother' crops *viz.,* cowpea and mung resulted in less weed growth which is in conformity with observations in other intercrop situations (Moody and Shetty, 1979).

The leaf area index was positively and significantly correlated with the percentage light interception (Fig. 4). Hence introduction of smother crops resulted in increased leaf area index and increased percentage light interception. The percentage light interception was observed to be negatively correlated with weed drymatter (Fig. 5). Such correlation was significant especially during first 45 days of the sorghum growth period. The inclusion of 'smother' crop thus resulted in less light interception by weeds and additional competition for space, light and nutrients which otherwise would have been wasted and used by weeds. This inturn resulted in observed reduced weed growth under smother cropping systems.

Sorghum grain yield under one hand weeding situation of smother cropping



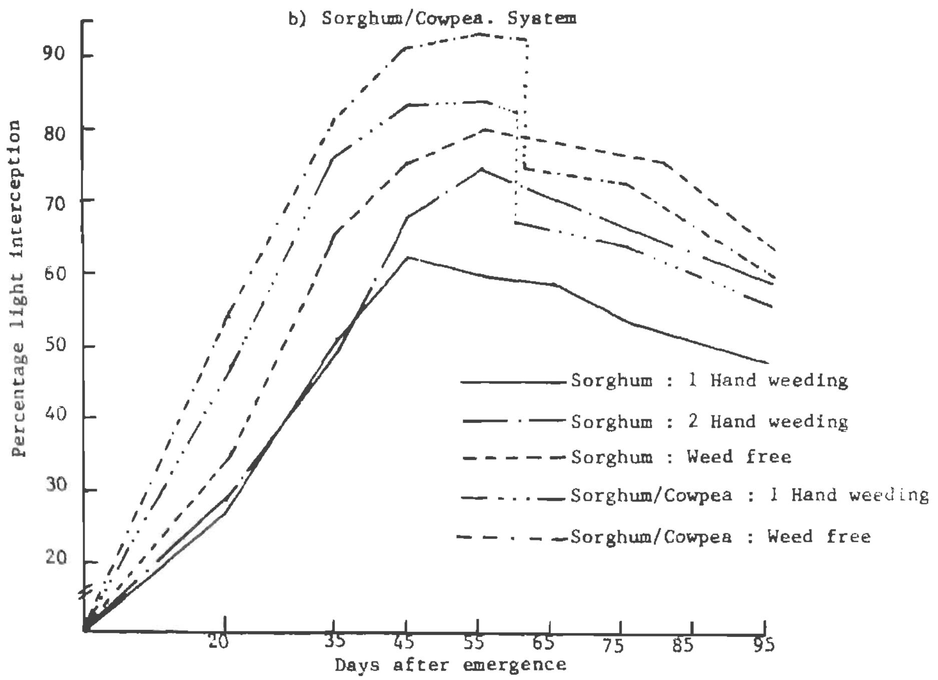


Fig. 2. Pattern of light interception by sorghum based smother cropping systems Under different weed managements

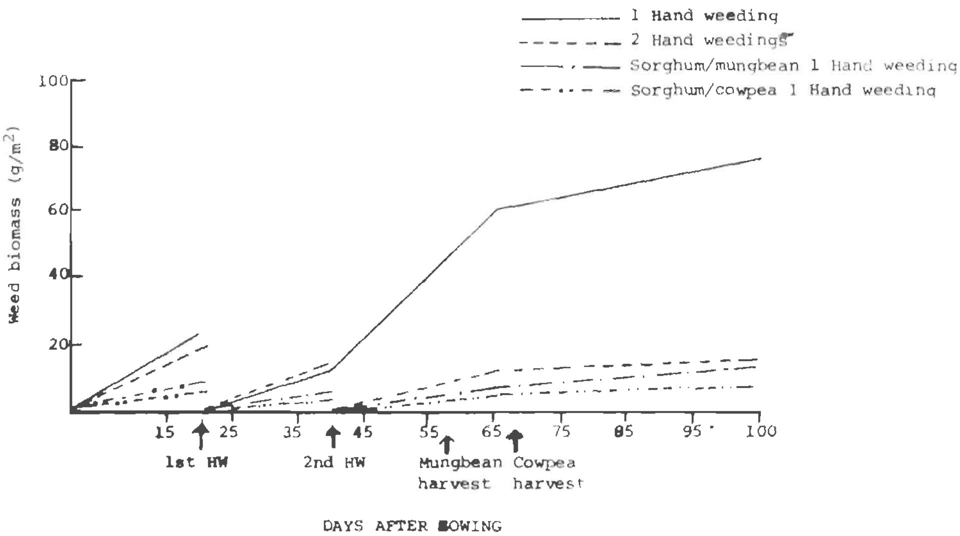


Fig. 3. WEED GROWTH IN VARIOUS 'SMOTHER' CROPPING SYSTEMS UNDER DIFFERENT WEED MANAGEMENT SITUATIONS (ALFISOLS, 1979, RAINY SEASON)

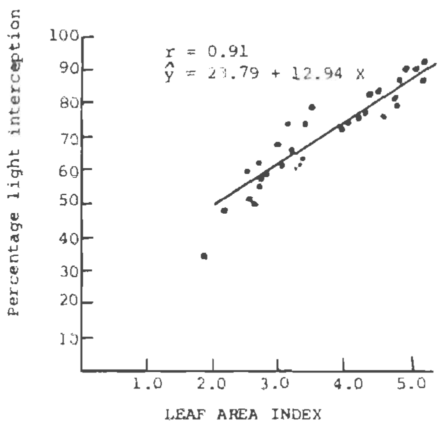


Fig. 4. RELATIONSHIP BETWEEN LEAF AREA INDEX AND LIGHT INTERCEPTION BY COMPONENT CROPS UNDER DIFFERENT CROPPING SYSTEMS

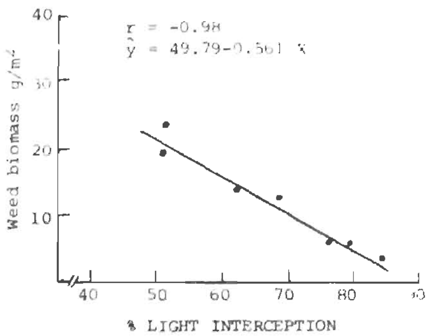


Fig. 5. RELATIONSHIP BETWEEN % LIGHT INTERCEPTION AND WEED BIOMASS DURING FIRST 40 DAYS CRITICAL PERIOD OF CROP WEED COMPETITION

system was less than that observed under sorghum given two hand weedings. However, it was not significantly different from that occurred with sorghum sole given two hand weedings. This is in conformity with earlier ICRISAT observations (ICRISAT, 1978). The smother crop yields observed during the present investigation were comparatively lesser than earlier ICRISAT observations (Cropping Systems Annual Report, 1976, ICRISAT 1978). This can be explained on the basis of crop cultivar incorporated as smother crop, since variation in competitive ability and production potentiality among crop cultivars is known (Shetty and Rao, 1977; Moody, 1978). Thus screening of cowpea and mungbean for their efficient weed 'smothering' ability would enable further improvement of 'smother' cropping which was improved to be superior in terms of monetary returns too.

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BASAL APPLICATION OF TRICLOPYR IN WATER SOLUTION TO RUBBER CUT STUMP IN THAILAND

CHARUCK BOONSRIRAT[1] ARAK CHUNTUMA[1] and PAOPONG PONGPONRATN[2]

[1] Rubber Research Centre, Hat Yai, Thailand

[2] Dow Chemical Thailand Ltd., Bangkok, Thailand.

ABSTRACT

Triclopyr ester was applied as a basal treatment in water and diesel on old rubber tree cut stumps at two trial sites in Thailand in 1979 and 1980. Evaluations a year after application revealed that such treatments were very effective. Triclopyr at the rates of 32-64 g/litre in water solution showed similar good final stump kill to the standard treatment of 32 g/litre 2, 4, 5-T in diesel. Although triclopyr in diesel gave a fast stump kill, triclopyr in water was slower to act, taking 6 months for good control compared with 3 months in diesel. 2, 4, 5-T (EC) in water gave poorer control and the results were variable. Applications can be made any time from 1 day before cutting to 7 days after cutting with equally effective results. Cut surface and combined cut surface/basal application of all treatments were generally less effective than only basal applications.

INTRODUCTION

Poisoning old rubber stumps after felling plays a very important role in a major rubber replanting project in Thailand. The project aims to increase the annual amount of replanting, thus helping to improve and maintain the incomes of rubber growers mostly small holders. The Office of the Rubber Replanting Aid Fund (ORRAF) was established in 1960 by the Government of Thailand to carry out a cooperative programme with the Rubber Research Centre of Thailand (RRCT) at Hat Yai and the Rubber Division, Department of Agriculture, Bangkok, Thailand.

Since a high-yielding variety is replanted under the programme, the best land preparation is required and the old rubber stump destroyed to avoid various rubber disease hosts which includes the regrowth of young shoots from the old stump. The current method of stump killing used is a chemical treatment. A 5 per cent solution of 2, 4, 5-T in diesel oil applied at 100 ml per stump is recommended for a standard basal paint (Charuck and Prasert, 1977) application.

In the light of the recent oil shortage in the country, a new chemical which can be applied with water, is urgently requested for field evaluation. With this in mind, the field trials were established to determine the effectiveness of triclopyr applied either as a basal paint in oil and in water as the carrier. Triclopyr (Anon. 1974) is a new highly translocated herbicide which was first registered by the Dow Chemical Company in 1979. Its biological activities and potential applications were discussed by Byrd *et al.* (1975) and Haagsma (1975). It performs very similarly to 2, 4, 5-T and is highly effective at low rates on a broad range of woody plant and broad leaved weeds as described by Ishikura *et al.* (1977). Triclopyr as an ester formulation applied as a basal spray in kerosene or diesel in

U. S. A. has confirmed its excellent woody plant activity. Basal applications in water plus surfactant also controlled most tree species but resulted in less rapid control than with diesel (Warren, 1976; Lichy, 1977).

The trials were conducted at Hat Yai rubber planting areas, Songkhla province, during 1979-80 under the cooperation with the RRCT and ORRAF. The purpose of these experiments was to define the activities of triclopyr using different methods of application.

MATERIAL AND METHODS

Herbicide formulations used in these comparisons included the following:

Triclopyr, containing 480 g/l triclopyr [(3, 5, 6-trichloro-2-pyridyl) oxy] acetic acid per gallon as the butoxy ethyl ester, as an EC.

2, 4, 5-T, containing 740 g/l 2, 4, 5-T as the butoxy propyl ester.

2, 4, 5-T, containing 720 g/l 2, 4, 5-T as the butyl ester as an EC.

Rating scale description

	% Control
0 - Fresh stump with white latex bleeding	= 0
1 - Fresh stump with latex bleeding on some part	= 10- 20
2 - Dried on the top of stump, some bleeding at the bottom part	= 20- 40
3 - Dried on the top of stump, no latex, hard wood, few borer attack	= 40- 60
4 - Dried stump without latex bleeding, much borer attack and rotted	= 60- 80
5 - Friable stump, heavy borer attack, ready to decompose	= 80-100

Trial 1

This experiment was established at Tam Bon Na-Mom, Hat Yai, August 1979, to evaluate triclopyr applied either in diesel or in water at a various dosages. Triclopyr in water treatments had 1 per cent surfactant of triton-B 1956 added.

Treatments were made either immediately after cutting or delayed 12 to 24 hours. Several methods of application were evaluated, including a basal paint treatment, cut surface paint treatment and combined both basal and cut surface treatment. The rubber tree was cut at about 50 cm above the ground and treatments were applied with a brush. There were several treatments including untreated control with 20 trees per treatment. The treated stumps were marked with aluminium tags and paint.

Trial 2

This experiment was established in September 1980 at Tam Bon Koh Mee, Hat Yai, to confirm some promising treatment from the previous trial. Triclopyr in water treatments had 1 per cent and 2 per cent surfactant (triton-B 1956) added and were compared with 2, 4, 5-T per cent in diesel as the standard treatment. Treatments were made only as a basal application or applied either 1 day before or 7 days after cutting. There were several treatments including untreated control with 20 trees per treatment.

In these experiments, the rubber trees were a native seedling variety about 25 years old with an average girth of 120 cm. Temperature during application was at 28-30°C and soil moisture was good. Each tree received 100 ml of chemical solution. The girth of each tree was recorded prior to treatment. Rating scale by sampling of 10 stumps out of 20 for each treatment and chopped around the stump

Table 1 : Trial 1. Control of rubber stump by different methods of application 9 months after treatment.

Treatment Chemical (carrier)	Rate g/litre	Girth cm	Control rating		
			Basal*	Cut** surface	Basal + cut** surface
2, 4, 5-T (diesel)	32	120	4	(–)	(–)
Triclopyr (diesel)	32	123	4	(–)	(–)
Triclopyr (diesel)	64	120	4	(–)	(–)
Triclopyr (water)	32	122	3	3	2
Triclopyr (water)	64	121	3	3	3
2, 4, 5-T EC (water)	32	121	2	3	4
2, 4, 5-T EC (water)	64	116	3	2	3
2, 4, 5-T EC (water)	96	126	3	2	3
Untreated check	0	126	0	0	0

Note : (–) = Treatment not in the trial, * – applied immediately before cut, ** = applied immediately after cut.

Table 2 : Trial 2. Control of rubber stump 9 months after application as a basal treatment either before or after cutting.

Treatment Chemical (carrier)	Rate g/litre	Girth cm	Control rating		
			B_1	A_1	A_7
2, 4, 5-T (diesel)	32	120	4	(–)	(–)
Triclopyr (water)	16	85	3	(–)	(–)
Triclopyr (water)	32	123	3	2	2
Triclopyr (water)	48	100	3	2	2
2, 4, 5-T EC. (water)	64	108	3	3	2
Untreated check	0	110	0	0	0

Note : B_1 = One day before cutting, A_1 = One day after cutting
A_7 = Seven days after cutting, (–) = Treatment not in the trial

Table 3 : Trial 1 and 2. Decomposition degree of rubber stump at 3, 6, 9, 15 and 18 months (mth) after basal application 1 day before cutting.

Treatment Chemical (carrier)	Rate g/litre	Girth cm	Decomposition rating				
			3 mth	6 mth	9 mth	15 mth	18 mth
2, 4, 5-T (diesel)	32	120	3	4	4	5	5
Triclopyr (diesel)	32	123	3	4	4	5	5
Triclopyr (diesel)	64	120	3	4	4	5	5
Triclopyr (water)	16	85	1	2	3	–	–
Triclopyr (water)	32	122	1	3	3	5	5
Triclopyr (water)	48	100	1	3	3	–	–
Triclopyr (water)	64	121	1	3	4	5	5
2,4,5-T EC (water)	32	120	1	2	2	4	5
2,4,5-T EC (water)	64	129	1	2	3	4	5
2,4,5-T EC (water)	96	126	1	3	3	4	5
Untreated check	0	118	0	0	0	0	1

with axe from the top part down to the bottom of the stump including top surface root.

Observations of stump kill were made periodically for 1-2 year. Response of stump was rated on 0-5 scale where 0 = no observable effect and 5 = friable and dry rot with readiness to decompose. The intermediate ratings indicate progressively better control with dried tissue without latex bleeding and a degree of borer attack. Results are expressed as control rating score.

RESULTS AND DISCUSSION

The results of the different trials are summarized in Tables 1-3.

The 3 methods of application in trial 1 have been summarised in Table 1. After 9 months, triclopyr at 32, 64 g/litre in either diesel or water as a basal treatment and 2, 4, 5-T at 32 g/litre in diesel gave excellent results. It is interesting to note that triclopyr applied in water either as a cut surface or basal plus cut surface treatment was not as good as basal only. 2, 4, 5-T in water gave poor variable results. Although it does not appear clear-cut, there is an apparent trend toward best results from basal applications compared with other application methods.

In trial 2, where the basal treatment was applied at different times (Table 2), the results indicate that there was no difference in control from treatments of 1 day before cutting, 1 day after cutting or 7 days after cutting. As in trial 1, triclopyr in water appeared more active than 2, 4, 5-T in water but both gave excellent results in diesel. Table 3 shows the decomposition degree of rubber stump in each treatment at different times of evaluation. All water treatments showed less speed of killing than oil treatments at 3 months after application but came to the same level of kill at 15 months after application. Triclopyr in diesel showed better degree of the decomposition than 2, 4, 5-T in diesel which was superior to all treatments.

Soil residual effect was observed in trial 1 where the rubber seedlings were planted in each plot along the row of treated stumps at 3 months after chemical application. There was no phytotoxicity found in the new seedlings but it was noticed only after 18 months. Upland rice, corn and peanut were also planted along the treated rubber rows without any phytotoxicity appearance.

In addition to the treatments shown, all water treatments also had 1 per cent and 2 per cent surfactant added. It was observed that the surfactant did not appear to increase the effectiveness of any treatment.

CONCLUSION

Although the results of these trials are not conclusive, it indicated that triclopyr, applied in a water solution as a basal application before or after cutting down old rubber trees, can give a level of stump kill currently achieved by the standard treatment of 2, 4, 5-T in diesel. Further work is needed to determine more accurately the most efficient cost of rate used.

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GERMINATION BEHAVIOUR OF COMMON COCKLEBUR

P. K. BISWAS
Department of Plant and Soil Science
Tuskegee Institute, Tuskegee, Alabama 36083, U.S.A.

ABSTRACT

The ability of many plant species to reappear in areas denuded of vegetation is due primarily to seed dormancy. Dormancy of seeds buried in soil is particularly long in a large number of plant species, especially those depending on natural conditions for germination. Germination of common cocklebur (*Xanthium pennsylvanicum*) seeds was tested by various physical and chemical treatments. Scarification, storage conditions and photoperiodic changes were tested in an attempt to increase the rate of germination or break the dormancy. The chemical treatments: GA_3, IAA, NAA, IBA, kinetin and thiourea were applied to freshly harvested seeds in an attempt to replace all or part of the germination requirements. On the basis of the results, the following conclusions were drawn:

1. The upper seed and lower seed in the bur exhibited distinctly different germination responses. The seeds of freshly harvested burs did not attain complete germination immediately after harvest, but required an after-ripening period. The lower seeds of freshly harvested burs attained 50% germination, whereas no germination was observed in the "upper" seeds.
2. The lower seeds required 12 weeks of dry storage at 5 or 25° C for complete germination, whereas the "upper" seeds required 20 weeks of moist storage at 5° C for complete germination.
3. Chemical treatments with GA_3, KNO_3 at 10, 100, 1000 ppm, kinetin at 100 ppm and thiourea at 1, 10, 100 ppm significantly increased the germination percentage of the "lower" seeds of freshly harvested cocklebur. These chemicals were able to increase the final germination of "upper" seeds in both scarified and stratified burs significantly.

INTRODUCTION

The ability of many plant species to reappear in areas denuded of vegetation is due primarily to seed dormancy. Dormancy of seeds buried in the soil is particularly long in a large number of species, especially those depending on natural conditions for germination. Once the land has become re-vegetated with natural cover of vegetation, it is virtually impossible to destory it permanently, since a large portion of the seeds that are on the ground will remain in a dormant state for many months and even years. The small proportion of seeds that germinate in any year and reach maturity will add more seeds to those already present.

Successful control and/or eradication of weeds necessitates the destruction of viable seeds. It is essential, therefore, to create a condition in the soil that will stimulate the germination of dormant seeds. The seedlings may later be destroyed by tillage, unfavourable weather or some other control or eradication method. To create such conditions requires a knowledge of the causes of dormancy of weed seeds, their germination requirements and behaviour under various conditions in the soil. Such knowledge can only be acquired from information provided by much needed research on weed seed germination in a controlled environment relative to their natural habitat.

The objectives of this investigation were:

To determine whether or not the seeds of common cocklebur, were dormant and to establish their optimum germination conditions,

to determine the effect of various synthetic chemical stimulants and mechanical treatments on the germination of seeds of common cocklebur,

to determine the effect of storage conditions on the germination and viability of seeds of common cocklebur.

MATERIAL AND METHODS

The cocklebur seeds used in this study were collected from the vicinity of the Tuskegee Institute Farm, Tuskegee, Alabama, during the months of October and November, 1978 and 1979. The cocklebur seeds were cleaned. Three storage conditions were used in the study: (a) dry storage at room temperature (25° C), (b) dry storage at 5° C and (c) moist storage at 5° C. The dry seeds stored at room temperature were placed in fumed coloured jars with airtight lids and kept in a refrigerator that was set at the desired temperature, those seeds that were stored moist at 5° C were soaked in distilled water for 24 hr. Fully imbibed seeds were then placed in polyethylene bags, the open-end tied and then transferred to a refrigerator previously set at 5° C for various periods of time. The bags were open occasionally and checked for moisture. The seeds were maintained at the above described storage conditions until they were used.

Chemicals evaluated in this study were gibberellic acid (GA_3), indoleacetic acid (IAA), naphthaleneacetic acid (NAA), indolebutyric acid (IBA), potassium nitrate, thiourea, 6-furfuryl- amino-purine (kinetin), cyclic-AMP (C-AMP), acetylcholine (Ach) and eserine sulfate. Concentrations of 100, 10, 1 and 0 mg/l were used for IAA, NAA, IBA, thiourea and kinetin; 1000, 100, 10 and 0 were used for GA_3, potassium nitrate, C-AMP, Ach and eserine sulfate. The stock solutions were adjusted to a pH of 6.0-6.5 before dilution and incorporation in the germination media. Sterilized distilled water was used for the control solution. Adequate moisture content was maintained thereafter throughout the experiments with sterilized distilled water as needed.

Germination media used in this study were Whatman 2 filter paper, sterilized sand and sandy loam soil. Germination containers used in this study were 9 cm plastic petri dishes, 100 cm glass petri dishes and small plastic jiffy trays. The seeds were surface sterilized prior to each test by placing them in a solution of sodium hypochlorite, methanol and distilled water (5:4:1 V/V/V) for 30 minutes and then rinsed in running tap water for one hr, followed by washing with three changes of distilled water. (Davis, 1930; Holm and Miller, 1972).

Germination studies: The burs of cocklebur were placed in 9 cm petri dishes and completely covered with sterilized sand moistened with 15 ml of the appropriate test solution; four replications with 50 burs per replicate at each concentration of the test solution were used. Germination was checked every three days for a period of 28 days. Emergence of the seedling through the surface of the sand was used as a criterion for germination in this study.

In all of the germination studies the seedlings were either discarded or placed to one side of the plate to observe effects of the chemicals on seedling develop-

Table 1: Effect of various storage conditions on the germination of common cocklebur seeds.

Treatments	Stored dry at 5°C		Stored dry at 25°C		Stored moist at 5°C	
Weeks of Storage	Per cent germination & ± S.D.	Germination values	Per cent germination & ± S.D.	Germination values	Per cent germination & ± S.D.	Germination values
0	24 ± 2.1 a	1.2	24 ± 2.2 a	1.2	24 ± 1.3 a	1.2
2	27 ± 1.4 b	1.4	27 ± 1.3 b	1.2	38 ± 1.4 b	1.4
4	31 ± 1.3 c	2.0	29 ± 1.0 c	1.2	39 ± 1.7 c	5.5
6	35 ± 1.8 d	2.2	34 ± 0.9 d	1.4	60 ± 1.3 d	7.2
8	41 ± 1.5 e	2.3	40 ± 1.5 e	2.2	65 ± 1.1 e	8.7
10	44 ± 2.7 f	2.7	43 ± 1.7 f	2.6	73 ± 1.0 f	11.9
12	50 ± 1.7 g	3.4	48 ± 1.1 g	3.1	84 ± 0.9 g	13.4
16	56 ± 1.4 h	4.7	56 ± 1.5 h	4.7	98 ± 2.6 h	19.8
20	73 ± 1.3 i	7.0	70 ± 1.4 i	6.9	99 ± 0.7 h	22.4
30	85 ± 1.9 j	8.4	81 ± 0.9 j	8.1		

Note: Means within a column followed by the same subscript are not significantly different at the 5% level of probability according to Duncan's New Multiple Range Test.
Data are based on four replications of 50 burs each. The burs were germinated at alternating temperatures of 31° C with 16 hr light and 22° C with 8 hr dark. The final germination counts were made on the 28th day.

ment after each count. All experiments were repeated two times. The data have been presented as per cent germination and germination value (GV). Germination value is a measure of both speed and completeness of germination and is the product of mean daily germination and peak value. Mean daily germination is computed at the end of the test; peak value is the highest number obtained by dividing cumulative germination by days of test (Czabator, 1962). The data were subjected to analyses of variance for completely randomized experiments and Duncan's New Multiple Range Test at the 5% probability.

RESULTS AND DISCUSSION

Germination as affected by various storage conditions: The fruit (bur) of common cocklebur contains two seeds: a small, upper dormant seed and a large, lower non-dormant seed (Kahn *et al.* 1957). It is this lower seed which germinates readily after a period of dry storage.

The results of the effects of various storage conditions on the germination of common cocklebur seeds are shown in Table 1, (here and throughout the entire study it is to be understood that all the tests were conducted on the intact burs and that all germination percentages greater than 50% are to be considered the germination results of the "upper" dormant seed). After 28 days, 24% germination and a germination value (GV) of 1.2 was observed for freshly harvested burs of the common cocklebur. With increasing periods of the three storage conditions studied, both the final germination percentages and germination values were significantly increased compared to those of controls. The following observations were made: 30 weeks of dry storage at 5° C and 25° C; 20 weeks of cold stratification at 5° C, 85%, 81% and 99% germination and values of 8.4, 8.1 and 22.4.

Germination as affected by dry storage at 25° C and chemical stimulants: The results of dry storage treatments at room tempe-

Table 2 : Effect of dry storage (25° C) and chemical treatments on the germination of common cocklebur

Treatments		Storage periods, germination percentages and standard deviations					
Chemical	Conc. (ppm)	2 Weeks % ± S.D.	4 Weeks % ± S.D.	6 Weeks % ± S.D.	8 Weeks % ± S.D.	10 Weeks % ± S.D.	12 Weeks % ± S.D.
Control		25±1.0 f	28±0.5 e	33±0.6 fg	37±2.0 e	45±2.1 f	55±2.4 i
GA_3	10	35±1.5 i	41±1.6 g	45±1.5 i	53±0.8 gh	62±1.7 i	72±1.3 no
	100	45±0.8 k	50±1.5 h	55±1.8 j	59±0.6 i	67±2.2 j	79±2.1 pq
	1000	56±0.6 m	61±3.2 i	70±0.8 k	73±2.5 j	84±1.8 k	92±2.2 st
KNO_3	10	35±1.3 i	41±1.0 g	44±2.0 i	52±1.0 g	61±1.9 i	71±2.0 n
	100	45±1.7 k	50±1.9 h	55±2.9 j	59±0.6 i	68±1.3 j	80 ±1.8 pr
	1000	53±0.6 l	59±1.3 i	70±0.9 k	71±2.1 j	84±1.0 k	91±1.9 s
IAA	1	21±1.9 d	23±1.6 cd	28±1.5 e	30±0.7 d	30±1.0 e	30±1.7 f
	10	21±2.3 s	19±1.0 b	21±2.2 c	22±1.0 b	24±1.6 cd	24±0.6 cd
	100	15±2.2 ab	15±1.9 a	14±1.7 ab	18±1.5 a	17±2.5 b	17±1.7 ab
NAA	1	22±2.1 de	22±2.0 cd	27±1.7 de	28±1.5 cd	31±1.9 e	31±1.3 fg
	10	18±1.4 bc	20±1.0 bc	21±1.7 c	21±1.4 b	22±1.1 c	23±1.0 c
	100	16±1.7 b	14±3.0 a	16±1.7 b	14±2.1 a	14±1.3 a	15±1.0 a
IBA	1	24±2.4 ef	24±1.3 d	25±1.8 d	27±1.0 c	31±1.7 e	24±1.3 h
	10	19±3.1 cd	20±0.8 bc	20±1.4 c	22±1.5 b	25±1.3 d	27±2.5 e
	100	13±1.5 a	13±1.9 a	13±1.0 a	13±1.9 a	15±2.7 ab	19±2.1 b
Kinetin	1	27±2.3 fg	27±2.2 e	31±2.3 f	40±1.7 f	52±2.8 g	61±1.0 j
	10	28±2.4 gh	28±0.5 e	32±1.0 fg	41±1.8 f	54±2.1 g	64±1.6 k
	100	27±2.2 fg	29±2.2 e	33±1.0 fg	42±0.2 f	55±2.5 g	66±1.7 kl
Thiourea	1	30±2.2 h	32±1.3 f	34±1.3 g	51±2.4 g	58±1.0 h	68±1.0 lm
	10	34±0.5 i	33±1.2 f	40±2.5 h	55±2.4 h	62±1.7 i	72±2.4 no
	100	40±2.0 j	42±2.4 g	45±2.6 i	58±1.5 i	68±1.7 j	78±1.7 p

Note : Means within a column followed by the same subscript are not significantly different at the level of probability according to Duncan's New Multiple Range Test.
Data are based on four replications of 50 burs each. The burs were germinated at alternating temperatures of 31° C with 16 hr light and 22° C with 8 hr dark. The final germination counts were made on the 28th day.

rature are summerized in Table 2. Seeds were stored for periods of 2, 4, 6, 8, 10 and 12 weeks, accounting for final germination percentages of 25, 28, 33, 37, 45 and 55 respectively. Final germination percentages of seeds treated with GA_3, KNO_3 at 10, 100, 1000 ppm and thiourea at 1, 10 and 100 ppm were significantly higher than those of the control. The germination percentages of seeds treated with IAA, NAA and IBA were significantly lower.

Germination as affected by chemical treatments: Germination responses of freshly harvested cocklebur seeds to various chemical treatments are summarizedin Table 3. All three concentrations of GA_3, KNO_3 and thiourea significantly increased both the final germination percentages and the germination values of the lower seeds of cocklebur as compared with the control seeds. But only GA_3 and KNO_3 at 100 ppm were capable of stimulating the germination of the lower seeds to completion; GA_3 and KNO_3 at 1000 ppm were capable of stimulating the upper

Table 3 : Effect of chemical treatment on the germination of freshly harvested common cocklebur seeds.

Treatments Chemical	Conc (ppm)	Per cent germination % ± S.D.	Germination values
Control		28 ± 2.0 h	2.3
GA_3	10	37 ± 2.4 k	4.3
	100	43 ± 1.4 l	5.7
	1000	56 ± 1.7 no	9.2
KNO_3	10	34 ± 1.9 j	4.0
	100	43 ± 1.9 l	6.1
	1000	55 ± 1.8 n	9.2
IAA	1	24 ± 1.7 f	1.4
	10	19 ± 1.6 d	0.7
	100	12 ± 1.3 a	0.2
NAA	1	25 ± 2.5 fg	1.4
	10	19 ± 1.7 d	0.7
	100	13 ± 2.2 ab	0.2
IBA	1	24 ± 1.7 f	1.4
	10	20 ± 1.4 de	0.7
	100	14 ± 1.3 ac	0.2
Kinetin	1	28 ± 1.0 h	2.2
	10	28 ± 1.4 h	2.6
	100	30 ± 1.4 hi	2.6
Thio-urea	1	32 ± 1.8 ij	3.3
	10	37 ± 1.6 k	4.7
	100	45 ± 1.5 lm	6.1

Note : Means within a column followed by the same subscript are not significantly different at the 5% level of probability according to Duncan's New Multiple Range Test.
Data are based on four replications of 50 burs each. The burs were germinated at alternating temperatures of 31°C with 16 hr light and 22°C with 8 hrs dark. The final germination counts were made on the 28th day.

Table 4 : Effect of scarification and chemical treatments on the germination of common cocklebur seeds.

Treatments Chemical	Conc (ppm)	Per cent germination % ± S.D.	Germination values
Control		65 ± 1.7 gh	8.3
GA_3	10	77 ± 1.0 j	11.9
	100	83 ± 2.7 kl	15.0
	1000	97 ± 1.5 mn	18.7
KNO_3	10	75 ± 1.3 ij	12.2
	100	81 ± 2.2 k	14.5
	1000	94 ± 2.1 m	17.8
IAA	1	36 ± 1.7 e	3.1
	10	30 ± 0.8 cd	1.6
	100	21 ± 3.7 b	0.6
NAA	1	37 ± 1.9 ef	2.6
	10	30 ± 1.4 cd	1.5
	100	20 ± 1.6 ab	0.3
IBA	1	36 ± 1.3 e	2.7
	10	29 ± 2.1 c	1.5
	100	18 ± 1.5 a	0.6
Kinetin	1	63 ± 1.7 g	7.9
	10	65 ± 1.7 gh	9.0
	100	66 ± 2.1 h	9.8
Thio-urea	1	63 ± 1.4 g	8.4
	10	66 ± 1.3 h	9.6
	100	74 ± 3.3 i	11.4

Note : Means within a column followed by the same subscript are not significantly different at the 5% level of probability according to Duncan's New Multiple Range Test.
Data are based on four replications of 50 burs each. The burs were germinated at alternating temperatures of 31°C with 16 hr light and 22°C with 8 hr dark. The final germination counts were made on the 28th day.

dormant seeds by 6% and 5% respectively. All concentrations of IAA, NAA and IBA significantly reduced both the germination percentages and germination values of the lower seds compared to the controls. With the exception of GA_3 and KNO_3 at 1000 ppm, none of the chemicals studied had any stimulating effect on the germination of the upper dormant seds of the cocklebur.

Germination as affected by scarification and chemical treatments: Scarification had a stimulating effect on germination of both the lower and upper seeds of cockle-

Table 5 : Effect of cold-stratification (5° C) and chemical treatments on the germination of common cocklebur seeds.

Treatments		Stratification period, germination percentages and standard deviation					
Chemical	Conc (ppm)	2 Weeks % ± S.D.	4 Weeks % ± S.D.	6 Weeks % ± S.D.	8 Weeks % ± S.D.	10 Weeks % ± S.D.	12 Weeks % ± S.D.
Control		40 ± 1.7 gh	47 ± 1.5 ij	59 ± 1.5 kl	65 ± 0.8 jk	75 ± 1.4 j	88 ± 1.7 ik
GA_3	10	54 ± 1.2 jk	64 ± 1.3 lm	70 ± 1.6 no	80 ± 2.8 no	87 ± 1.5 n	96 ± 1.6 lm
	100	68 ± 1.3 m	74 ± 1.9 no	8 ± 0.7 q	90 ± 1.3 qr	96 ± 2.3 op	100 ± 0.0 no
	1000	75 ± 1.7 n	82 ± 2.9 pq	91 ± 1.0 st	99 ± 0.8 st	99 ± 0.5 pq	100 ± 0.0 no
KNO_3	10	52 ± 2.1 ik	64 ± 1.7 lm	69 ± 0.6 n	79 ± 1.1 n	85 ± 0.8 mn	95 ± 1.0 l
	100	68 ± 1.2 m	73 ± 0.8 n	79 ± 0.8 qr	89 ± 2.4 q	94 ± 1.5 o	100 ± 0.0 no
	1000	75 ± 1.1 n	80 ± 1.0 p	89 ± 2.6 s	98 ± 1.0 s	99 ± 0.5 pq	100 ± 0.0 no
IAA	1	35 ± 1.6 f	39 ± 2.6 fh	41 ± 1.7 gh	54 ± 0.5 i	59 ± 1.7 i	62 ± 1.3 h
	10	31 ± 1.4 de	31 ± 2.6 de	33 ± 1.5 ef	44 ± 1.3 fg	46 ± 2.0 fg	44 ± 1.6 e
	100	24 ± 1.9 c	21 ± 2.4 ac	23 ± 1.0 b	34 ± 1.3 c	36 ± 1.9 c	35 ± 1.5 c
NAA	1	35 ± 1.1 f	37 ± 1.7 f	40 ± 0.8 g	43 ± 1.9 f	45 ± 1.7 f	49 ± 2.4 f
	10	31 ± 2.1 de	31 ± 1.3 de	24 ± 1.3 bc	38 ± 1.5 d	37 ± 1.9 cd	40 ± 1.0 d
	100	21 ± 1.0 ab	20 ± 1.0 ab	20 ± 1.3 a	24 ± 13 a	24 ± 1.4 a	29 ± 1.5 a
IBA	1	34 ± 1.7 ef	38 ± 2.3 fg	42 ± 1.3 gi	50 ± 1.7 h	49 ± 1.4 h	50 ± 1.8 fg
	10	30 ± 2.6 d	30 ± 3.4 d	31 ± 0.8 e	39 ± 1.9 de	38 ± 1.4 ce	40 ± 1.7 d
	100	20 ± 1.5 a	19 ± 1.9 a	25 ± 1.0 bd	29 ± 1.5 d	30 ± 1.7 b	30 ± 2.1 ab
Kinetin	1	39 ± 1.4 g	45 ± 0.5 i	55 ± 0.6 j	63 ± 2.2 j	75 ± 1.0 j	86 ± 1.4 i
	10	39 ± 1.0 g	48 ± 1.0 ik	58 ± 1.3 k	65 ± 1.3 jk	76 ± 1.6 jk	87 ± 1.8 ij
	100	39 ± 1.7 g	45 ± 1.8 i	59 ± 2.4 kl	69 ± 2.2 l	77 ± 1.7 jl	89 ± 0.3 j
Thiourea	1	49 ± 1.0 i	61 ± 3.0 l	59 ± 1.0 kl	71 ± 1.9 lm	80 ± 1.0 l	89 ± 1.0 j
	10	51 ± 1.3 ij	67 ± 1.9 m	65 ± 1.0 m	79 ± 1.5 n	83 ± 1.6 lm	95 ± 2.2 l
	100	60 ± 0.8 l	73 ± 2.1 n	74 ± 1.1 p	84 ± 1.3 p	87 ± 0.9 n	99 ± 1.0 n

Note : Means within a column followed by the same subscript are not significantly different at the 5% level of probability according to Duncan's New Multiple Range Test.
Data are based on four replications of 50 burs each. The burs were germinated at alternating temperatures of 31° C with 16 hr light and 22° C with 8 hr dark. The final germination counts were made on the 28th day.

bur. After 28 days, 65% germination and germination value of 1.7 were observed (Table 4). All concentrations of GA_3, KNO_3 and thiourea at 100 ppm sgnificantly increased both the final germination percentages and germination values of the lower and upper seeds of scarified cocklebur compared to the controls. Gibberellic acid and KNO_3 at 1000 ppm were able to stimulate the germination of the upper dormant seeds of scarified cocklebur to near completion; 97% and 94% were observed respectively. All three concentrations of kinetin and thiourea at 1 and 10 ppm had no effect on germination, whereas IAA, NAA and IBA significantly reduced the germination of both the lower and upper seeds compared to the controls.

Germination as affected by cold-stratification and chemical treatments: Germination responses of cocklebur seeds to various cold stratification periods are summarised in Table 5. Stratification alone had appreciably increased the total germination of the seeds. Seeds were stratified from 2 to 12 weeks. All concentrations of GA_3 and KNO_3 significantly increased the final germination percentages compared to the controls. After 12 weeks of stratification, GA_3 and KNO_3 at 100 and 1000 ppm were able to stimulate the final germination of both the upper and lower seeds to complete germination. All concentrations of IAA, NAA and IBA significantly reduced the final germination percentages of stratified seed after 2, 4, 6, 8, 10 and 12 weeks of stratification compared to the controls.

CONCLUSION

Germination of common cocklebur seeds was tested by various physical and chemical treatments. Scarification, storage conditions and photoperiodic changes were tested in an attempt to increase the rate of germination or to break dormancy. The chemical treatments GA_3, KNO_3, IAA, NAA, IBA, kinetin, thiourea and C-AMP were applied to freshly harvested seeds in an attempt to replace all or part of the germination requirements. On the basis of the experiments, the following conclusions are drawn:

1. The upper seed and the lower seed in the bur exhibited distinctly different germination responses. The seeds of freshly harvested burs did not attain complete germination immediately after harvest, but required an after-ripening period. The lower seeds of freshly harvested burs attained 50% germination, whereas no germination was observed in the "upper" seeds.

2. The lower seeds required 12 weeks of dry storage at 5° C and 25° C for complete germination, whereas the "upper" seeds required 20 weeks of moist storage at 5° C for complete germination.

3. Chemical treatments with GA_3, KNO_3 at 10, 100, 1000 ppm, kinetin at 100 ppm and thiourea at 1, 10, 100 ppm significantly increased the germination percentages of the "lower" seeds of freshly harvested cocklebur, whereas these chemicals had little or no effect on the "upper" seeds compared to the controls. However, the chemicals were able to increase the final germination of "upper" seeds in both scarified and stratified burs significantly.

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THE SUSCEPTIBILITY OF INDONESIAN RICE VARIETIES TO 2, 4-D INJURY AS AFFECTED BY AIR TEMPERATURE

M. SUNDARU,[1] I. BABA, T. TANABE, F. TAMAI, Y. MOTODA[2]
[1] Central Research Institute for Food Crops Bogor, Indonesia.
[2] Crop Science Lab., Tokyo University of Agriculture.

ABSTRACT

To study the inter-relationship between 2, 4-D injury on rice and low air temperature, a pot experiment was carried out at the greenhouse of Tokyo University of Agriculture in summer season of 1980 using IR-36, an indica variety and Hawara Batu, a japonica one. Inhibition and abnormalities of top and root growth caused by 2, 4-D and low temperature were observed more often in IR-36 than Hawara Batu. Therefore, the susceptibility to 2, 4-D and low temperature is higher in IR-36 than Hawara Batu. Yellowish discoloration, chlorosis were induced by 2, 4-D and low temperature, followed by reddish brown discoloration in IR-36. This symptom was assumed to be similar to iron chlorosis. Evolution of ethylene from the leaf was increased by both factors especially in IR-36.

INTRODUCTION

The phytotoxicity of 2, 4-D, a phenoxy type herbicide is increased in rice plants at low temperatures (Arai, 1950; Coly, 1980).

2, 4-D has a potential toxicity to the rice plant at an average temperature less than 16° – 17°C and the phytotoxicity occurs in the northern part of Japan where unusual low temperature often happens (Noda, 1977).

Therefore milder phenoxy type herbicides than 2, 4-D such as MCPA and MCPB are presently recommended to the farmers. In tropical region, the phytotoxicity of 2, 4-D takes place on paddy fields located at high elevation.

A pot experiment was carried out using Indonesian indica variety, IR-36 and japonica one, Hawara Batu in order to clarify the mode of the occurrence of 2, 4-D injuries under low temperature conditions.

MATERIAL AND METHODS

Seeds were sown on June 16, 1980 on a box nursery and seedlings were grown under field condition. Four seedlings were transplanted in a flooded Wagner pot (1/5,000 a) filled with subsoil of upland field on July 1. The soil was previously mixed with peat, one third of soil in volume; 1.5 g of ammonium sulphate, 2 g of superphosphate and 0.6 g of potassium chloride were applied as fertilizers.

The experimental plots were as follows:

	High temperature		Low temperature	
	HT	2, 4-D	LT	2, 4-D
IR-36	1	2	3	4
Hawara Batu	5	6	7	8

600 g dosage of 2, 4-D amine per ha was applied on July 18, 1980.

In the high temperature plot, pots were placed in the glasshouse. When the temperature dropped, pots were transferred to a growth cabinet room in which

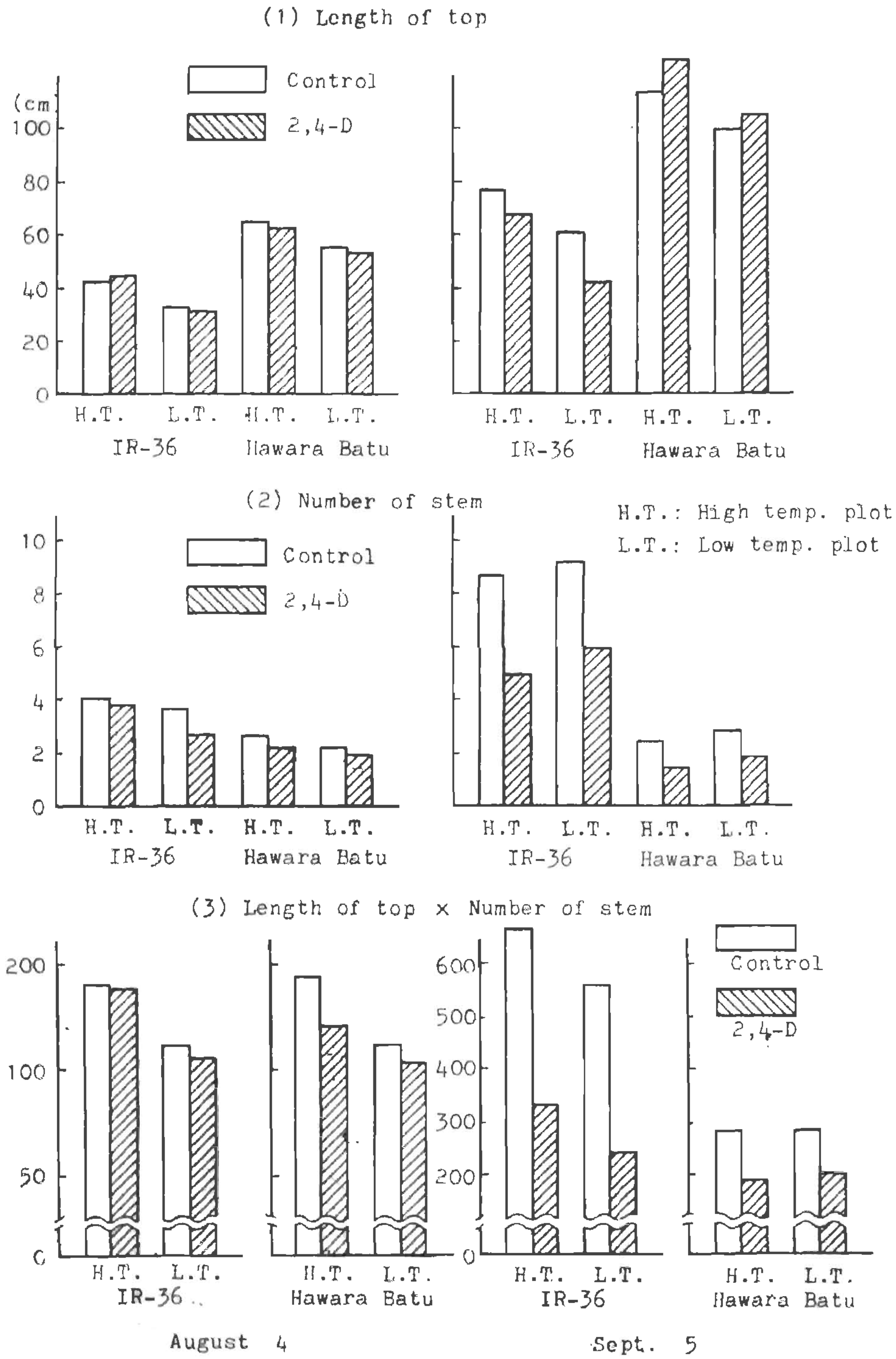


Fig. 1. Top growth as affected by 2,4-D and air temperature in indica and japonica varieties.(I)

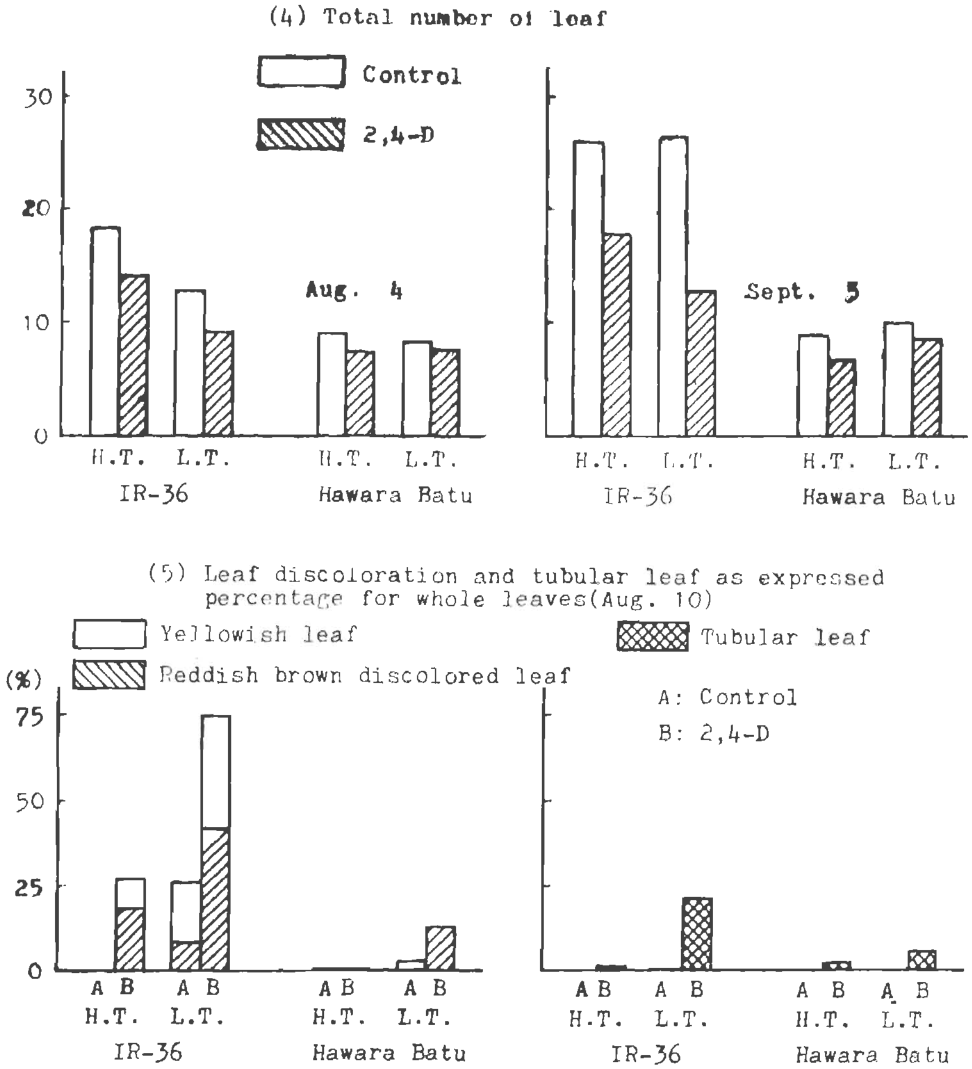
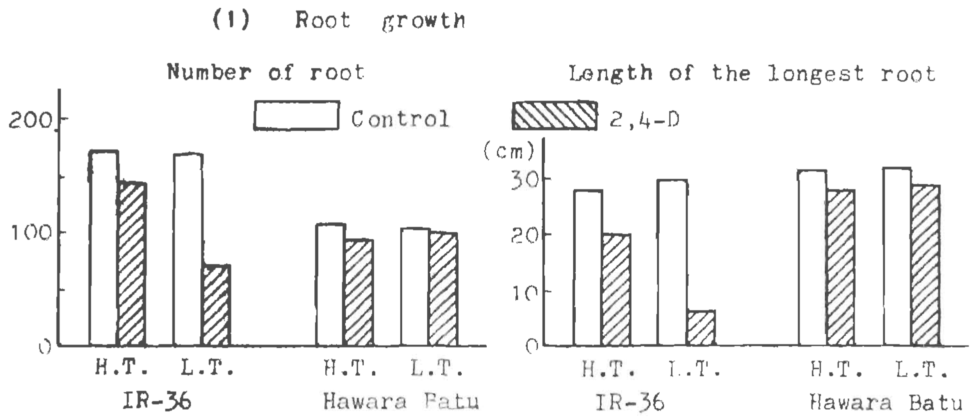


Fig. 2. Top growth as affected by 2,4-D and air temperature in indica and japonica rice varieties.(II)

Note; H.T. and L.T. : the same as in Fig. 1.



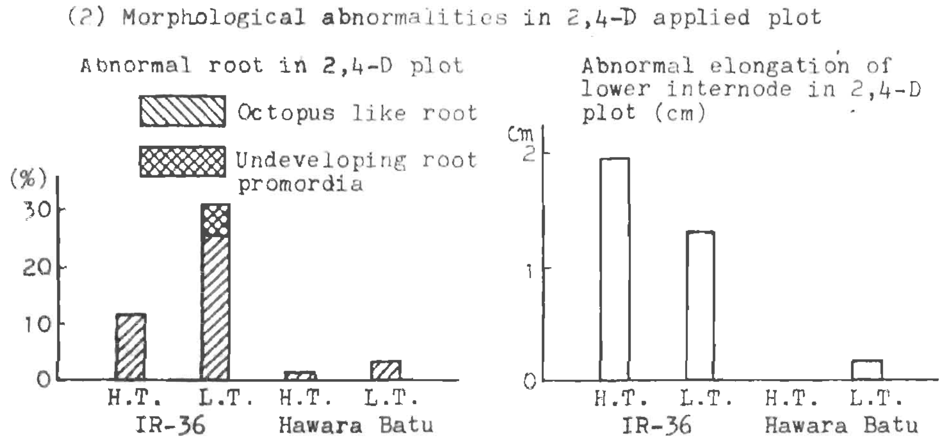


Fig. 3. Abnormalities of top and root caused by 2,4-D and air temperature.

Note; H.T. and L.T. : the same as in Fig. 1.

temperature was maintained at 24°C. The average temperature during the experiment in high temperature plot was 25.2°C. In the low temperature plot pots were placed in a growth cabinet room where temperature was maintained at 21.5°C.

RESULTS

The plant growth and abnormality caused by 2, 4-D were measured on August 4 and September 5, 1980.

Generally speaking, the retardation of top and root growth, caused by 2, 4-D were greater in IR-36 than Hawara Batu especially under low temperature conditions (Fig. 1, 2, 3).

The decrease in dry weight of the top caused by low temperature treatment was more remarkable in IR-36 than Hawara Batu (Fig. 4). The yellowish discoloration of the upper two leaves occurred 10 days aftet the application of 2, 4-D in IR-36 and followed by Hawara Batu. The yellowing of leaves was followed by the reddish brown discoloration, necrosis. The yellowish discolored leaves appeared even in the pots where 2, 4-D was not applied on low temperature plot (Fig. 2).

The occurrence of discoloration of leaves was greater in the next order. L.T. 2, 4-D (IR-36) > H.T. 2, 4-D (IR-36), L.T. Control (IR-36) < L.T. 2, 4-D (Hawara Batu) < L.T. Control (Hawara Batu).

The symptom of leaf discoloration was quite similar between 2, 4-D applied plot and low temperature and no 2, 4-D plot. Tubular leaf appeared 22 days after 2, 4-D application in 2, 4-D applied plot. Its appearance was more remarkable in low temperature plot as described by Noda (1977). As for root growth, the number of roots and the length of the longest root were reduced by 2,4-D application, especially under low temperature condition in IR-36 (Fig. 3), whereas they were only slightly decreased in Hawara Batu.

The appearance of thick and short, abnormal shaped roots, resemble "Octopus-tentacle-like" roots and undeveloping root primordia, was observed in 2, 4-D applied plots, especially in IR-36. The occurrence of abnormal roots was increased by low temperature treatment (Fig. 3).

Abnormal elongation of lower internode was observed in 2, 4-D applied plot, especially in IR-36 (Fig. 3). Evolution of ethylene from leaves induced by both 2, 4-D application and low temperature treatment, and a marked evolution of ethylene was observed in L.T. 2, 4-D plot in IR-36 (Table 1).

DISCUSSION

The experimental result showed that, generally speaking the susceptibility of rice plants to both factors, 2, 4-D injury and the low temperature is higher in IR-36 than in Hawara Batu. The most extreme growth inhibition and yellowing of leaves and appearance of abnormal roots were observed in 2, 4-D, low temperature plot in IR-36.

The yellowing symptom of leaves was similar to the symptom of iron chlorosis, and yellowing was partly recovered by spraying $EDTA_{Fe}$. Therefore, the yellowing of leaves observed in the above experiment is assumed to be a kind of iron chlorosis.

In general, rice varieties in tropical regions are highly susceptible to low temperature and are liable to show chlorosis (Okura and Haku, Miyata, 1942, Sato and Haku, 1980, Coly, 1980).

Takagi (1966) has found that rice seedlings grown in the organic-matter-free artificial soil showed chlorosis due to iron deficiency under flooded condition when the pH of the solution was high, above 6 and he called the phenomenon flooding-induced chlorosis.

Table 1 : Ethylene evolution from leaves as affected by 2, 4-D application under the different temperature conditions.

		Plot	Ethylene evolution from leaves	
			nl/g F.W./hr	%
H.T.	IR-36	Control	3.4	100
		2, 4-D	3.7	109
	Hawara Batu	Control	1.7	100
		2, 4-D	2.6	153
L.T.	IR-36	Control	4.3	100
		2, 4-D	11.6	270
	Hawara Batu	Control	4.8	100
		2, 4-D	5.7	119

Note : H.T.: High Temperature, L.T.: Low Temperature

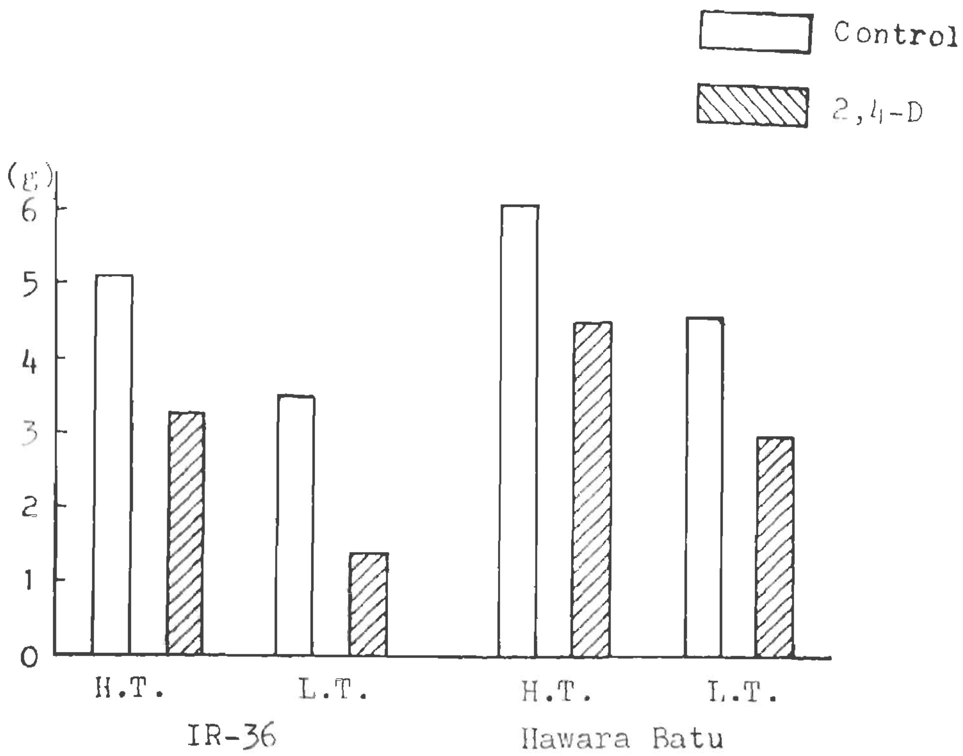


Fig. 4. Dry weight of top as affected by 2, 4-D and air temperature.
Note : H.T. and L.T.: the same as in Fig. 1.

He suggests that the cereal crops excrete some chelate substance which dissolves the insoluble iron adhering to the roots at the high pH level, preventing the occurrence of chlorosis while in the case of the rice plant such a root function is so poor compared with oat and barley plants. As a result, chlorosis easily appears.

The iron chelating substance was found to be muginetic acid, a new amino acid by Takemoto *et al.* (1978) and Takagi (1966) found that the flooding-induced iron chlorosis is more severe in indica variety than japonica ones. The same phenomenon was observed in the present study. The yellowing of leaves, chlorosis observed in this experiment is assumed to be similar to Takagi's flooding-induced chlorosis.

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GEOGRAPHICAL VARIATION OF ESSENTIAL OILS IN TUBERS OF PURPLE NUTSEDGE

KOICHIRO KOMAI * and KUNIKAZU UEKI **
* Faculty of Agriculture, Kinki University, Osaka, 577 Japan.
** Faculty of Agriculture, Kyoto University, Kyoto, 606 Japan.

ABSTRACT

Geographical variation of purple nutsedge (*Cyperus rotundus* L.) in sesquiterpenes was studied by analyzing the major components in tubers obtained from the Republic of China and Japan. Three chemo-types were found as follows:

(1) H-type: α-cyperone and ß-selinene

(2) M-type: α-cyperone, ß-selinene, cyperene and cyperenone

(3) O-type: cyperene and cyperenone.

Variation on the constitution of sesquiterpenes observed was inherited. The H-type was found in tubers collected from the regions of Okinawa, Kyushu, shikoku districts and the southern parts of Honshu up to Saitama Prefecture. The M-type was found in tubers from the southern Kyushu and Okinawa districts. But O-type was not found in the regions north up to the Tanegashima Island. Chemo-types of purple nutsedge tubers were also examined by using tubers from the other countries. There were differences among three chemo-types in such ecological and physiological characters as tuber production, seed production, seed weight, locusta length and plant height.

INTRODUCTION

Purple nutsedge *Cyperus rotundus* L., is a persistent weed with a worldwide distribution. It is native at India, and is known in Japan by the common name "HAMASUGE". The tubers remain viable in the soil for many years and are attacked by insects or other pests. The soil around tubers has a strong, pungent odor that might be responsible for resistance of the tubers to attack by insects and diseases. Recently, we have reported the phytotoxic effects of an extracted fraction of purple nutsedge on lettuce (*Lactuca sativa* L.), large crabgrass (*Digitaria adscendens* Henr.), broad leaved dock (*Rumex obtusifolius* L.) and white clover (*Trifolium repens* L.) and presented evidence that sesquiterpenes were related to the phytotoxicity (Komai and Ueki, 1980). The sesquiterpenes are quite likely to be responsible for resistance of nutsedge to disease and attack by insects and soil microorganisms. Nutsedge adapts to almost the soils with a wide range of soil types, humidities, soil moisture levels and pH from the tropical region to the temperate region. This fact on distribution of the plants suggests existence of the ecotypes. But there have been little studies on ecotypes of purple nutsedge. Ranade and Burns (1925) have described types from India with variation in glume color. Claver (1977) recognised different types of purple nutsedge from Argentine in growth and development. The present study was conducted with an objective to reveal geographical variation in components of purple nutsedge.

MATERIAL AND METHODS

One hundred eight clones of purple

nutsedge tubers were obtained from the Republic of China and the regions of Okinawa, Kyushu, Shiko Districts and the southern parts of Honshu up to Saitama Prefecture. Essential oils were extracted by steem distillation from grounded tubers, and sesquiterpenes were quantitatively and qualitatively determined by GC-MS analysis. On the other hand, the purple nutsedge reproduced from the clones were used to investigation of some characters after growth in pots for a period of 4 months.

RESULTS AND DISCUSSION

Gas chromatograms of essential oils extracted from each tuber of 180 clones are shown in Fig. 1. By the major components of sesquiterpenes in tubers of the nutsedge used were classified to three chemo-types (H, O, M-types). The H-type comprised mostly two bicyclic sesquiterpenes of α-cyperone and ß-selinene, and all the nutsedge collected from the Honshu were this type. But this type was also found in the regions of Okinawa, Kyushu, Shikoku districts. The O-type was composed of two tricyclic sesquiterpenes of cyperenone and cyperene and prevailed at the highest frequency in Okinawa region and not found in the regions north up to the Tanegashima Island. Further, the M-type contained all the above four sesquiterpenes in their tubers (Fig. 2). A preliminary examination of the tubers from other areas such as Thailand, Vietnam, China, Indonesia, Australia, United States of America, Brazil, Egypt and Isreal showed that all of them were either O- or M-types. Thus, these geographical variation of nutsedge in sesquiterpenes in tubers can be mainly owed to a climatic selection. The sesquiterpenes are C_{15} compounds derived from farnesyl pyrophosphate, which is then either *cis*- or *trans*- transformed into bicyclic or tricyclic skeleton.

As shown in Fig. 3, main sesquiterpenes in purple nutsedge are assumed to be biosynthesized through two pathways. Beta-selinene and its oxide, α-cyperone, are biosynthesized from guaiane through the tricyclic sesquiterpenes pathway. Nutsedge with H-type tubers are likely to biosynthesize sesquiterpenes through the former pathway and those with O-type tubers through the later pathway. But both the pathways may be operative in those nutsedge with M-type tubers. Many interesting terpenoid compounds have taxonomic significance. Fluck (1963) has indicated that changes in essential oils may arise from changes in the environmental conditions for plant growth. However, these experiments were carried out with the clonal materials and indicated that constitution of sesquiterpenes was altered neither by the environmental conditions nor plant ages. Some climatic factor that vary with both latitude and altitude seem to be involved in the molding of this geographical line in sesquiterpenes. There were also differences among the three eco-types in such ecological and physiological characters as tubers production, seeds production, seed weight and locusta length. The sesquiterpenes composition in purple nutsedge tubers can have a taxonomic significance.

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ALLELOPATHIC INFLUENCES OF THREE WEEDS ON TWO CROP PLANTS

S. C. DATTA and A. K. BANDYOPADHYAY
Department of Botany, University of Calcutta – 700 019, India.

ABSTRACT

When mustard and wheat plants were subjected to spray and soil applications of leaf and inflorescence-extracts of *Amaranthus spinosus* L., the vegetative and reproductive phases of the treated plants were seriously affected. In these experiments, the ærial spray was found to be more potent than the soil dressing. Though inflorescence-extracts of *Chrysopogon aciculatus* Trin., hampered the vegetative growth of mustard plants in the two forms of treatment, the reproductive growth of the same set of plants was not much inhibited. Similar extracts of *C. aciculatus* showed a greater inhibitory power over both vegetative and reproductive growth of wheat plants. The phytotoxicity of leaf-extracts of *Eupatorium odoratum* L., was noted to be high against vegetative as well as reproductive stages of both test plants. While both forms of extract application yielded reduction in growth values, the sprayed extracts were more effective than the soil-applied extracts.

INTRODUCTION

The phenomenon of allelopathy has been studied earlier (Whittaker, 1970; Datta and Sinha-Roy, 1974). Grümmer and Beyer (1960) recorded that flax plants in the vicinity of flax weeds (*Camelina alyssum*) formed 40% less dry matter than control plants. Bell and Kœppe (1972) reported that exudates of mature giant foxtail (*Setaria faberii*) roots inhibited growth of corn plants. Dubey (1973) studied the allelopathic effects of the weed *Digera alternifolia* Aschers., on several vegetables. Further, Rice (1974) observed that many species of weeds produce toxins that are inhibitory to other weeds and often to themselves. He also suggested that the same toxins would affect many crop plants.

MATERIAL AND METHODS

Taking into account the view point of Rice, a study was made on the effect of aqueous extracts of three weeds *Amaranthus spinosus* L. (Amarantaceæ), *Chrysopogon aciculatus* (Retz.) Trin. (Poaceæ) and *Eupatorium odoratum* L. (Compositæ) on the growth and development of two crop plants, mustard (*Brassica juncea*) Czern. & Coss) and wheat (*Triticum vulgare* L.). The weed-extracts were applied to the crops in two forms, ærial spray and soil dressing. While the leaf-extract was tried for *E. odoratum* and the inflorescence-extract for *C. aciculatus*, extracts of both plant-parts in the case of *A. spinosus*. As to the nature of phytotoxins, plant-extracts of the above weeds were chemically analysed and toxins identified.

Mustard and wheat seeds of a local variety were sown in 30 cm pots, containing loamy soil fertilised with cowdung manure. When sufficient number of seedlings emerged, they were thinned down to 10 per pot. Aerial spray and soil dressing of weed-extracts were started 25 days after sowing and followed on alternate days for 12 days (with a total of 6 applications per treatment). There were four pots per treatment. Adequate controls, which received no weed-extracts, were maintained throughout the experimental period of 3 months. All plants, whether treated or not, were watered as and when necessary.

Before every application, 20g of fresh material of leaf and inflorescence of *A. spinosus*, inflorescence of *C. aciculatus* and leaf of *E. odoratum* were ground separately with 100 ml of distilled water and kept as such overnight. The filtrate obtained from these crushed mass served as the stock aqueous extract and taken as 1 : 5 concentration from which 1 : 10 concentration was prepared by way of dilution. The two concentrations were applied in the case of ærial spray and the higher concentration only was used for soil dressing. The ærial spray consisted of spraying the aboveground part of the test plants with 100 ml of the leaf or inflorescence-extract per application by means of a mouth sprayer. For soil dressing, the same amount of extract was poured each time directly into the pots where the test plants were raised.

All treated and untreated plants were allowed to grow into maturity. Results from various treatments were compared to the corresponding controls and the level of significance was judged by the standard 't' test.

Since the repository plant-parts of the three weeds were suspected to contain inhibitors, they were systematically extracted with various organic solvents. The extract obtained from each solvent was assayed for inhibitory capacity against the seed germination of mustard. In case of *A. spinosus*, benzene, chloroform and petroleum-ether extracts were inactive while acetone, ethanol and methanol extracts were extremely active. Benzene, petroleum ether, chloroform and ethylether extracts of both *C. aciculatus* and *E. odoratum* were less inhibitory but methanol and ethanol extracts were highly inhibitory. In order to know the chemical nature of the suspected solvent-extracts, each was concentrated, fractionated and ultimately purified by column chromatography. After purification, each type of compound was identified by R_f values, chromogenic tests and other physical properties like mp, UV and IR absorption spectrum.

RESULTS AND DISCUSSION

(a) Effect of leaf – and inflorescence -extract of A. spinosus *on mustard*

As compared to the control, the height of mustard plants was significantly reduced by both ærial spray and soil dressing with *A. spinosus* extracts (Table 1). Although 1 : 5 and 1 : 10 concentrations of sprayed leaf-extract were more effective in reducing plant height than the corresponding soil-applied leaf-extract, 1 : 10 concentration of sprayed inflorescence-extract was as strong as similar extract placed in the soil. Root lengths of treated plants were lowered by higher concentration of the two extracts regardless of their mode of application. In lowering root lengths, the leaf-extract appeared to be more potent than the inflorescence-extract. Except at higher concetration of the leaf – and inflorescence-extract, the number of branches did not decrease significantly.

Flower formation in mustard plants was significantly inhibited by 1 : 5 concentration of both leaf and inflorescence-extract, with the ærial spray being more effective than the soil dressing. At the same concentration and under the impact of ærial spray, fruit yield as well as fruit length were more curtailed by the leaf-extract than by inflorescence-extract. The number of seeds per fruit was significantly lowered when the leaf-extract was applied; this was only true for higher contraction of ærial spray of the inflorescence extract. At 1 : 5 concentration of both leaf and inflorescence-extracts, there was a significant reduction in the number of seeds per plant. At the same concentration, dry weight of plants registered a decrease following the ærial spray of the

Table 1: Mustard plants as affected by spray and soil application of *A. spinosus* leaf and inflorescence-extract.

Growth parameter	Control	Leaf			Inflorescence		
		Aerial spray		Soil dressing	Aerial spray		Soil dressing
		1:5	1:10	1:5	1:5	1:10	1:5
Plant height (cm)	49.4 ±1.64	29.0 ±2.09***	34.9 ±1.78***	41.05 ±1.99**	30.5 ±1.92***	36.3 ±1.62***	36.7 ±2.29***
Root length (cm)	16.2 ±1.13	11.5 ±1.57*	16.6 ±1.03	11.5 ±0.79**	14.4 ±1.29	17.2 ±0.95	13.0 ±0.59*
Branches/ plant	4.3 ±0.34	3.4 ±0.31	4.1 ±0.28	3.2 ±0.29*	3.4 ±0.27*	3.9 ±0.28	3.5 ±0.27
Leaves/ plant	12.8 ±1.25	10.3 ±1.08	11.0 ±0.67	10.8 ±0.68	11.3 ±1.07	12.2 ±0.53	11.4 ±0.86
Flowers/ plant	75.4 ±4.46	36.2 ±5.15***	60.6 ±6.83	61.9 ±6.70	40.4 ±4.91***	66.1 ±5.49	54.3 ±4.77**
Fruit/ Plant	26.1 ±2.15	12.8 ±2.45***	25.8 ±2.68	21.0 ±1.99	16.0 ±1.77***	27.7 ±2.58	20.8 ±2.02
Fruit length (cm)	5.7 ±0.22	4.2 ±0.54*	5.5 ±0.17	5.3 ±0.18	5.05 ±0.30	5.4 ±0.35	5.1 ±0.25
Seeds/ fruit	15.1 ±0.80	9.8 ±1.49**	11.7 ±1.18*	12.0 ±0.93*	11.0 ±1.28*	13.6 ±1.20	12.5 ±0.85
Seeds/ plant	394.0 ±32.44	125.4 ±23.97***	301.6 ±31.29	252.0 ±23.88	145.3 ±17.38***	315.7 ±31.74	259.7 ±25.29**
Dry wt/ Plant (g)	1.05 ±0.12	0.55 ±0.07**	0.95 ±0.12	0.97 ±0.11	0.73 ±0.08**	0.97 ±0.10	0.75 ±0.07**

't' value significant at p = 0.05*, 0.01**, 0.001***

leaf-extract as well as the ærial spray and soil dressing of the inflorescence-extract.

(b) Effect of leaf- and inflorescence -extract of A. spinosus *on wheat*

The height of wheat plants was significantly lowered by 1:5 and 1:10 concentrations of ærial spray of extracts of leaf and 1:5 concentration of inflorescence material of *A. spinosus,* with the leaf-extract being more effective than the inflorescence-extract (Table 2). Tiller number was significantly reduced by higher concentration of the ærial spray of the leaf-extract and soil-dressing of the inflorescence-extract. Leaf production was significantly inhibited by the ærial spray of the two extracts - 1:5 concentration of the leaf-extract and 1:5 and 1:10 of the inflorescence-extract; here the inflorescence-extract was more effective than the leaf-extract.

As to ear number, 1:5 concentration of the ærial spray of the leaf-extract as well as soil dressing and ærial spray of the inflorescence-extract was inhibitory. Ear length of wheat plants was significantly decreased with almost all treatments of leaf and inflorescence-extract. In this case, the inflorescence-extract proved to be more effective than the leaf-extract. The weight of ears re-

Table 2: Wheat plants as affected by spray and soil application of *A. spinosus* leaf and inflorescence-extract.

Growth parameter	Control	Leaf			Inflorescence		
		Aerial spray		Soil dressing	Aerial spray		Soil dressing
		1:5	1:10	1:5	1:5	1:10	1:5
Plant height (cm)	52.4 ±1.48	40.3 ±1.56***	46.4 ±2.33*	49.3 ±1.58	39.6 ±3.63**	50.0 ±2.21	54.9 ±1.52
Tillers/ plant	3.0 ±0.30	1.8 ±0.20**	3.1 ±0.31	2.5 ±0.17	2.4 ±0.22	3.0 ±0.29	2.2 ±0.36*
Leaves/ plant	14.5 ±1.16	9.7 ±0.75**	12.7 ±1.41	13.6 ±1.16	8.0 ±0.65***	10.6 ±0.81*	15.1 ±2.56
Ears/ plant	2.7 ±0.30	1.5 ±0.17**	2.5 ±0.34	2.0 ±0.26	1.7 ±0.15**	2.1 ±0.23	1.9 ±0.23*
Ear length (cm)	7.5 ±0.32	5.6 ±0.29***	6.8 ±0.49	6.2 ±0.39	6.2 ±0.24**	6.5 ±0.29*	6.9 ±0.12*
Ear wt (g)	0.9 ±0.08	0.4 ±0.09***	0.8 ±0.10	0.5 ±0.03***	0.5 ±0.06***	0.6 ±0.09*	0.9 ±0.04
Grains/ ear	17.3 ±0.70	8.5 ±1.78***	18.1 ±2.59	14.4 ±1.87	13.3 ±0.80**	14.4 ±1.19	17.2 ±1.22
1000-grain wt (g)	4.60 ±0.09	2.7 ±0.14***	3.4 ±0.14***	3.6 ±0.17***	2.8 ±0.09***	4.5 ±0.08	3.9 ±0.13**

corded a decrease following the soil dressing and ærial spray of 1:5 concentration of the leaf-extract as well as the ærial spray of 1:5 and 1:10 concentrations of the inflorescence-extract. The number of grains per ear was significantly reduced by 1:5 concentration of the leaf-extract as well as 1:5 and 1:10 concentrations of the inflorescence-extract, all under the influence of ærial spray; here the leaf-extract seemed to be more inhibitory than the inflorescence-extract at 1:5 concentration and the inflorescence-extract more than the leaf-extract at 1:10 concentraction. The grain yield per plant was reduced considerably, being more by the ærial spray than by the soil dressing and more by higher concentrations of the inflorescence-extract. The 1000 grain weight decreased significantly with all treatments of the leaf-extract and two treatments of the inflorescence-extract. In both cases, the same concentration of the ærial spray was more effective in reducing the grain weight than the soil dressing.

(c) *Effect of inflorescence-extract of C. aciculatus* on mustard

In comparison with the control, the height and root length of mustard plants were significantly lowered by both soil dressing and ærial spray *C. aciculatus* inflorescence-extract (Table 3). Although these effects were observed at 1:5 concentration, inhibition was more by ærial spray than by soil dressing. While there was no difference between the two treatments, the number of branches decreased with the use of higher concentration of the extract.

Table 3: Mustard plants as affected by spray and soil application of *C. aciculatus* inflorescence-extract.

Growth parameter	Control	Aerial spray 1:5	Aerial spray 1:10	Soil dressing 1:5
Plant height (cm)	49.4 ±1.64	31.2 ±1.49***	51.5 ±1.84	37.9 ±2.43**
Root length (cm)	16.2 ±1.13	10.7 ±0.78***	16.3 ±0.88	12.7 ±0.52*
Branches/ plant	4.3 ±0.34	3.3 ±0.26*	4.2 ±0.25	3.2 ±0.47*
Leaves/ plant	12.8 ±1.25	10.8 ±0.84	12.9 ±1.28	10.8 ±1.34
Flowers/ plant	75.4 ±4.46	60.4 ±7.39	79.1 ±4.42	54.6 ±4.19**
Fruits/ plant	26.1 ±2.15	24.6 ±3.71	30.1 ±2.29	22.0 ±3.63
Fruit length (cm)	5.7 ±0.22	5.4 ±0.27	5.8 ±0.61	5.6 ±0.20
Seeds/ fruit	15.1 ±0.79	13.6 ±1.01	16.1 ±0.55	13.5 ±2.51
Dry wt/ plant (g)	1.05 ±0.12	0.80 ±0.14	1.05 ±0.12	1.05 ±0.12

Flower formation in mustard plants was significantly inhibited by 1 : 5 concentration of the extract when applied in the form of soil dressing only.

(d) *Effect of inflorescence-extract of C. aciculatus on wheat*

The height of wheat plants was lowered by the ærial spray and not by the soil dressing, with 1 : 5 concentration being more inhibitory than 1 : 10 concentration (Table 4). However, tiller number was significantly reduced by the soil dressing of the inflorescence extract and not by the ærial spray of the same; the latter treatment significantly inhibited leaf production.

Ear number and ear length decreased significantly following the ærial spray of 1 : 5 concentration of the inflorescence-extract; here the lower concentration of the same application and the higher concentration of the soil dressing were ineffective. The number of grains per ear was significantly inhibited by the ærial spray and not by the soil dressing, with the higher concentration being more inhibitory than the lower one. The grain yield per plant was reduced considerably, being most by ærial spray of 1 : 5 concentration and lower concentration of the same application was as effective as soil dressing of 1 : 5 concentration. Ear weight and 1000 grain weight decreased significantly with ærial spray of higher concentration only.

(e) *Effect of leaf-extract of E. odoratum on mustard*

Plant height, root length, branch number, leaf production, flower formation, fruit yield, fruit length and seed number per fruit decreased significantly following the use of the leaf-extract of *E. odoratum* in soil and

Table 4 : Wheat plants as affected by spray and soil application of *C. aciculatus* inflorescence-extract.

Growth parameter	Control	Aerial spray 1:5	Aerial spray 1:10	Soil dressing 1:5
Plant height (cm)	52.4 ±1.48	40.7 ±2.53***	45.1 ±2.09*	53.2 ±1.38
Tillers/ plant	3.0 ±0.30	2.3 ±0.26	2.8 ±0.20	2.2 ±0.20
Leaves/ plant	14.5 ±1.16	9.7 ±1.07**	13.6 ±1.21	11.6 ±1.02
Ears/ plant	2.7 ±0.30	1.8 ±0.20*	2.4 ±0.22	2.1 ±0.23
Ear length (cm)	7.5 ±0.32	6.7 ±0.22	7.3 ±0.27	7.3 ±0.40
Ear wt (g)	0.9 ±0.08	0.7 ±0.07**	0.8 ±0.07	0.9 ±0.07
Grains/ ear	17.3 ±0.70	11.2 ±1.59**	13.3 ±1.46*	15.5 ±1.70
1000-grain wt (g)	4.6 ±0.09	3.9 ±0.09***	4.5 ±0.09	4.5 ±0.08

ærial surface of plants (Table 5). In almost all treatments, the ærial spray was better than the soil dressing. The dry weight of plants was lowered in soil dressing and ærial spray, both being at 1 : 5 concentration.

(f) *Effect of leaf-extract of E. odoratum on wheat*

The height of wheat plants was significantly lowered by both soil dressing and ærial spray of *E. odoratum* leaf-extract (Table 6). However, tiller number was significantly reduced by ærial spray of 1 : 5 concentration and not by soil dressing of the same concentration. Leaf production was significantly inhibited by the ærial spray.

While ear length did not decrease significantly with the ærial spray and soil dressing, ear number decreased significantly in both treatments. The weight of ears recorded a decrease with the ærial spray and not with the soil dressing. The number of grains per ear was significantly inhibited by both treatments. The 1000-grain weight decreased significantly with ærial spray of higher concentration only.

(g) *Chemical nature of phytotoxins*

In *A. spinosus*, two active compounds were isolated, one being a liquid and the other a solid (mp. 90° C). The R_f values (in TLC) of the two constituents in benzene : chloroform mixture (1 : 1) were calculated to be 0.20 and 0.98 respectively. The oily liquid responded to Ninhydrin and Earlisch reagents, but the solid responded to 2,4-dinitrophenylhydrazine and conc. H_2SO_4. The UV absorption of the liquid showed peaks at 223, 231, 258 and 285 nm and the solid showed end absorption. The IR data of the liquid proved that the compound contained $-NH_2$ functions as well as carbonyl and alkene groups but the solid contained $-CH_2$ chain and carbonyl function. From these findings as well as elemental analysis and molecular weight

Table 5: Mustard plants as affected by spray and soil application of *E. odoratum* leaf-extract.

Growth parameter	Control		Aerial spray	Soil dressing
		1:5	1:10	1:5
Plant height (cm)	31.0 ±2.88	12.6 ±1.43***	16.2 ±1.61***	18.2 ±1.66**
Root length (cm)	16.2 ±0.91	11.2 ±0.67***	11.3 ±0.80***	8.9 ±1.07***
Branches/ plant	3.3 ±0.30	1.2 ±0.20***	1.4 ±0.43**	1.8 ±0.47*
Leaves/ plant	12.6 ±0.95	5.2 ±0.29***	6.8 ±0.70***	9.3 ±1.03*
Flowers/ plant	40.9 ±2.70	22.4 ±1.70***	25.1 ±1.91***	28.8 ±2.57**
Fruits/ plant	21.0 ±1.74	10.7 ±0.94***	11.3 ±0.88***	14.3 ±1.28**
Fruit length (cm)	5.5 ±0.25	1.7 ±0.39***	3.7 ±0.29***	3.8 ±0.23***
Seeds/ fruit	14.0 ±0.84*	3.1 ±0.81***	8.4 ±1.26**	11.0 ±0.88*
Dry wt/ plant (g)	0.8 ±0.09	0.5 ±0.05	0.6 ±0.07	0.4 ±0.03**

Table 6: Wheat plants as affected by spray and soil application of *E. odoratum* leaf-extract.

Growth parameter	Control	Aerial spray	Soil dressing	
		1:5	1:10	1:5
Plant height (cm)	54.9 ±1.73	43.0 ±2.08***	45.0 ±1.91**	48.1 ±2.34*
Tillers/ plant	2.7 ±0.15	2.1 ±0.23*	2.3 ±0.20	2.7 ±0.15
Leaves/ plant	15.8 ±1.29	10.3 ±0.49***	11.9 ±0.98	13.1 ±0.89
Ears/ plant	1.4 ±0.16	1.0 ±0*	1.0 ±0*	1.0 ±0*
Ear length (cm)	9.05 ±0.93	7.9 ±0.37	8.3 ±0.39	8.0 ±0.19
Ear wt (g)	1.5 ±0.16	0.9 ±0.12	0.9 ±0.11*	1.4 ±0.18
Grains/ ear	22.1 ±1.60	14.9 ±1.61**	15.3 ±1.59**	15.6 ±1.51*
1000-grain wt. (g)	4.5 ±0.56	2.9 ±0.12*	3.4 ±0.41	4.9 ±0.40

determination of the liquid by mass spectrometry M^+ 281), it may be concluded that the molecular formula of the liquid was $C_{17}H_{31}NO_2$. The solid showed molecular ion-peak at M^+506, which along with the above facts indicated that the solid may be a keto-derivative of a long-chain fatty compound ($C_{32}H_{58}O_4$).

C. aciculatus inflorescence-extract furnished two solid crystalline compounds. The first one had a melting point of 165-166° C and responded to $FeCl_3$ solution. The R_f values (in PC) and in different solvent systems like n-butanol : acetic acid : ethanol : water (4 : 1 : 2 : 2) were 0.88, 0.12 and 0.82 respectively. It showed UV absorption peaks at 235 and 324 λ nm as well as it indicated NaOH shift at 344 λ nm. From these observations, it seemed that the compound may be ferulic acid, the structure of which was further confirmed by direct comparison with an authentic sample. The second one also responded to $FeCl_3$ and showed UV absorption peaks at 227 and 310 λ nm. Moreover, it also showed NaOH shsift at 350 λ nm. The R_f values of the compound (in PC) and in the above mentioned solvents were 0.92, 0.16 and 0.88 respectively. From these findings, it can be stated that the compound may be p-coumaric acid, the structure of which was also determined by direct comparison with an authentic sample.

From the leaf-extract of *E. odoratum*, three active compounds were isolated. The first one was a yellow compound (mp. 185° C); it responded to alcoholic $FeCl_3$ and Mg-kurnings + HCl test and showed UV absorption peaks at 330 and 274 λ nm. The IR spectrum of the compound indicated that it contained a chelated carbonyl group, aromatic system and p-substituted phenyl ring but no band for OH (pointing out the presence of five -OH group). All these data showed that the compound was identical with salvigenin. Direct comparison with authentic salvigenin also led to the same conclusion. The second compound had paleyellow crystals (mp. 257° C), responding to Shinoda's test and giving violet colour with alcoholic $FeCl_3$. It showed UV absorption peaks at 325, 291 and 282 λ nm and bathocaromatic shift when treated with $AlCl_3$ (pointing out the existence of a free 5-OH group). The IR spectrum of the compound showed that it contained a free OH group and a carbonyl group which was not chelated (λ max cm^{-1} 3200 and 1600). All these data, along with direct comparison with an authentic sample, revealed that the compound may be acacetin. The last compound possessed white crystals (mp. 199° C) which responded to Liebermann Buchard test and gave a red colour when treated with conc. H_2SO_4. These colour reactions indicated that the compound may be a terpene. Furthermore, it did not show any characteristic peak in UV spectrum and showed peaks for OH group (λ max in cm^{-1} 3250) and Me group (λ max in cm^{-1} 1450) in the IR spectrum. Thus, the data indicated that the compound may be ß -amyrin which was further confirmed by direct comparison with an authentic sample.

The foregoing will convince one that extracts of *A. spinosus, C. aciculatus and E. odoratum* are endowed with allelopathic activity. However, the activity depends on the type of the extract, the concentration of the extract, the manner of extract application and the kind of the test plant. where both leaf-extract and inflorescence-extract are used, the former is more potent than the latter. As to the two concentrations of the extract, 1 : 5 is generally more effective than 1 : 10. With respect to the dual treatments, the ærial spray of the extract is more effective than the soil dressing of the extract. While *A. spinosus* extract is equally effective on wheat and mustard plants, wheat plants are more strongly affected than mustard plants by *C. aciculatus* extract and mustard plants are more adversely affected than wheat plants by *E. odoratum* extracts.

As each weed extract acts differently on each test crop, it is necessary to analyse the extract of each plant material and find out the inhibitory principle responsible for carrying out the allelopathic effect. The toxicity of leaf-and inflorescence-extract of *A. spinosus* is ascribed to a peptide and a long-chain fatty compound. In case of *C. aciculatus* inflorescence, the inhibition is due to the presence of two phenolics – p – coumaric and ferulic acid. Flavonoids like acacetin and salvigenin and a terpene ß-amyrin are identified from *E. odoratum* leaves.

More crop plants should be subjected to the treatment of weed extracts, using a wide range of concentrations for both ærial spray and soil dressing. At the same time, the treatment should be started at the flowering rather than at the seedling stage.

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ALLELOPATHY IN *ARGEMONE MEXICANA* L.

D. LEELA
Division of Plant Physiology, Indian Institute of Horticultural Research
Bangalore-560 080, India.

ABSTRACT

Soaking the seeds for 24 hr in aqueous leaf leachates of *Argemone mexicana* resulted in total inhibition of germination in mustard, fenugreek and wheat and reduction in germination and seedling growth in sorghum, cucumber, tomato and fingermillet. Flower of Argemone brought about maximum reduction of germination in wheat compared to other parts of the plant. The inhibitors were of phenolic nature belonging to cinnamic and benzoic acids. The total yield of phenolic contents in both leaves and ovaries was 50–60 mg/100 g dry weight when methanol was used as extraction agent and 10 and 20 mg respectively when distilled water was used. The phenolic contents in the soils taken at 0.5–1.0 cm depth under the canopy of natural stand of Argemone was 0.2 – 0.3 mg/100 g dry weight of soil. The residues of air dried leaves of Argemone in soil had harmful effect up to 10 days and promotory effect after 20 days on the growth of wheat seedlings.

INTRODUCTION

The production and release of allelopathic substances into the environment by many plants have been reported earlier (Kosh Khui and Bassiri, 1979, Drost and Doll, 1980. *Argemone mexicana* is an obnoxious weed found in large numbers in abandoned fields. Singh (1977) reported that root exudates and root extracts of *A. mexicana* have varying effects on the growth of some fungi in culture. So far there is no report of the allelopathic effects of *A. mexicana* on the crop plants. This work was taken up with a view to study the presence and distribution of the allelopathic factor within the weed and its effect on the germination and seedling growth of some selected horticultural and cereal crops. The nature of the allelopathin, its estimation and behaviour under natural conditions was also included in this study.

RESULTS AND DISCUSSION

The aqueous leaf leachates from *A.mexicana* inhibited the germination of mustard, fenugreek and wheat, brought about varying degrees of reduction in germination per cent in crops like sorghum, cucumber and fingermillet when their seeds were soaked for 24 hr in 10 ml of leachate (equivalent to 5 g dry weight of leaves) and germinated in petridishes (Table 1). In wheat, even 8 hr soaking brought about reduction in germination (81.6%) compared to control (98%) which was significant at 1% level. The shoot and root length were significantly less in case of cucumber and tomato. In fingermillet, only the root length were significantly affected compared to coleoptile. Similar inhibitions of seedling growth were observed in wheat and fenugreek (Ambika and Jayachandra, 1980) when they were germinated in petridishes containing aqueous leaf leachates of *Parthenium hysterophorus* L. and *Eupatorium odoratum* respectively. Drost and Doll (1980) found that the extracts of tubers and foliage of nutgrass decreased the dry weight of corn and soyaben.

Table 1 : Effect of soaking for 24 hr in aqueous leaf leachates of *Argemone mexicana* on the germination and seedling growth of crops at the end of 96 hr.

Crop species	Germination per cent				Root length (cm)				Shoot length (cm)			
	Control	Leaf leachate	SEm±	CD5%	Control	Leaf leachate	SEm±	CD5%	Control	Leaf leachate	SEm±	CD5%
Tomato	52.0	52.0	0.82	0.00	2.80	0.49	0.05	0.30	6.14	1.03	0.09	0.57
Sorghum	52.0	5.3	3.70	23.0	4.20	1.20	1.20	0.00	5.90	1.77	0.85	0.00
Finger-millet	84.0	62.3	1.70	10.3	0.32	0.25	0.09	5.60	1.93	1.20	0.03	0.00
Mustard	75.0	0.0	0.00	0.00	2.76	0.00	0.00	0.00	3.02	0.00	0.00	0.00
Cucumber	76.6	8.3	4.20	25.9	6.03	2.60	0.38	2.30	9.73	1.20	0.10	0.63
Fenugreek	100.0	0.0	0.00	0.00	2.20	0.00	0.00	0.00	2.80	0.00	0.00	0.00
Wheat	100.0	0.0	0.00	0.00	4.26	0.00	0.00	0.00	4.90	0.00	0.00	0.00

Flower of Argemone brought about significant reduction in germination of wheat followed by leaf and mature seed (Table 2). This might be due to the presence of more water soluble inhibitors in the ovaries than in leaves as reported in this paper. When floral parts were separated, the germination of wheat was not affected. This clearly shows that the inhibition of germination by the total flower is due to the combined effect of the inhibitors present in various parts of flower. Maximum reduction in the length of the coleoptile was brought about by total flower and ovary respectively. Flowers, buds, fruit covers and leaves of *Myrtus communis* (Khos Khui and Bassiri, 1979) had the greatest inhibitory effect on the germination and seedling growth of *Lolium perenne*. In *P. hysterophorus* (Sukhada, 1975), the concentration of the inhibitor was highest in leaves followed by inflorescence and fruits. In *E. odoratum* (Ambika and Jayachandra, 1980) the highest concentration of inhibitor was found in leaves followed by cypsella and root material.

The non acidic fraction did not inhibit the growth of wheat seedlings (wheat bioassay) and thus omitted from further studies. The acidic fraction answered the bioassay test and all the other tests for phenolic compounds. The inhibitors be-

Table 2 : Effect of different parts of Argemone on the germination and seedling growth of wheat.

Treatment	Germination per cent	Coleoptile length (cm)
After 48 hr		
Control	100.0	1.32
Leaf	62.7	0.31
Stem	100.0	0.95
Root	100.0	1.32
Flower	13.4	0.18
Immature fruit	91.1	0.8
Mature fruit	100.0	0.9
Immature seed	95.5	1.27
Mature seed	85.1	1.32
S Em±	3.3	0.06
CD 5%	10.0	0.19
After 24 hr		
Control	85.0	0.98
Petal	80.0	0.32
Stamen	86.6	0.31
Ovary	86.0	0.28
S Em±	1.8	0.009
CD 5%	–	0.03

Table 3: Residual effect of air-dried leaf material of *Argemone mexicane* on the growth of one week old wheat seedlings.

Days	Germination per cent					Coleoptile length (cm)					Dry wt. of coleoptile (mg)					Root length (cm)					Dry wt. of root (mg)				
	Con.	5 g	10 g	20 g	Mean	Con.	5 g	10 g	20 g	Mean	Con.	5 g	10 g	20 g	Mean	Conc.	5 g	10 g	20 g	Mean	Conc.	5 g	10 g	20 g	Mean
1	93.3 (81°)	46.6 (43°)	53.3 (47°)	46.6 (43°)	53.3	10.4	4.8	4.8	5.9	6.4	20.0	8.4	8.4	8.2	11.3	4.7	0.7	2.8	0.6	2.2	10.0	4.8	4.8	1.4	5.3
10	86.7 (72°)	93.3 (81°)	66.6 (55°)	46.6 (43')	62.8	4.1	4.3	4.1	4.6	4.3	4.0	4.3	3.4	4.6	4.1	2.5	2.7	2.8	2.8	2.7	3.9	2.5	3.3	2.9	3.2
20	86.6 (72°)	86.6 (72°)	86.6 (72°)	40.0 (39°)	63.9	5.7	10.6	9.6	9.1	8.8	6.2	11.6	9.9	8.9	9.2	3.6	6.6	4.8	4.3	4.8	5.2	8.6	6.1	6.9	6.7
	75.2	65.3	58.0	41.5		6.7	6.6	6.2	6.5		10.1	8.1	7.3	7.2		3.6	3.3	3.5	2.6		6.4	5.3	4.7	3.7	
F Test																									
D			NS					**					**					**					**		
Tr			**					NS					**					*					**		
D x Tr			NS					**					**					**					**		
CD 5 %																									
D			–					1.0					1.40					0.65					0.86		
Tr			14.1					–					1.60					0.75					0.99		
D x Tr			–					2.1					3.80					1.30					1.70		

longed to the group of cinnamic and benzoic acids. The Rf values (0.30, 0.43, 0.56, 0.64, 0.72, 0.79) and their fluorescence under UV light compared well with ferulic acid, P-coumaric acid, vanillic acid, P-hydroxy benzoic acid and caffeic acid respectively when co-chromatographed with authentic samples. The last band with Rf 0.79 could not be identified.

In the present study, the total phenolic content (in terms of caffeic acid) in the leaves and ovaries was respectively 10 and 20 mg/100 g dry weight when distilled water was used for extraction and 50-60 mg/100 g dry weight when methanol was used. Thus methanol proved to be a better extraction agent than distilled water. In the stem of *P. hysterophorus* (Sukhada, 1975), the total phenolic content (in terms of caffeic acid) was 30 mg/100 g dry weight and in the leaf, cypsella and root of *Eupatorium* (Ambika and Jayachandra, 1980), was respectively 343, 289 and 173 mg/100 g dry weight when distilled water was used for extraction. The phenolic contents in the soils taken at 0.5-1.0 cm soil depth under the canopy of natural stand of Argemone was 0.2-0.3 mg/100 g dry weight of soil.

The residues of air dried leaves of Argemone had harmful effect up to 10 days and promotory effect after 20 days on the growth of wheat seedlings (Table 3). The harmful effect of leaf residues lasted up to 20 days and disappeared completely by 30th day in case of *P. hysterophorus* (Sukhada and Jayachandra, 1979) as evidenced by wheat bioassay. The same leaf residues had promotory effect on the growth and yield of bajra.

A survey of natural stand of Argemone indicated that a single healthy plant would give approximately 130 g of fresh weight of leaves or 30 g dry weight of leaves. Considering the fact that the leaves bring about inhibition of germination and seedling growth of some selected crop species even at 0.5 g dry weight, the problem encountered by these crops planted in nature could be enormous especially when one thinks of cultivating the fallow fields where Argemone is growing in abundance. Proper care should be taken to see that no residues of plant parts of Argemone are left in the soil before sowing of crop plants. Otherwise temporary set back in germination and seedling growth may occur. Possibility of using *A. mexicana* as organic manure in some crop plants may also be investigated as they had promotary effect on the growth of wheat seedlings after remaining in soil for 20 days.

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CYANAZINE – A VERSATILE MEMBER OF A VERSATILE GROUP

R. G. JONES and R. A. AH-SUN
Shell International Chemical Company Limited, London.

ABSTRACT

Examination of the two series of triazine the chlorotriazines and the methylthiotriazines, shows that there are basic differences in properties between them. Cyanazine seems to combine some of the best features of both groups.

Although Cyanazine is a chlorotriazine it has a higher solubility than the other members of this series which means that it enters into soil solution very readily and is also taken up by weeds through their foliage. While the solubility of Cyanazine is similar to that of the methylthiotriazines it does not have the disadvantage of a high P.K. value which means that its leaching characteristics are optimal for a wide crop use. The leachability of Cyanazine is similar to atrazine but because of its higher solubility entry of Cyanazine into soil solution is faster.

While other chlorotriazines have medium to long soil persistance Cyanazine has short persistance – similar to the methylthiotriazines. This is a useful property in most agricultural crops where residues may harm succeeding crops. Where increased persistance is necessary Cyanazine may be mixed with reduced rates of more persistant herbicides.

In common with the other triazines crop tolerance is usually dependent on depth protection. However, in maize tolerance to Cyanazine is physiological; like the other chlorotriazines Cyanazines is broken down by benzoxazine in the maize sap.

Cyanazine controls a broad range of weeds – including some grasses such as *Panicum, Digitaria* and *Setaria spp.* which have proved resistance to atrazine. The weed spectrum can be widened further by the use of herbicide mixtures. The effect of Cyanazine on emerged weeds can be usefully employed by post-emergence application in a number of crops such as cereals, peas and maize.

The choice of application rate of the triazines is dependent on the soil type, soil organic matter, soil moisture, weed spectrum and crop. With judicious choice of application rate Cyanazine can be used in a wider range of crops than any of its fellow triazines. Cyanazine is undoubtedly the most versatile member of an extremely versatile herbicide group.

INTRODUCTION

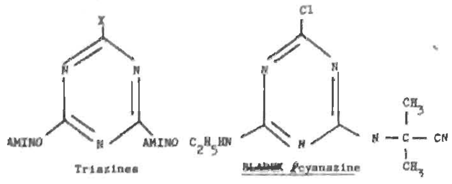
The triazine herbicides have proved to be extremely important to world agriculture. The diverse properties of the group members confer on the triazines a great versatility as is shown by their use on a wide range of crops in many geographic locations.

In this paper an attempt has been made to examine the properties of the triazine group and the way in which these properties influence usage recommendations. The Shell triazine cyanazine **Bladex** is used as an example. Cyanazine combines in one herbicide many of the outstanding features of the whole group, making it an extremely versatile herbicide which is used in many crops.

Chemical structure of the triazines

The chemical structure is based on a triazine ring which carries substituted amino groups at two of the carbon atoms and a chloro, methylthio or methoxy group at the third.

The methoxy series of compounds are not widely used in agriculture, with some exception e.g., Secbumetone. The ending



of the common name denotes which series a triazine belongs to *azine* for chloro triazines (*e.g.,* Cyanazine), *tryne* for methylthio triazines (*e.g.,* Prometryne) and *tone* for methoxy triazines. Each series has particular chemical and herbicidal properties which dictate their use and effectiveness as herbicides.

The Influence of soil and climate

Although some triazines, such as Cyanazine, may also be taken up by weeds through their leaves, they are primarily soil acting herbicides. Before examining the properties of the triazine herbicides it is therefore necessary to consider soil and climatic factors which influence their efficacies.

The soil is a complex, living structure. The features of the soil which have the greatest effect on the activity of the triazines are the soil particle size, the organic colloid content and soil moisture.

Soil particle size is dependent on the ratio of sand, silt and clay in the soil and Table 1 illustrates dramatically how the surface area increases as the soil particle size decreases.

It is the clay particle with diameter below 0.002 mm which play an important part in herbicide dynamics in the soil by adsorbing herbicide molecules on to their surfaces, mainly by electrostatic forces. Soils with a high clay content therefore have an extremely high adsorptive capacity. Indeed different types of clay have differing adsorptive capacities; for example montmorillonite clays may be 10 times more adsorptive than kaolinite clays. organic colloids, like clay particles, also carry negative charges on their surface and hence also adsorb positively charged herbicide molecules. On a weight for weight basis organic matter is more adsorptive than montmorillonite clay.

Table 1 : Surface area in relation to particle size.

Fraction	Particle diameter (mm)	Surface area (cm^2/g)
Coarse sand	2 - 0.2	21
Fine sand	0.2 - 0.03	210
Silt	0.02 - 0.002	2100
Clay	<0.002	23000

The adosrptive capacity of a soil is therefore a function of both the proportion of clay particles and organic colloids within it and the negative charges that they carry, though this can be considerably modified by temperature and rainfall. This is because prior to adosrption a herbicide must become dissolved in the soil moisture, thus forming an equilibrium (the concentration ratio or Kd value) with part of the herbicide adsorbed and part in solution. The concentration in the soil solution may be reduced by an increase in soil moisture due to rainfall, by herbicide degradation or by herbicide uptake by roots. Herbicide molecules then detach themselves from the colloids until the concentration ratio is restored to its optimum for that particular herbicide. This ensures that herbicides are not irretrievably lost by adsorption. Adsorption is also reduced at high temperatures, probably by increased solubility. The adsorption of basic herbicides, such as triazines, is increased in acidic soils and reduced in alkaline ones.

The total effect of adsorption is to confer some soil persistence on a herbicide, but also to reduce the amount of material available for weed control. Thus

Table 2: Comparison of the common triazine herbicides.

	Vapour pressure (mm Hg at 20°C)	Water solubility (mg/l)	P.K. value	Leachability
Methylthiotriazines				
Desmetryne	1.0×10^{-6}	48		
Terbutryne	9.6×10^{-7}	58	4.43	2
Methoprotryne	2.8×10^{-7}	320		
Prometryne	1.0×10^{-6}	48	4.05	4
Aziprotryne	2.0×10^{-6}	55		
Ametryne	8.4×10^{-7}	185	4.0	7
Chlorotriazines				
Simazine	6.1×10^{-9}	5	1.65	5
Propazine	2.9×10^{-8}	8	1.85	5
Atrazine	3.0×10^{-7}	28	1.68	10
Cyanazine (Bladex)	1.6×10^{-9}	171	1.0	10

Note – Trifluralin has a leachability index of 1 while picloram, which leaches readily, has an index of 250.

finely textured soils require higher dose rates of herbicide than coarser soils to achieve a comparable weed control performance. A soil with a high organic matter will also require a higher dose rate.

Properties of the triazines

Although the triazines herbicides belong to a single group, their physical properties vary – particularly between the different series. This confers on them different properties in the soil. The properties of the main chloro and methylthio – triazines are shown in Table 2.

Volatility: As the vapour pressures indicate, chlorotriazines are less volatile than methylthio triazines, and cyanazine is the least volatile of the whole group. Even the methylthiotriazines have low volatilities compared with most other herbicide groups. However, reports have been received of phytotoxicity, particularly with prometryne and desmetryne, under high temperature conditions following evaporation from warm soil surfaces.

Solubility: A herbicide must enter into soil solution before it can either be absorbed into the soil structure or be absorbed into plant roots. Water solubility is therefore important since it affects herbicide distribution. The methylthio series of triazines are generally classed as having medium solubilities and the chlorotriazines as low. Cyanazine is unusual in this latter group as being of medium solubility. This means that cyanazine is rapidly washed into the soil by adequate rainfall, becoming readily available to the roots of weeds. In the absence of rainfall incorporation into the soil by shallow cultivation is necessary. Cyanazine is also absorbed by weeds through their leaves.

Alkalinity (P. K. value): The P.K. value is a measurement of the ability of a herbicide to become positively charged by absorbing hydrogen ions (i.e., to become basic and be more readily absorbed by negatively charged soil colloids). The higher the P. K. value the greater the tendency for absorption to occur.

Again differences are apparent between the chloro and methylthio triazines with the latter being more prone to absorption. Cyanazine has a very low P. K.

value, which together with its solubility confers on it desirable leaching properties.

Leaching: The leachability of a herbicide is largely a function of solubility, volatility and P. K. value and is a measurement of movement into and through the soil. Cyanazine, which has a solubility of 171 mg/l and a P.K. value of 1 has a similar leachability index to atrazine (i.e., 10). Practical experience shows that soil acting herbicides of regularly good efficacy have leachability indices in the range 7-12. Cyanazine will be carried into the surface layer of the soil by moisture more rapidly than atrazine because of its solubility. Absorption then prevents leaching to a greater depth, so avoiding crop damage and reducing herbicide loss. However its low P. K. value means that excessive absorption of cynazine does not occur and adequate amounts are immediately available for weed control.

The lower leaching properties of methylthiotriazines mean that they can be used in very sensitive crops *e.g.*, terbutryne in cereals. However experience in Brazil and in a number of Balkan countries shows that by selecting dose rates for particular soil types cyanazine can be safely used in the very sensitive soyabean crop.

The leaching indices presented are relative and increased movement in the soil can be anticipated under conditions of high rainfall, high temperature and where the absorptive capacity of the soil is small, i.e., where there is a small clay and organic matter fraction. Under these conditions the applied dose rate must be reduced. For example, the application rates for cyanazine applied to peas vary according to soil type as shown in Table 3.

Crop tolerance: The mechanisms of selectivity of herbicides to the crop are complex but may be physiological or mechanical.

Table 3 : Pre-emergence cyanazine recommendations for Peas (U.K.).

Soil types	Dose rate kg ai/ha
Sands, coarse sands	Do not treat
Very fine sands, loamy sands	0.85
Sandy loams	1.25
Silty loam, loam	1.75
Silt loam, Clay loam, Clay	2.1
Soils with over 10% o.m.	Treat post-emergence

Note: The soil should be consolidated and free of clods to prevent irregular entry of the herbicide into the soil.

Physiological: Physiological selectivity is dependent on differences between weeds and crop plants in rates of absorption and translocation to the sites of action and in degradation reactions. The speed of herbicide degradation in the crop can vary, being greater in a vigorously growing plant. One of the best known examples of degradation is the conversion of chlorotriazines, such as atrazine or cyanazine by the maize plant to harmless breakdown products by splitting off the chlorine atom from the triazine ring and replacing it with a hydroxy group. This degradation is carried out by benzoxazine which is present in maize juice. Benzoxazine is also present in other plants *e.g.*, wheat, but generally at lower levels than in maize. Benzoxazine has no effect on methylthiotriazines. There are, however, other degradation mechanisms for this series of compounds within the maize plant but they are probably not as effective as the benzoxazine route.

Other examples of physiological selectivity include the prevention of absorption into the crop leaf by a waxy cuticle *e.g.*, the use of cyanazine post-emergence on peas and onions, or by holding in 'sinks' *e.g.*, the deposition of premetryne in the lysiginic glands of the stem of cotton.

Table 4 : Results of 3 official trials in France, illustrating the effects of atrazine persistence on subsequent sugarbeet crops in 1975.

kg ai/ha of Atrazine 1974	Sugarbeet population/ ha	%	Yield of roots in tonnes/ha	%	Sugar content in per cent	%	Yield of sugar in tonnes/ha	%
1.25	56532	85	40.73	90	15.55	97	6.28	88
2.5	49267	74	31.66	70	14.85	93	4.71	66
0	66387	100	45.07	100	15.88	100	7.09	100

Mechanical selectivity: This can cover a wide range of mechanisms. One example is the use of directed sprays to prevent the herbicide coming in contact with the crop such as in post-emergence applications of cyanazine to cotton. The most important method in the case of triazines is depth protection whereby the crop seeds and roots at are such a depth in the soil that they do not come into contact with the herbicide treated layer of soil above them. Weeds, however, generally germinate in this herbicide treated band of soil. This mechanism is exemplified by cyanazine recommendations for peas, potatoes, cereals etc. It is dependent on a thorough knowledge of the leaching properties of each herbicide whereby application rates can be adjusted to take account of varying soil and climatic conditions.

Mode of Action: Before any herbicide can perform its function it must reach the site within the plant that is vulnerable to its toxic activity. Triazines have a direct effect in photosynthesis; specifically by inhibiting the Hill reaction whereby oxygen is liberated from water during the synthesis of carbohydrate from carbon dioxide and water. Typical symptoms include initial leaf chlorosis followed by complete necrosis and death of the plant. Translocation of this group in plants is upwards in the water stream *i.e.*, acropetally. The principle site of uptake is specifically via the roots or mesocotyl for the more insoluble members of the group (*e.g.* simazine). Those with greater solubilities, particularly the methylthiotriazines, also exhibit leaf uptake and so can be applied post as well as pre-weed emergence. Unusually for a chlorotriazine, cyanazine exhibits good foliar uptake because of its solubility. With a few notable exceptions such as *Urtica urens* large weeds are unable to take up sufficient amounts of cyanazine either through the foliage or by their roots, to kill them. Therefore, post weed emergence applications are usually made to small plants – possibly up to 4 cm tall.

Degradation: The effective life of a herbicide is determined by its distribution in the soil and its tendency to degrade in the various soil phases. The processes are influenced by climate since both chemical and biochemical breakdown occurs more rapidly under conditions of high temperature and moisture level. Likewise, the high level of microbiological activity in soils with a high organic matter content hastens breakdown. Microbial and chemical breakdown (i.e., hydrolysis) are the main degradation routes of the triazines.

Practical conditions dictate the rate of degradation required of a herbicide in a particular crop; too short an effective life can lead to poor weed control, too long a life can injure subsequent crops as has been reported following atrazine use on maize (Table 4).

The triazines can be grouped according to their relative effective persistences in the soil, as shown in Table 5.

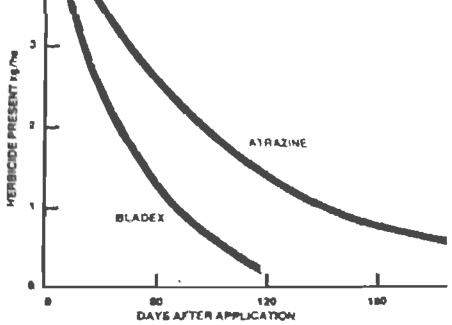
Table 5: Average persistence periods* of triazines.

Less than 3 months	3-6 months	Over 6 months
Aziprotryne	Trietazine	Atrazine
Cyanazine (BLADEX)		Simazine
Prometryne		
Terbutryne		

* Safe period between application and the sowing of a succeeding susceptible crop.

It can be seen that chlorotriazines are degraded at a slower rate than the methylthio series, with the exception of cyanazine which has an unusually short persistence. The short persistence of cyanazine is due to the ease with which microbial activity is able to break down the cyano molecule attached to the triazine ring. This is more apparent if degradation curves are examined and is a property which makes ideal for use in crops such as peas or maize where residues can cause serious damage to succeeding crops.

Degradation curves under optimum conditions



When degradation is considered together with soil absorption, leaching losses and uptake by non target plants, it is inevitable that only a small proportion of a herbicide applied to the soil is actually available for the control of weeds.

Choice of herbicides: As already intimated, it is the physical properties of the triazines as well as the tolerances of particular crops and weeds which dictate their uses. This becomes very apparent if the recommended uses of the principle triazines are examined.

Table 6: Main uses of common triazines.

Product	Uses
(a) *Chlorotriazines*	
Cyanazine (BLADEX)	Wide range of crops e.g., maize, peas, beans, cereals, sugarcane, groundnut, potatoes, onions, forestry, cotton, sorghum, soyabean.
Simazine	Deep rooted and/or long term crops e.g., plantation crops, beans.
Atrazine	Maize, sorghum, sugarcane, pineapple, forestry.
Propazine	Umbelliferous crops, millet.
(b) *Methylthiotriazines*	
Desmetryne	Brassicaes.
Terbutryne	Cereals, sunflower, potatoes.
Methoprotryne	Cereals for grass control.
Prometryne	Wide range of crops.
Aziprotryne	Brassicaes, peas.
Ametryne	Sugarcane, pineapple, potatoes.

Thus, for example, aziprotryne because of its very high leaf activity has a limited crop range. Simazine, because of its long persistence is used mainly on deep rooted or long term crops. Cyanazine with its shorter persistence and optimum leachability is presently recommended for use on a wide range of crops.

Weed spectrum: The weed spectrum of the various triazines is extremely wide, too wide for a comprehensive survey in this report. Instead the weed spectrum of cyanazine can be taken as an example.

Cyanazine—Susceptible weed list

Susceptible weeds – usually controlled by up to 2.0 kg ai/ha cyanazine applied pre-emergence

Alopecurus myosuroides
Anagallis arvensis
Anthemis cotula
Apera spica-venti
Aphanes arvensis
Arrhenatherum avenaceum
Artemisia spp.
Atriplex patula
Campanula patula
Capsella bursa-pastoris
Cassia tora
Chenopodium spp.
Chrysanthemum segetum
Cucurbita spp.
Dactyloctenium aegyptium
Datura stramonium
Digitaria sanguinalis
Diplotaxis muralis
Erodium spp.
Euphorbia spp.
Filago arvensis
Fimbristylis spp.
Fumaria officinalis
Galeopsis spp.
Galinsoga parviflora
Ipomoea spp.
Juncus bufonius
Lamium spp.
Lapsana communis
Lepidium draba
Malvastrum peruvianum
Matricaria spp.
Mercurialis annua
Momordica spp.
Myosotis arvensis
Phyllanthus amarus
Poa annua
P. trivalis
Polygonum lapathifolium
P. persicaria
Portulaca oleracea
Ranunculus trilobus
Raphanus raphanistrum
Scandix pecten-veneris
Senecio vulgaris
Setaria viridis
Seda acuta
S. rhombifolia
Solanum nigrum
Sonchus oleraceus
Spergula arvensis
Stellaria media
Thlaspi arvense
Tripleurospermum spp.
Veronica spp.
Vicia cracca
Viola spp.
Medicago lupulina

Moderately susceptible weeds – usually control by up to 3.0 kg ai/ha cyanazine applied pre-emergence.

Amaranthus spp.
Ambrosia artemisiifolia
Bellis perennis
Brachiaria spp.
Cerastium arvense
Cyperus diffusus
Digitaria filiformis
D. velutina
Diodia teres
Diplotaxis erucoides
Echinochloa crus-galli
Echium vulgare
Erigeron canadensis
Galium aparine
G. tricornutum
Geranium molle
Leptochloa filiformis
Lolium multiflorum
L. temulentum
Mentha arvensis
Mollugo verticillata
Panicum capillare

P. dichotomiflorum
Physalis spp.
Plantago spp.
Polygonum aviculare
P. convolvulus
P. pensylvanicum
Potentialla spp.
Raphanus sativus
Richardia scabra
Rumex acetosella
Setaria faberii
S. glauca
S. verticillata
Silene inflata
Sinapis arvensis
Sonchus arvensis
Urtica spp.
Xanthium spp.

The list is comprehensive and shows the product to be active against a number of grasses which have proved resistant to atrazine, including Digitaria, Setaria and *Panicum spp.*

Herbicide mixtures: No herbicide is effective against all weeds and it is in this respect that another useful property of triazines such as cyanazine becomes apparent – their compatability with other herbicides. Mixtures can provides a wider weed spectrum, increased timing flexibility, improved crop selectivity and possibly reduced soil residues.

While mixtures of cyanazine with various herbicide groups have been used in a range of crops, it is in maize that the greatest number of mixtures have been evaluated. Mixture partners in maize include atrazine, alachlor, metolachlor, EPTC + safener, butylate, phendimethalin and paraquat. Three component mixtures have also been used.

The following results from a trial which was carried out in Yugoslavia in 1979 is a good example of the mixture possibilities of cyanazine.

The main weeds present were *Amaranthus spp., Chenopodium album, Datura stramonium, Sorghum halepense, Cynodon dactylon* and *Convolvulus arvensis*. The weedicides were applied pre-emergence on the 7th May.

While atrazine is still the most widely used herbicide in maize, growers are becoming increasingly aware of its shortcomings in terms of weed control and persistency. As the trials reported show more specialised herbicides such as cyanazine are now available for use. The activity of cyanazine enables the control of broad leaved weeds to be maintained, while at the same time giving an adequate control of annual grasses with a reduced risk of soil residues, since mixtures permit lower rates of atrazine to be used.

Cyanazine *plus* a single pack formulation of 2 : 1 cyanazine + atrazine, has recently been developed for use in sugar cane at the recommended dose of 4.5 kg ai/ha. The addition of a surfactant helps to ensure maximum wetting of the emerged weeds. Cyanazine *plus* is now used for weed control in sugarcane in several countries and is being evaluated in others.

Table 8 summarises the results of a trial carried out in 1979 by the A Sri Lanka Sugar Corporation Research Institute at Uda Walawe. Applications were made pre-emergence of the crop. The weed control figures refer to both grass and broad leaved weeds. Cyanazine *plus* gave significantly better control than the local standard herbicide.

In addition to excellent weed control, cyanazine *plus* has also given yield increases significantly higher than those obtained with standard products. This is partly due to the fact that cyanazine *plus* is one of the safest sugarcane herbicides available. In a series of large scale field trials designed to examine the effects of post-emergence herbicide treatments on

Table 7: Weed control and crop yield in maize – 1979.

Treatment	Kg ai/ha	% Weed Control	Crop yield t/ha
BLADEX + alachlor	2.0 + 1.9	99	7.82
BLADEX + Metolachlor	2.0 + 2.0	90	6.90
BLADEX + alachlor + atrazine	1.5 + 1.9 + 0.5	95	8.00
Alachlor + atrazine	1.9 + 1.0	95	7.10
BLADEX + atrazine	3.0 + 1.0	95	7.70
Control		0	6.25

Table 8: Weed control in sugar cane: Pre-emergence treatment.

Treatments	kg ai/ha	Weed Control %		
		4	10	14 weeks after treatment
BLADEX/atrazine	2.0 + 1.0	96	79	73
BLADEX/atrazine	3.0 + 1.5	98	89	83
BLADEX/atrazine	4.0 + 2.0	98	91	89
Diuron/paraquat	4.5 + 2.8 l			

sugarcane, scientists at the Mount Edgecombe Sugar Research Station, South Africa, have consistently recorded highest yields from plots treated with cyanazine *plus*.

Cyanazine is also proving to be a useful mixture partner for the cotton crop. Dinitro-aniline products such as nitralin, trifluralin and dinitramine are widely used in cotton as pre-planting, incorporated treatments. This group gives poor control of some broad leaved weeds and Cyanazine can supplement control as either a pre-planting or pre-emergence application.

Alternately cyanazine can be applied as a tank mix with pre-emergent grass killers such as metolachlor or as a post-emergence directed spray.

From recent trials in the USA, Brazil, West Africa and the Middle East countries one of the more promising mixtures for cotton has proved to be a mixture of cyanazine and norflurazon (Zorial). This mixture is being introduced in Ivory Coast and the Cameroons as ZORIADEX.

11) *Crop spectrum* — The original development of cyanazine was in temperate agriculture, since then use has been extended into sub-tropical and tropical crops. Apart from maize, sugar cane and cotton, BLADEX and BLADEX mixtures are also used in crops such as soyabean, sorghum, vicia beans, peas, small grain cereals, forestry, plantation crops, onions, potatoes etc.

WIPER EQUIPMENT CONCEPT FOR GLYPHOSATE HERBICIDE

T. HAYASAKA[1] and L. Q. WU[2]

[1] Monsanto Japan Ltd., C.P.O. Box 1558, Tokyo 100-91, Japan.

[2] Monsanto Far East Ltd., P.O. Box 3949, Taipei, Taiwan

ABSTRACT

The unique properties of isopropylamine salt of glyphosate (roundup) has encouraged the development of new application techniques. Small hand-held wiping equipment was developed with fiber, sponge and rope applicator parts to resemble a "hockey stick" with the solution tank in the pipe handle. Rates were based upon percentage of product/water volume.

Hand-painting treatments indicated that partial coverage of *Imperata cylindrica* foliage with higher percentage solution provided comparable efficacy to conventional spray. Field tests with proto-type equipment compared several model types, number of application passes, per cent solution, and total solution applied. In dense standa of *Imperata c., Paspalum distichum, Tylophora tanaka,* and *Artemisia princeps,* efficacy was a function of the solution concentration and total applied solution volume. Efficacy from wiper treatments of 5% solution/200 l/ha, 10% solution/100 l/ha, 20% solution/50 l/ha, 40% solution/25 l/ha and a 1% conventional spray-to-wet were comparable.

Several other tests recommended 17 to 33% solutions. Depending upon the weed, one or two double sweeps (application passes) may be required to deliver the appropriate volume. Wiper application is an innovative technique to maximize the strength of glyphosate and the advantages of the wiping concept.

INTRODUCTION

Traditionally, foliar herbicides are applied with a spray. The unique herbicidal properties of glyphosate[1] have encouraged the development of "Wiping" applications (Dale, 1978; Wu and Derting, 1981).

The features of glyphosate permit control of perennial weed from the treated plant foliage to the underground roots and rhizomes (Daito and Morianaga, 1980; Sprankle *et al.* 1975; Wyrill and Burnside, 1976). The non-selective herbicidal property and the potential drift of indiscriminate spray to adjacent sensitive desirable plants restrict the use of glyphosate in certain situations. Wiper application would extend the versatility of glyphosate.

The objectives of this study were to: (1) investigate the effectiveness of glyphosate when applied by wiping, (2) evaluate equipment design for efficacious application and (3) determine the application rate and volume of glyphosate for key perennial weed species.

MATERIAL AND METHODS

All experiments were conducted on dense weed infestations growing under natural field conditions in 1979 and 1980. Many types of hand-held equipment were prepared. The most desirable design and shape resembled a "hockey stick" for easy movement. The various equipment was composed of a pipe handle which

[1] For purposes of this paper only the term glyphosate is defined as the commercial formulation Roundup® herbicide by Monsanto Company having as the active ingredient therein the isopropylamine salt of N-(phosphonomethyl) glycine.

Table 1 : Influence of rate and degree of foliage contact of glyphosate solution on the control of *Imperata cylindrica*.

Foliage Contact	Application Method[1]	Solution Concentration	Controlling rating 25 DAT	80 DAT	325 DAT
		(%)	(%)	(%)	(%)
Upper 1/8	Wipe	2	45	88	83
Upper 1/8	Wipe	4	55	100	92
Upper 1/8	Wipe	10	70	100	99
Upper 1/4	Wipe	2	55	95	93
Upper 1/4	Wipe	4	70	100	98
Upper 1/4	Wipe	10	80	100	100
Total coverage	Spray-to-wet	1	75	98	95

[1] Application were made on July 16, 1979 with a cloth glove to natural field infestation of 1.2 m in height

was also the solution holding tank and an applicator component made of various materials.

Herbicide solutions were prepared as a percentage concentration (v/v) of the formulated product. For easy understanding and calculation, all solution concentration rates in this paper are expressed as percentage (v/v) of the formulated product in water. Rates of application on an area basis are given in kg ae ha^{-1}.

The herbicide was applied to the vegetation in a sweeping or back and forth motion. While a sweep was one movement or direction, a double sweep was a back and forth movement over the same area.

RESULTS

Initial studies to examine the effectiveness of partial foliage contact with glyphosate solutions indicated that complete coverage was not necessary when higher rates were used. Treatments to the upper 1/4 and 1/8 portion of 1.2 m tall *Imperata cylindrica* (L.) P. Beauv with a cloth glove saturated with 2, 4 and 10 per cent (v/v) solution were comparable to a one per-cent (v/v) spray-to-wet treatment (Table 1). Early burndown at 25 DAT was rate and contact responsive. However, 80 and 325 DAT observations showed similar excellent efficacy among all treatments with the exception of the two per cent (v/v) concentration with 1/8 coverage.

Several proto-types of wiper application equipment were constructed for comparison (Fig. 1). Tests on *Artemisia princeps* (Pampan), *Paspalum dilatatum* (Poir) and *I. cylindrica* revealed differences between the various equipment. Only the volume of total solution applied and the level of control varied between the study of species. The *I. cylindrica* tests indicated generally greater control from hand-held applicator units with sponge or fiber applicator components than rope components (Table 2). Concentrations of 10 and 40 per cent (v/v) provided similar control to the conventional one per cent spray treatments. Poor control from the 10 per cent concentration with the rope applicators suggests that the total solution volume applied and flow rate or "wicking" action is an important consideration.

"Wiping broom" applications on *Tylophora tanakae* (Maxim.) suggested that concentration can be overcome when the total applied solution volume is controlled (Table 3). In this test, control of

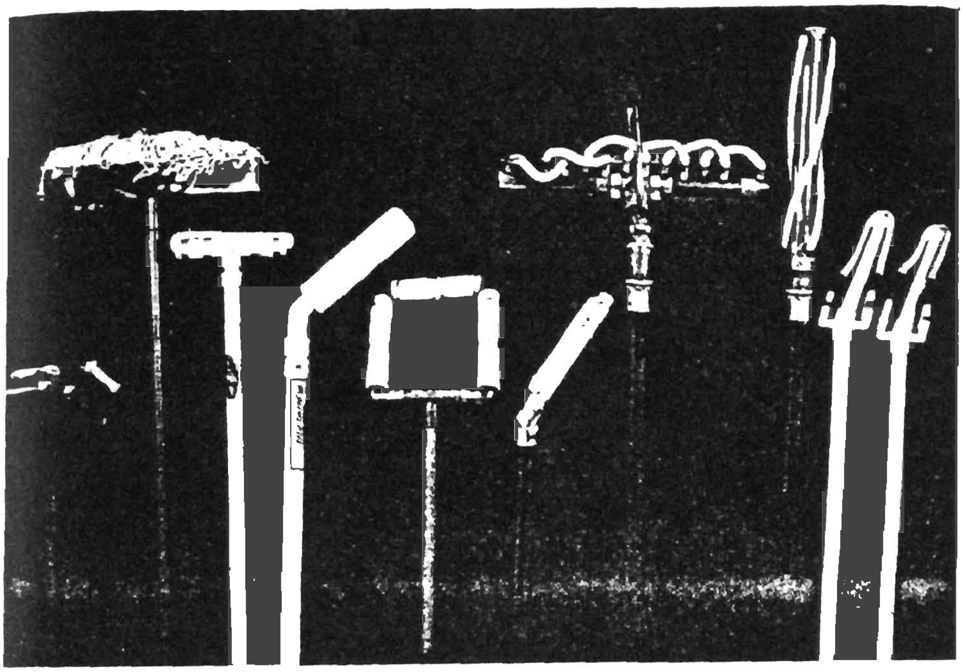


Fig. 1. Various proto-types of hand-held wiping equipment.

Table 2 : Comparison of various hand-held equipment proto-types on the control of *Imperata cylindrica* with glyphosate[1].

Equipment code No.	Applicator component	Control at 53 DAT Solution concentration (v/v) 10 (%)	40 (%)
A	Rope	57	63
B	Rope	79	93
C	Rope	0	95
D	Rope	28	85
E	Sponge	91	90
F	Sponge	70	83
G	Fiber	89	90
Spray	(1 per cent spray-to-wet)	91	91

[1] Applications were made on April 12, 1981 to a stand of 90-100 per cent ground cover of *Imperata cylindrica* at 40-50 cm in height.

87 to 96 per cent was achieved when 3.6 kg ae ha^{-1} was delivered to the troublesome vine weed via a wiper or spray.

Table 3 : Effect of solution concentration and applied volume on control of *Tylophora tanakae* when applied with "wiping broom".

Solution concentration	Solution volume applied	Glyphosate rate	Control rating at 47 DAT
(%)	(L/ha)	(kg ae/ha)	(%)
5	200	3.6	88
10	200	7.2	92
10	100	3.6	87
10	50	1.8	66
20	50	3.6	90
1 (Spray)	1000	3.6	96

In another study on *I. cylindrica* the total applied solution volume was varied by changing the number of sweeps or passes across the weeds. Increasing the number of double sweeps increased the control when a 10 per cent (v/v) concentration was used (Table 4). At the higher rates of 20 and 40 per cent, the number of double sweeps did not significantly al-

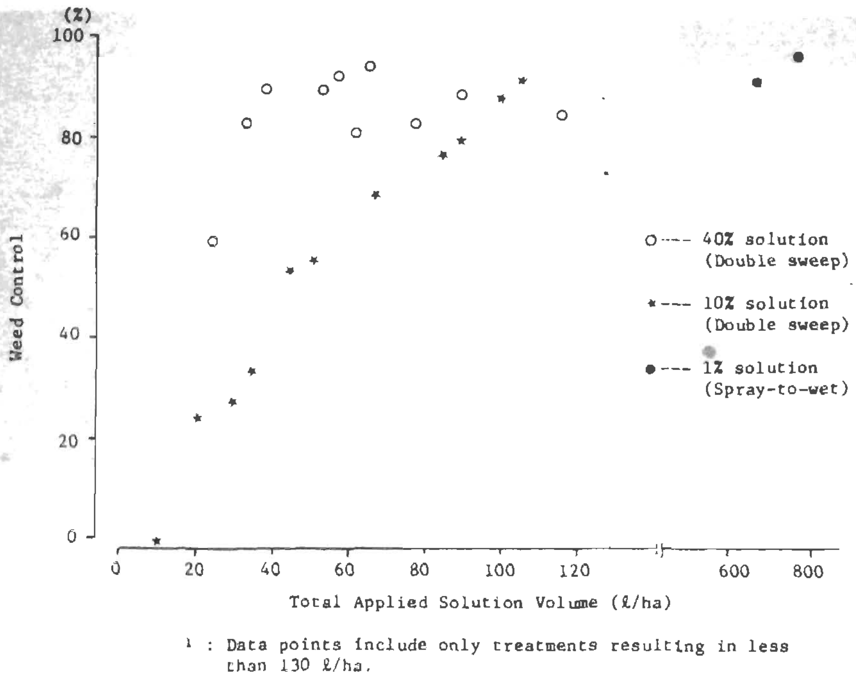


Fig. 2. Relationship between solution concentration and total applied volume on the control of *Imperata c.* at 70 DAT.

Table 4 : Effect of number of sweeps and herbicide concentration on solution volume and efficacy of *Imperata cylindrica* applied with hand-held equipment.

Application		Observation		
Solution concentration	No. of double sweeps[1]	Total volume	Glyphosate rate	Control Rating at 64 DAT
(%)		(l/ha)	(kg ae/ha)	(%)
10	1	47	4.7	76
10	2	97	9.7	91
10	4	103	10.3	91
20	1	42	8.4	86
20	2	56	11.2	92
20	4	69	13.8	88
40	1	28	11.2	96
40	2	58	23.2	95
40	4	61	24.4	97
1 (Spray)		783	7.8	100

[1] A double sweep represents a back and forth movement of equipment over the same area

ter the efficacy with each rate. Due to the difference in viscosity of the various solutions, relationships between the number of sweeps and total solution applied of the various concentrations are not proportional. However, a double sweep of a 10 per cent concentration and a single or double sweep of a 20 per cent concentration provided 86 to 92 per cent control of *I. cylindrica*. A single sweep of a 40 per cent concentration provided 96 per cent control, compared to perfect control at 64 DAT with a one per cent spray-to-wet treatment.

At a given concentration, efficacy was related to the volume of solution applied. Consequently, the amount of glyphosate applied is the determining factor. Satisfactory control of *I. cylindrica* was achieved with 10 and 40 per cent concentrations when 100 and 30 l/ha were delivered (Fig. 2).

A similar rate response was observed on *A. princeps*. Application with a 20 per cent (v/v) concentration delivered 2.5 kg ae ha^{-1} of glyphosate for 90 per cent control. An application of a 40 per cent (v/v) concentration resulted in the same 3.6 kg ae ha^{-1} of glyphosate as the spray and resulted in similar efficacy.

Equipment was selected and tested across 19 official locations on 18 perennial weed species. The equipment delivered 30 to 60 l/ha of 17 to 33 percent (v/v) solutions with one or two double sweeps. For most perennial weeds, a double sweep of a 33 per cent solution or two double sweeps of a 17 per cent solution provided similar control as the conventional spray. Although the single-double sweep treatment with 17 per cent solution provided less consistent control than the higher rates, the control was superior to manual control or paraquat treatment check plots. In addition, wiper plots on rice leaves or adjacent to desirable crop plants did not result in drift or crop injury.

DISCUSSION

Wiper application to the foliage of perennial weeds provided effective control of aerial and underground plant parts. Many factors influence the effectiveness of glyphosate applied by wiper application. Equipment design, weed species, weed size of growing conditions, applicator, amount of foliage contact, solution concentration and solution delivery volume or number of sweeps are a few of the variables.

Although initial hand-wiping tests showed that only 1/4 of the top foliage of *I. cylindrica* general applications with the wiper require at least 1/2 of the foliage as the target for wiping. Generally, the number of sweeps determine the volume applied at a given rate. Solution concentrations of 10 to 17 per cent (v/v) generally provided good control of perennial weeds with two double sweeps when application is not difficult. Weed in dense stands or decumbent growth habit and harder-to-control weeds as *Solidago altissima* (L.), *Oenanthe javanica* (DC.), *Phragmites communis* (Trin.), *Miscanthus sinensis* (Anderss.) and *Sasa spp.*, may require 33 per cent (v/v) concentration for more consistent control.

Many types, designs and materials may be used for wiper equipment. A continuous flow of solution at a specific concentration must be delivered uniformly to the weeds. The weed size and density influences the volume delivered per unit area but do not influence efficacy if the solution is applied uniformly.

CONCLUSION

The wiper concept offers several advantages over conventional sprays in certain situations, but it is not a replacement for spray solutions of the non-selective herbicide. The main advantages of the wiper concept include: (1) selective placement to control tall weeds in shorter desirable vegetation, (2) eliminate drift potential to nearby sensitive plants, (3) reduced water volume requirements and (4) convenient application method. The concept offers new weed control potential for use in various cropping and weed control systems in Asia.

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3,6–DICHLOROPICOLINIC ACID MIXTURES FOR WEED CONTROL IN NEW ZEALAND

E. A. UPRITCHARD
Research Division, Ivon Watkins-Dow Limited, Box 144,
New Plymouth, New Zealand.

ABSTRACT

3,6–Dichloropicolinic acid (3,6–DCPA) is a selective broadleaf weedkiller with a variety of potential uses in New Zealand. A mixture of 3,6–DCPA with MCPA and bromoxynil gives broad spectrum weed control in cereals with improved crop yield when applied at most stages of cereal development. Thistles such as *Carduus nutans* in pasture are readily controlled at advanced rosette or early flowering stage with a 3,6–DCPA/MCPB mixture with satisfactory tolerance to pasture legumes. Mixtures of 3,6–DCPA with selective rates of 2,4,5–T or triclopyr (3,5,6–trichloro-2-pyridyloxyacetic acid) have successfully released *Pinus radiata* from *Ulex europæus* competition. Other potential uses of 3,6–DCPA are discussed.

INTRODUCTION

In 1975, 3,6–dichloropicolinic acid (3,6–DCPA) was introduced in New Zealand as a promising new herbicide for control of broadleaf weeds tolerant to phenoxy herbicides in cereals. It had been developed in Europe for this purpose and registered in a variety of mixtures with MCPA, mecropop, dichlorprop, bromoxynil and ioxynil. Subsequent developments in Europe have been for use on sugarbeets, oilseed rape, maize, linen flax, strawberries and onions, alone or in mixture with benazolin, propyzamide or phenmedipham.

In New Zealand the major development has been for weed control in cereals and ryegrass/white clover pasture. 3,6–DCPA also shows promise for release of *Pinus radiata* from competing woody weeds, such as *Ulex europæus*. This paper outlines typical results with 3,6–DCPA mixtures for weed control in cereals, pastures, *P. radiata* transplants and discusses other potential uses in New Zealand.

CEREALS

Development of a proprietary formulation containing 3,6–DCPA/bromoxynil/MCPA (30/100/300 g/litre) was reported by Rutherford and Lobb (1979). Their work is expanded in Table 1 to include a further season's half paddock farmer assessments compared with standard commercial recommendations based on dicamba including dicamba/MCPA (150/900 g/ha), dicamba/MCPA/dichlorprop (70/440/2000 g/ha) and dicamba/MCPA/bromoxynil (75/750/300 g/ha). Yields were determined by harvesting adjoining equal areas from both treatments as paired samples.

The results (Table 1) confirm the suggestion of Rutherford and Lobb (1979) that

Table 1 : CEREALS : Summary of farmer tank lot trials.

Crop mean yields (tonnes/ha)	Wheat	Barley
3,6–DCPA mixtures :	5.01***	4.30***
Dicamba mixture :	4.34	3.93
No of trials :	11	19
SE mean difference :	0.109	0.062

dicamba mixtures can cause yield suppression in cereals. Probably the most common reson in New Zealand is late spraying because of unfavourable weather conditions at the recommended growth stage or delayed spraying to allow emergence of perennial weeds such as *Cirsium arvense.*

The 3,6-DCPA/bromoxynil/MCPA mixture has excellent selectivity to cereals allowing advanced crops to be safely treated with the proprietary formulation although early treatment is emphasised for maximum weed control. This formulation controls a wide range of typical seedlings bradleaf weeds including phenoxy-susceptible species such as *Chenopodium album, Brassica campestris, Capsella bursa-pastoris, Solanum nigrum, Sisymbrium officinale, Amaranthus retroflexus* and *Rumex sp.* and phenoxy resistant species such as *Polygonum aviculare, P. convolvulus, P. persicaria, Spergula arvensis, Fumaris officinalis.* It has specific activity on the "mayweed" group dominantly *Anthemis cotula, Matricaria inodora and M. Matricarioides.* Where *Stellaria media, Galium aparine* or *Vicia spp.* are present, a tank mix with mecoprop is recommended. Recent results indicate that smaller spray droplets may increase reliability of control and trials have been initiated to evaluate this aspect.

PASTURE

Annual and biennial thistles (Healy, 1976) can become a severe problem in ryegrass/clover pasture particularly if the sward has been damaged by drought conditions, pugging or overgrazing which allows weed seeds to germinate. *Carduus nutans* is a widespread biennial recognised as the most aggressive of these and as such has been declared a noxious weed. Other strongly competitive thistles such as *Carduus tenuiflorus, Silybum marianum* and occasionally other species can also be a problem in local areas.

About 600,000 to 750,000 ha of pasture are treated annually for thistle control, mainly *C. nutans,* most being helicopter applied at 50 to 100 litres spray mix/ha or 200 litres/ha for ground application. The largest area treated is the East Coast of the North Island where 2,4-D ester (1 kg/ha) is mainly applied by helicopter. On the East Coast of th South Island, MCPA salt (1 to 1.5 kg/ha) is used as it is more selective than 2,4-D ester to subterranean clover which is more prevalent on the lighter alluvial soils.

Poor control of *C. nutans* with MCPA and 2,4-D often occurs under drought conditions, where flower initiation has commenced or in the second season of growth.

A formulation containing 3,6-DCPA/MCPB (15/500 g/litre) gave a high degree of thistle control with minimum damage to pasture legumes. Rutherford *et al.* (1981) gave details of trial results which are summarized in Table 2.

Thistle control and *Trifolium* spp. tolerance were visually assessed using a 1 to 10 scale. For thistle control 0 = untreated and 10 = complete removal; for tolerance 0 = complete removal and 10 = untreated. *Trifolium* spp. tolerance was also measured by dry matter yield, expressed as a percentage of untreated.

Recommendations for use are based on the crown diameter of the tap root as a means of overcoming problems of visually estimating age and stage of growth of plants. The 3,6-DCPA/MCPB formulation is recommended at 15/500 g/ha for thistles up to 20 mm crown diameter, 22/750 g/ha for 20-40 mm diameter and 30/1000 g/ha over 40mm diameter. The 30/1000 g/ha rate may cause loss of pasture production by partial removal of legume species.

C. tenuiflorus and *S. marianum* show similar variability in control with 2,4-D and similar susceptibility to 3,6-DCPA/MCPA. *Cirsium vulgare* is also widespread but more readily controlled with MCPA, MCPB and 2,4-D.

The use of this mixture for *Cirsium ar-*

vense control shows promise but it has yet to be deterined if clover selective rates will give acceptable results.

FORESTRY

Pinus radiata is the major species for exotic forestry plantings in New Zealand, in excess of 750,000 ha being already established and a further 50,000 ha being planted annually.

Clearing land of woody weeds prior to winter planting is a major problem, with *Ulex europæus* one of the important weeds. Established cover of *U. europæus* is normally removed by autumn burning following chemical or mechanical desiccation. Scarification of seed by fire may cause massive germination and extensive root crown regrowth can also occur. This competition can severely suppress or even kill *P. radiata* transplants and cause severe problems with subsequent silvicultural operations.

Established release methods are hand cutting or aerial spraying with 2,4,5–T (1 kg/ha) or picloram/2,4,5–T (150/600 g/ha) which effectively suppresses weed competition for one season.

Selectivity of 3,6–DCPA to *P. radiata* and activity against woody legumes was evaluated in 16 trials summarised in Table 3. Tree tolerance was determined by calculating the growth factor (diameter^2 by height) for individual trees at treatment and appropriate subsequent intervals and expressing the growth increase as a percentage relative to untreated. Weed control was visually assessed using a 0 to 10 scale, where 0 = untreated and 10 = maximum effect.

Herbicide treatments (Table 3) had a greater effect on actively growing trees than on dormant trees particularly when in mixture with picloram or triclopyr.

Treatment related short term tree growth check, when it occurred, was greatly outweighed by the competitive advantage given by brushweed suppression.

U. europæus is highly competitive to establishing *P. radiata* for several years. The growth factor increase resulting from herbicide treatment is therefore expected to provide an even greater long term growth response than indicated by the 5 to 12 month data presented.

3,6–DCPA has little effect on trees and can be applied alone or in mixture with low rates of 2,4,5–T during active growth. 3,6–DCPA alone (6 to 8 kg/ha) or in mixture with selective rates of 2,4,5–T or triclopyr (4.0 plus 0.5 or 0.25 kg/ha) suppressed regrowth for at least two seasons after treatment giving the trees a further season's growth advantage compared to the standard treatments.

All treatments have given good control of *Cytisus scoparius*. *Acacia* sp., *Schelefflera digitata, Aristotelia* spp., *Leycesteria formosa* and *Coriaria* spp., have been defoliated by 3,6–DCPA mixtures in the season of treatment but further time is required to assess regrowth suppression.

CONCLUSIONS

3,6–DCPA is a useful all round chemical for suppression or control of a wide range of broadleaf weeds with good selectivity to a variety of crops. Its best potential appears to be as an additive to established chemicals for increasing efficiency and improving crop tolerance by enabling lower rates to be applied.

ACKNOWLEDGEMENTS

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Table 2: Pasture: Summary of *Carduus nutans* control and *Trifolium spp.* tolerance

		North Island					South Island				
Response Factor Rated		*Cn* C[1]	*Tr* T[2]	*Ts* T[3]	% *Tr*	DM[4]	*Cn* C	*Tr* T	*Ts* T	% *Tr*	DM
No. of trials		12	5	3	4	4	13	11	4	4	4
weeks after treatment		>8	>14	>14	9	24-26	>8	>14	>14	6-19	23-36
Treatment	g ai/ha										
MCPA salt	1600						7.8	8.7	9.0	93	110
2,4–D ester	1400	7.5	8.3	6.9	39bcB	87					
3,6–DCPA/MCPB	15/500	7.6	8.1	8.7	47bB	96	7.7	9.1	9.1	104	115
3,6–DCPA/MCPB	22/750	9.1	7.3	5.9	42bcB	88	9.3	8.3	7.2	91	114
3,6–DCPA/MCPB	30/1000	9.4	6.9	3.8	29cB	71	9.6	7.3	5.8	52	83
Untreated		0	10	10	100aA	100	0	10	10	100	23.7
CV%		11.6	10.6	13.6	26	51.6 NS	8.3	12.5	12.6	38.6 NS	23.7 NS

[1] = *Carduus nutans* control [2] = *Trifolium repens* tolerance [3] = *Trifolium subteraneum tolerance* [4] = % *Trifolium repens dry* matter production (relative)

Table 3. Summary of *Pinus radiata* tolerence and weed control with 3,6 – DCPA mixtures.

Crop condition/ Weed species		Crop tolerance				Weed control		
		Dormant[1]	Active[2]	Weed Free[3]	Weedy[4]	*U. europeaus*	*U. europeaus*	*C. scoparium*
MAT[9]		6 – 12	5 – 12	5 – 12	5 – 12	4.5 – 7	6.5 – 14	7 – 13
Treatment	kg/ha	%I[5] *n*[6]	%I*n*	%I*n*	%I*n*	BO[7] *n*	RS[8] *n*	RS*n*
Picloram + 2,4,5–T	0.15 + 0.6	108–*5*	75–*4*	87–*4*	98–*5*	5.7–*7*	3.2–*8*	9.5–*1*
3,6–DCPA	4	113–*5*	86–*5*	100–*4*	112–*3*	5.8–*5*	4.6–*5*	6.3–*2*
3,6–DCPA	6	59–*3*	92–*3*	97–*2*	140–*4*	7.1–*7*	6.5–*8*	– –
3,6–DCPA	8	141–*4*	92–*3*	103–*2*	126–*5*	8.2–*5*	7.4–*6*	7.1–*3*
3,6–DCPA + 2,4,5–T	4.0 + 0.5	120–*5*	104–*4*	95–*4*	127–*5*	8.1–*7*	7.0–*7*	8.4–*3*
3,6–DCPA + triclopyr	4.0 + 0.25	126–*4*	66–*2*	88–*2*	115–*4*	7.9–*6*	6.6–*7*	7.5–*2*
2,4,5–T	1.08	116–*4*	82–*1*	84–*2*	91–*5*	5.7–*4*	3.2–*5*	9.1–*1*
Untreated		100–*5*	100–*4*	100–*4*	100–*5*	0 –*7*	0 –*8*	0 –*3*

[1] = Crop treated while dormant (early spring) [2] = Crop treated in active growth stage (summer) [3] = No weed compitition [4] = Competing weeds present [5] = Growth factor at assesment minus growth factor at planting expressed as % relative to untreated [6] = Number of trials [7] = Brownout foliage [8] = Regrowth suppression [9] = Months after treatment

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ARD 13/31, A NEW FORMULATION OF ASULAM AND DALAPON FOR THE CONTROL OF *IMPERATA CYLINDRICA* (L.) BEAUV. IN TROPICAL CROPS

D. H. HILL and P. VEERASEKARAN
May & Baker Ltd., Ongar Research Station, Fyfield Road, Ongar, Essex, UK.

ABSTRACT

Studies with greenhouse grown *Imperata cylindrica* (L.) Beauv. plants under controlled environments have indicated that mixtures of asulam and dalapon produced synergistic effects in preventing regrowth in humid conditions at 20-30°C temperatures.

A new formulation of asulam and dalapon, ARD 13/31, has been specially developed to control the pernicious grass weed *I. cylindrica* in a wide range of crop and non-crop situations in tropical countries.

ARD 13/31 (11.25–18.0 kg ha^{-1}) applied in 800-1000 l ha^{-1}has exhibited a higher level of control and greater persistence than dalapon (22.2 kg ha^{-1}) alone and has demonstrated greater reliability than glyphosate (4.9-9.8 l ha^{-1}) whether applied in shade or non-shade conditions. ARD 13/31 has given excellent crop tolerance in all the crops evaluated.

INTRODUCTION

Asulam [Methyl(4-aminobenzenesulphonyl)carbamate] is a systemic herbicide and has given good control of several perennial weeds in a wide range of plantation crops in many parts of the world. Mixtures of asulum with other translocated herbicides were tested to improve the long term control of *Imperata cylindrica* (L.) Beauv. Evidence from the pot experiments in the UK suggested that a mixture of asulam and dalapon (2, 2-dichloropropionic acid) exhibited synergism in controlling the regrowth of *I. cylindrica* under high humidity conditions (Veerasekaran, 1980) and this was confirmed in the field by Hill and Ingram (1980). This report deals with the studies carried out under controlled environment using pot plants to examine the synergistic interaction of this mixture and the subsequent field evaluation of the formulated mixture ARD 13/31 in Malaysia and Thailand.

MATERIAL AND METHODS

Environmental cabinet studies

I. cylindrica plants were grown in the greenhouse from rhizome fragments in 13 cm diameter plastic pots for 20 weeks to obtain a well developed rhizome system in each pot. The shoots of the plants were clipped 10 cm above the soil surface and grown for another six weeks. The main shoot had 5-6 leaves when treated. Three days prior to treatment uniform plants were conditioned in growth cabinets (Fisons Scientific Apparatus, CM 94 PG) at either 20 or 30°C and 40 or 95% rh with 14 hr illumination. The herbicides, 4 kg a.i. ha^{-1}asulam; 8 kg a.i. ha^{-1} dalapon; 6 or 12 kg a.i. ha^{-1} asulum/dalapon mixtures were sprayed at a volume rate of 800 1 ha^{-1} using a Teejet 8008 fitted to the laboratory sprayer. The treated plants were transferred to the growth cabinets and maintained at the appropriate environmental conditions for 3 weeks, the shoots were then clipped and all the pots were moved to the greenhouse. The activities were compared by assessing shoot fresh weight reductions after 3 weeks and regrowth one month after clipping. Data were analysed using Duncan's multiple F range test.

The uptake and translocation of ring labelled ^{14}C-asulam when treated alone or mixed with dalapon was studied under low and high relative humidity. Two solutions of ^{14}C-asulam, one containing asulam alone (20 mg ml^{-1}) and the other containing asulam/dalapon (60 mg ml^{-1}) with similar specific activities (40 μCi ml^{-1}) were prepared. The youngest fully expanded leaf of *I. cylindrica* plants at the growth stage described before, was treated with ^{14}C solutions as 7, one μl drops (0.25 Ci plant^{-1}), distributed uniformly on the adaxial surface. The treated plants were maintained in growth cabinets at 30°C and at either 40 or 95% rh and the distribution of ^{14}C in the various regions of the plant was radioassayed after 1 and 7 days (Veerasekaran, 1980).

Field evaluation

The performances of the ARD 13/31 sp (63.5% w/w asulam/dalapon) as compared with glyphosate [N-(phosphonomethyl) glycine, 36% v/v) and dalapon Sp (85% w/w) were tested in several field trials under a wide range of conditions in Malaysia and Thailand during 1979-81. All the field trials were of randomised block design with three replicates. The plots were sprayed with a knapsack sprayer calibrated to deliver a volume of 800-1000 l ha^{-1}. Weed control was assessed using percentage control figures.

RESULTS

Environmental cabinet studies

The efficacy of asulam, dalapon and asulam/dalapon mixtures in reducing the shoot fresh weight and regrowth was significantly increased when the treated plants were exposed to high relative humidity (95%) either at 20°C or 30°C (Table 1). Asulam dalapon mixture at 6 kg a.i./ha^{-1} under 95% rh at 20° and 30°C greatly reduced the regrowth (over 96%), as compared to asulam at 4 kg a.i. ha^{-1}, but under 40% rh at 20°C and 30°C greatly reduced the regrowth (over 96%), as compared to asulam at 4 kg a.i. ha^{-1} or dalapon at 8 kg a.i. ha^{-1}, but under 40% rh increase in activity was less. Even at the high rate of asulam/dalapon mixture 12 kg a.i. ha^{-1} complete control of regrowth was achieved only at 95% rh both at 20 and 30°C.

High relative humidity (95%) markedly enhanced the uptake and translocation of ^{14}C-asulam or its ^{14}C-metabolites. An increase from 40 to 95% rh resulted in a seven to eight-fold increase in uptake during 24 hr when ^{14}C-asulam was applied to the leaves with and without dalapon. The presence of dalapon in the mixture increased the initial uptake of ^{14}C-asulam at 95% rh after 24 hr, but did not enhance the translocation to the rhizomes (Table 2). After 7 days, the translocation to the rhizomes and aerial shoots was five times greater under 95% rh than under 40% rh, and there was little effect of dalapon addition.

Field evaluation studies

During 1979-80 ARD 13/31 was widely tested in Malaysia for the control of *I. cylindrica* and also in some non-crop situations in the West Indies and Africa. The main target weed in Malaysia was *I. cylindrica* which is a serious problem in the two major plantation crops, rubber and oil palm. Trials during 1979-80 (Table 3) have shown that ARD 13/31 applied at 18.0 kg ha^{-1} in 0.30% shade and

Table 1 : The effect of temperature and relative humidity on the efficacy of asulam/dalapon mixtures untreate (control = 0).

Treatments kg a.i. ha^{-1}	Temp rh	Fr. wt. reduction (%)[a]				Suppression of regrowth (%)[b]			
		20°C		30°C		20°C		30°C	
		40%	95%	40%	95%	40%	95%	40%	95%
Asulam 4		29	46	35	60[a]	37	84[a]	59	83[a]
Dalapon 8		50	61	46	63[a]	67[a]	82[a]	71[a]	83[a]
Asulam/dalapon 6		63	72	63	74	68[a]	96[b]	71[a]	98[b]
Asulam/dalapon 8		76	88	76	94	84	100[b]	84	100[b]

[a] Fresh weight reductions were recorded 3 weeks after treatments.
[b]Regrowths were assessed one month after clipping the shoots.
Within each column (vertical), means followed by same letter postscripts are not significantly different at P = 0.05. (Duncan's Multiple Range Test).

Table 2 : The uptake and translocation of ^{14}C 1 and 7 days following application of ^{14}C-asulam alone and ^{14}C-asulam/dalapon mixture under lower and high relative humidity at 30°C.

Treatments and relative humidity at 30°C (%)	Days	^{14}C-distribution (% of applied activity)[a]				
		Treated leaf		Translocation to		
		Leaf surface	inside the leaf	Shoot	Rhizome and roots	Total uptake
^{14}C-asulam 95	1	40.3	32.3	14.3	8.0	54.6
	7	16.1	37.5	26.1	16.7	80.3
^{14}C-asulam 40	1	89.0	5.6	0.9	0.5	7.0
	7	79.4	10.1	3.9	3.1	17.1
^{14}C-asulam/ 95 dalapon	1	23.2	53.6	12.9	7.7	74.2
	7	7.6	54.7	17.7	15.9	88.3
^{14}C-asulam/ 40 dalapon	1	89.6	8.0	0.5	0.2	8.7
	7	74.2	14.8	4.1	2.9	21.8

[a] Fully expanded young leaf of each plant was applied with 0.25μCi ^{14}C-asulam as seven oneμl drops.

Table 3 : Percentage of trials sites* with 85-100% control of *I. cylindrica*, Malaysia 1979-80.

Treatment	Dose rate ha^{-1}	% shade	35-50 DAS	102-182 DAS
ARD 13/31	18.0 kg	<30	80	36
	13.5 kg	>30	100	60
Glyphosate	9.8 l	<30	60	55
	4.9 l	>30	60	100
Dalapon	16.8 + 5.4 kg**	<30	10	0
	16.8 kg	>30	0	20

* Means from 11 sites in <30% shade, 6 sites in >30% shade.
** 5.4 kg ha^{-1} dalapon applied at approx. 42 DAS.
'Touch up' sprays were applied where appropriate.
DAS = Days after spraying

Table 4 : Percentage *I. cylindrica* control in 0% shade conditions. Thailand 1980-81.

Treatment	Dose rate ha^{-1}	No. of tillers at 0 days	% Reduction of tillers	
			60	90 DAT
	11.25 kg	94.7	97.1	93.9
ARD 13/31	13.5 kg	52.9	94.7	95.1
	18.0 kg	75.1	98.0	93.8
Glyphosate	7.5-7.8 l	59.8	99.7	95.2
Dalapon	12.5 + 10.0* kg	70.0	99.3	95.0
Unsprayed control (no. of tillers)	–	81.6	103.5	106.1

* 10 kg ha^{-1} dalapon applied 2 weeks after 1st application. Meaned from 2 sites.
DAT = days after treatment.

Table 5 : Percentage *I. cylindrica* control in 50-70% shade conditions. Thailand 1980-81.

Treatment	Dose rate ha^{-1}	No. of tillers at 0 days	% Reduction of tillers	
			60	90 DAT
ARD 13/31	11.25 kg	28.5	97.9	95.1
	18.0 kg	20.7	100	99.5
Glyphosate	7.5 l	17.0	100	100
Dalapon	12.5 + 10.0* kg	23.1	100	99.6
Unsprayed control (no. of tillers)	–	30.0	36.7	91.5

* 10 kg ha^{-1} dalapon applied two weeks after 1st application.
DAT = days after treatment
One trial site.

13.5 kg ha^{-1} in > 30% shade conditions will give good control of *I. cylindrica*.These trials and the commercial applications of the product have demonstrated that the level of control achieved up to 50 days after application was superior to dalapon (16.8-22.2 kg ha^{-1}) alone and was more consistent in activity than glyphosate (4.9-9.8 l ha^{-1}). Results obtained at 102-182 days after application have also shown that ARD 13/31 was till achieving satisfactory control. However, glyphosate has demonstrated significant variability in activity whilst ARD 13/31 was more consistent in its generally high level of efficacy. Dalapon in all cases was out-performed by both glyphosate and ARD 13/31. Subsequent to the field trials in Malaysia, ARD 13/31 (11.25-18.0 kg ha^{-1}) was evaluated in Thailand during 1980-81. Three trials were conducted; two sites in 0% shade and one in 50-70% shade (mature rubber) (Tables 4 and 5). The results from these trials show that ARD 13/31 (11.25-18.0 kg ha^{-1}) has given more than 95% control of *I. cylindrica* in 0% shade and more than 90% control in 50-70% shade up to 90 days after application, which was comparable to the control achieved with glyphosate (7.5-7.8 l ha^{-1}) and dalapon (22.5 kg ha^{-1}).

The crop tolerance of the major varieties of rubber (seedling to >3 years), oil palm (>2 years old), coconut (seedling to >3 years) and established mangoes, to directed sprays of ARD 13/31, avoiding foliar contact, has been excellent. Even where volunteer coconut palms and rubber have been oversprayed, only initial yellowing of the coconut fronds has occurred, but these subsequently recovered to normal health. Studies during 1980-81 have shown that 10 month old seeding oil palms planted into ground immediately post-spraying of 36 kg/ha^{-1} ARD 13/31 have not exhibited phytotoxic effects.

DISCUSSION

The results of pot experiments suggest that a reliable control of *I. cylindrica* should be possible with an asulam/dalapon mixture in areas where the humidity is high all the year round, as the mixture showed a synergistic interaction under humid conditions in the temperature range of 20 to 30°C (Table 1). Under high rh greater uptake of ^{14}C-asulam and maximum accumulation of ^{14}C in the rhizomes was evident (Table 2). It has been shown that high rh also markedly enhances uptake and translocation of ^{14}C-dalapon in several perennial grass weeds (Prasad *et al.* 1967; Mc Whorter and Jordan, 1976). These results indicate that high rh apparently favours the uptake and subsequent accumulation of both asulam and dalapon at the sites of action where they interact to produce a synergistic effect.

The field testing of the formulated asulam/dalapon mixture, ARD 13/31, has confirmed the laboratory results by showing that asulam can enhance the performance of dalapon in the control of *I. cylindrica* in a wide range of tropical plantation crops. ARD 13/31 (11.25-18.0 kg ha^{-1}) has been shown to give greater reliability of control than glyphosate (4.9-9.8 l ha^{-1}) and superior control than dalapon alone (22.2 kg ha^{-1}). These trials have also shown control of a wide range of other weed species including *Cynodon dactylon* Pers, *Digitaria sanguinalis* Scop. *Eleusine indica* Gaertn., *Eupatorium odoratum* L., *Mikana cordata* Robins., *Ottochloa nodosa* Dandy, *Panicum maximum* Jacq. and *Paspalum* sp.

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FLUAZIFOP-BUTYL A NEW TYPE OF HERBICIDE WITH SELECTIVITY BETWEEN GRAMINEOUS WEEDS AND BROAD LEAF CROPS

F. KIMURA, R. NISHIYAMA, K. FUJIKAWA, I. YOKOMICHI, T. HAGA and N. SAKASHITA
Central Research Laboratory, Ishihara Sangyo Co. Ltd., Shiga, Japan.

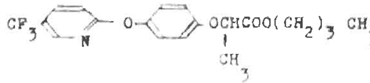
ABSTRACT

A new selective herbicide Fluazifop-butyl, butyl 2-4-(5-trifluoromethyl-2-pyridyloxy) phenoxy propionate has been jointly developed by Ishihara Sangyo Company and Imperial Chemical Industries all over the world. This compound is characteristic mainly in the clear selectivity between gramineous weeds and broad leaf crops and in the distinguished translocation through leaves and roots. Fluazifop-butyl can be safely used for almost any broad leaf crops to control annual and perennial grasses by overall treatment as well as by soil surface treatment and soil incorporation. Its excellent translocatability through leaves and roots brings special effect for the control of perennial grasses quite tolerant to any herbicides now in use. The average application rates of Fluazifop-butyl are 0.125-0.25 kg a.i./ha and 0.5-1.5 kg/ha for annual and perennial grass control, respectively.

Here in this paper, structure-activity relationship, selectivity between broad leaf crops and grasses, translocation through leaves and some field test results are presented.

INTRODUCTION

It is very important that herbicides for crop lands should have so-called direct or indirect selectivities between crops and weeds as well as high activities. Among them the selectivity which can be displayed by post-emergence treatment is especially desirable and valuable for practical field. During the extensive course studies in the compounds having the general structure shown in Table 1, it has been revealed that a lot of compounds were highly active only against gramineous plant species. Above all, fluazifop-butyl [butyl 2-(4-(5-trifluoromethyl-2 pyridyloxy) phenoxy)propionate] is the most prominent in activity, selectivity and translocatability among these analogs. The chemical structure of fluazifop-butyl is as follows:



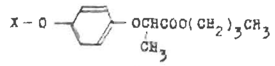
This herbicide has been jointly developed by Ishihara Sangyo Co. and Imperial Chemical Industries Ltd. over the world since 1978 and the general information and some field test results have already been reported (Plowman *et al.* 1980; Finney and Sutton, 1980). In this paper, chemical structure-activity relationship, the selectivity between perennial grasses and the translocatability through leaves are mainly presented.

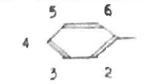
MATERIAL AND METHODS

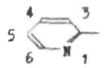
Structure-activity relationship

All the compounds tested were formulated as 35% EC and dispersed in the water at a volume of 500 l/ha with surfactant of 0.3% (v/v). Overall treatment

Table 1 : Structure and biological activities.



X (benzene ring)					Activity*				Translocation**
 2	3	4	5	6	*Digitaria adscendens*	*Sorghum halepense*	*Xanthium strumarium*	Soybean	in *Cynodon dactylon*
		CH_3			1	1	1	1	1
		Cl			1	1	1	1	1
		I			6	2	1	1	1
					9	4	1	1	1
		CF_3			10	7	1	1	2
	CF_3				1	1	1	1	1
CF_3					1	1	1	1	1
Cl		Cl			5	2	1	2	1
Cl		CF_3			8	5	1	3	2

X (pyridine ring)				Activity*				Translocation**
 3	4	5	6	*Digitaria adscendens*	*Sorghum halepense*	*Xanthium strumarium*	Soybean	in *Cynodon dactylon*
				1	1	1	1	1
		CH_3		1	1	1	1	1
		Cl		5	3	1	1	3
		Br		10	7	1	1	4
		I		10	8	1	1	4
	CF_3			1	1	1	1	1
		CF_3		10	10	1	1	5
		CF_3		1	1	1	1	1
Cl		Cl		10	9	1	1	3
Cl		CF_3		10	10	1	1	4
		CF_3	Cl	9	3	1	1	3

* Activity at 0.5 kg/ha : 1...No effect ~ 10... Death
** Translocation: 1...No ~ 5... Remarkable

was made at rate of 0.5 kg a.i./ha (a.i.) using a hand sprayer in the glasshouse when the test plants were 5 to 6 leaf stage. Herbicidal activity and phytotoxicity were visually assessed using a scale of 1 to 10 with 1 representing no control (no damage) and 10 indicating complete death. The translocatability was estimated with 1 to 5 scale using *Cynodon dactylon* Pers. In Table 1 the biological data are shown. The compounds consist of the two groups, the one with benzene ring and the other with pyridine ring in X position.

RESULTS AND DISCUSSION

Structure – activity relationship

a) Benzene ring compounds: Substitution by CF_3 or a halogen atom at 4 position in benzene ring is essential for the

Table 2: Selectivity of fluazifop-butyl between crops and grasses.

		Soy-bean	Cot-ton	Sugar beet	Sunf-lower
D. adscendens	(3 l)	33	42	25	25
E. crusgalli	(3 l)	67	83	50	50
A. repense	(6 l)	10	13	8	8
Rhizome	(5 l)	16	20	12	12
S. halepense					
C. dactylon	(40cm)	33	42	25	25

$$\text{Selectivity} = \frac{\text{Dosage to give 5\% growth inhibition to crops (kg/ha)}}{\text{Dosage to give 95\% control of grasses (kg/ha)}}$$

against gramineous species and di-substitution by the same substituents at 2 and 4 positions also gives active compounds although they are less active and more phytotoxic against soybean than the former mono-substituted compounds. In the case of mono-substitution, the substituents contribute to the activity in the order of $CF_3 > I > Cl$. The translocatability of these active compounds is far inferior to that of pyridine compounds mentioned below.

b) Pyridine ring compounds

For these analogs the substitution at 5 and 3,5 positions of the ring is important to enhance the herbicidal activity and little difference in activity and in phytotoxicity against crop is noted between mono and di-substituted compounds. Other compounds which have the same substituents mentioned above at 2, 4 or 6 positions of the ring are quite inactive. Generally the herbicidal activities of pyridine compounds are higher than those of benzene compounds. Translocation behavior is also sensitive to structure. Optimum translocatability among these two groups is associated with the pyridine derivatives, in which 5-CF_3 compound is outstanding. From these results butyl 2-[4-(5-trifluoro-methyl-2-pyridyloxy) phenoxy] propionate was selected as the final compound for development.

Selectivity by foliage application

This test was conducted to know the selectivity between gramineous weeds and broad leaf crops. The leaf stages of the test plants at the time of treatment were as follows: *Digitaria adscendens* Henr. (3L), *Echinochloa crus-galli* Beauv. (3L), *Agropyron repense* Beauv. (6L), *Sorghum halepense* Pers. (5L), *Cynodon dactylon* Pers. (40 cm), broad leaf crops (3L). Fluazifop-butyl was applied at various rates and the dosages required to give 95% growth inhibition against weeds and 5% inhibition against crops by dry weight of the untreated check were obtained four weeks after treatment. The selectivity was calculated by the expression shown under Table 2: the larger number means the higher selectivity. Generally the safety margins between annual grasses and broad leaf crops were much larger than those between perennial grasses and the crops. The highest safety level was obtained between cotton and *E. crusgalli*, on the other hand, the lowest case was between sunflower and *A. repense*. However, even in the lowest case, sunflower was tolerant by eight times at 5% inhibition level to the dose required for the control of *A. repense* at 95% inhibition level.

Effects on perennial grasses

Five species of some troublesome perennial grasses were grown outdoor in small plots (Table 3) Fluazifop-butyl was applied with spray volume of 500 l/ha with 0.2% (v/v) surfactant at rates of 0.5, 1.25 and 2.5 kg a.i./ha when the growth stages of each grass were as follows: *S. halepense* (5-6 l), *A. repense* (15-20 cm), *C.*

Table 3: Herbicidal effect on perennial grasses.

Chemicals	kg/ha	*Sorghum halepense*		*Agropyron repense*		*Cynodon dactylon*		*Imperata cylindrica*		*Miscanthus sinensis*	
		T	R	T	R	T	R	T	R	T*	R**
Fluazifop-butyl	0.5	10	5	10	5	10	5	6	3	7	2
	1.25	10	5	10	5	10	5	9	4	9	4
	2.5	10	5	10	5	10	5	10	5	10	5
Glyphosate	0.5	4	1	5	2	4	2	3	1	2	1
	1.25	6	2	9	4	7	3	5	1	4	1
	2.5	10	5	10	5	10	5	7	3	7	3
Alloxydim-sodium	0.5	1	1	3	1	4	1	1	1	1	1
	1.25	2	1	5	1	7	3	1	1	1	1
	2.5	4	1	8	3	9	4	3	1	4	1
Diclofop-methyl	0.5	1	1	1	1	2	1	1	1	1	1
	1.25	1	1	4	1	5	1	1	1	1	1
	2.5	2	1	6	1	8	2	2	1	2	1

Note* T : Top kill 1 ... No effect ~ 10 ... Complete kill
** R : Regrowth inhibition 1 ... No inhibition ~ 5 ... Complete

Table 4: Translocation by top treatment on *C. dactylon.*

Chemicals	Top kill*	Sprout inhibition** — Nodes of stolon 1	2	3	4	5	6	7	8	9	10	11	12	Basal part
Fluazifop-butyl	10	5	5	5	5	5	5	5	5	5	5	5	5	4
Diclofop-methyl	4	1	1	1	1	1	1	1	1	1	1	1	1	1
Glyphosate	7	5	5	5	5	4	4	4	4	4	4	4	4	3-4
Alloxydim-sodium	7	5	5	5	4	4	4	1	1	1	1	1	1	1
Paraquat	10	1	1	1	1	1	1	1	1	1	1	1	1	1

Note: * Top kill 1 ... No effect ~ 10 ... Complete kill
** Sprout inhibition 1 ... No inhibition ~ 5 ... Complete inhibition

dactylon (completely covered the soil surface), *I. cylindrica* Beauv. (15-20 cm) and *Miscanthus sinensis* Andress (50 cm). Sixty days after treatment top-kill and regrowth from rhizomes were visually observed with 1 (no effect) to 10 (complete kill) scale for the former, and with 1(no effect) to 5 (no regrowth) for the latter. The order of the sensitivity of the five species was *C. dactylon* > *S. halepense* > *A. repense* > *M. sinensis* > *I. cylindrica*. The rates of fluazifop-butyl required for the control of *C. dactylon, S. halepense* and *A. repense* were 0.25 to 0.5 a.i. ko/ha which were sufficient enough to control even the regrowth from the rhizomes. *M. sinensis* and *I. cylindrica* were far more tolerant than the former three species and the rates for their complete control were 2.0 to 4.0 kg/ha. Fluzaifop-butyl is slow in acting especially in low temperature. The first symptoms are usually not clear until a week or more. Their typical symptoms are necrosis on nodes and on growing point, chlorosis on young leaves, accumulation of anthocyan on old leaves and general growth inhibition. Following these symptoms, total death occurs three to five weeks after application. At this time all the buds on the rhizome nodes were completely killed and this phenomenon suggests that fluazifop-butyl is absorbed through leaf and translocates far up to the end tips of the rhizome through phlœm.

Translocation through leaves

One of the stolons of the transplanted *C.dactylon* was grown 1.5 m long. Its end tip having two nodes (about 15 cm) was immersed in a 2000 ppm dispersion of fluazifop-butyl for a few seconds and dried. The damage of the treated part and the inhibition of the sprouts from each node and from basal part of the stolon were assessed with the same scale used for previous tests. The test results are shown in Table 4. Fluazifop-butyl moved much more compared with other translocating herbicides, such as glyphosate or alloxydim-sodium. It could inhibit all the sprouts from any nodes and finally led the entire body to complete death. Neither glyphosate nor alloxydim-sodium could prevent sprouting from farer nodes than the fifth from the treated part and the basal part. This high translocatability of fluazifop-butyl seems to contribute to the successful control of vigorous perennial grasses.

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DEVELOPEMENT OF THE ISOPROPYLAMINE SALT OF GLYPHOSATE FOR WEED CONTROL IN TEA

V. SRINIVASAN[1], N. S. NEGI[2], C. S. PERERA[3], L. M. ARCEO[4]

[1,2] Monsanto Chemicals of India Ltd.,3/8 Asaf-Ali Road, New Delhi, 110 002, India.
[3] Monsanto Far East Ltd., Steaurt Place, Galle Road, Colombo 3, Sri Lanka.
[4] Monsanto Singapore Company Pvt. Ltd., 26th Floor, Clifford Centre, Raffles Place Singapore 0104.

ABSTRACT

The development program for the use of the isopropylamine salt of glyphosate in tea *(Carmellia sinensis)* started with preliminary screening trials for weed control and continued systematically through to completion of crop residue analysis. Weed control evaluations concentrated primarily on the problem perennial weed species *Imperata cylindrica*(L) Beauv. and *Panicum repens* (L) both of which are effectively controlled. Crop tolerance trials reveal tea exhibits considerable tolerance to the herbicidal effects of the isopropylamine salt of glyphosate from drift or accidental spray contact.

INTRODUCTION

Tea is a major crop of commerce in the world and *Imperata cylindrica* and *Panicum repens* are two of the most serious weed problems in the major tea producing countries. Holm *et al.* (1977) reported that *Imperata cylindrica* is ranked among the three most serious weeds in tea in India and Sri Lanka. Somaratne and Manipura (1974) reported that *Panicum repens* is one of the most noxious weeds in tea in Sri Lanka.

Both grasses have very extensive rhizome systems which make complete control and eradication difficult. Rhizomes of *Panicum repens* can penetrate to a depth of 7m (Somarane and Manipura, 1974), while *Imperata cylindrica* rhizomes may penetrate as deeply as 120 cm (Holm *et al.* 1977). Studies in India (Panchal, 1977) indicated that bromacil (5-bromo-3-sec-butyl-6- methyl-uracil) or terbacil (3-tertbutyl- 5-chloro-6-methyluracil)-1, or dalapon (2,2 - dichloro propionic acid) plus diuron [3-(3,4-dichlorophenyl)-1-dimethyl-urea] sequentially followed by paraquat (1,1' -dimethyl - 4,4'- bipyridibium ion) will provide some degree of *Imperata cylindrica* control. Complete control or eradication within economical limits or without sterilization of the ground has not been possible with early herbicides.

In the Philippines, Abad *et al.*(1981) reported excellent control of *Imperata cylindrica* with 3.08 kg ai ha^{-1} (2.70 kg ae ha^{-1}). Wong (1975) reported the results of his trials with glyphosate to control *Imperata cylindrica* and observed 91 to 94% control at 150 days after application with 2.2 kg ae ha^{-1}. Somaratne and Manipura (1974) reported 90 to 99% control of *Panicum repens* with glyphosate at rates of 2.24 to 4.48 kg ai ha^{-1}.

Glyphosate was tested in tea as early as 1974 by United Planters Association of Southern India and Tea Research Association of North India. In Sri Lanka, the Tea Research Institute conducted trials with glyphosate to control *Panicum repens* in 1974. Monsanto had conducted preliminary screening trials with glyphosate to control *Imperata cylindrica* and *Panicum repens* as early as 1971. This paper summarizes rate refinement studies and crop tolerance studies conducted with glyphosate in tea from 1978 to 1980 in India and Sri Lanka.

MATERIAL AND METHODS

The rate refinement trials in India were conducted in the tea estate of Sonabheel, Tarajulie, Darrang, Sonajuli and Borjuli in Assam. The plot size was 150 sq m with no replications. Knapsack sprayers calibrated at 400 L ha^{-1} were used in all trials. The trials were established in June and July of 1978 and 1979.

In Sri Lanka, trials were conducted in the tea estates of Wattagoda, Devon, Holyrood, Ramboda, Labrookelle, Gonadika and Harrington. The *Imperata cylindrica* plots were 36 sq m while the *Panicum repens* were 40-49 sq m. The 1979 trials were replicated twice while the 1980 trials were replicated three times. Knapsack sprayers with cone nozzles calibrated at 930 L ha^{-1} were used in all trials. The 1979 trials on *Imperata cylindrica* were established in June and July while the 1980 trials were established in December, 1979. The *Panicum repens* trials were established in October and November 1979 and August and September 1980.

In crop tolerance studies, the plot size was 36 sq m with no replications. The trials were conducted in Harrington, Drayton, and Holyrood. A knapsack sprayer with a cone nozzle calibrated at 930 L ha^{-1} was used. Young tea bushes, abot one year old were used in the trials and 2% solution of glyphosate, equivalent to 6.69 kg ae ha^{-1} was applied. Three methods of application were used, normal spraying, side branch and blanket spray. In normal spraying, glyphosate spray was directed only to the weeds growing around the bush. In the side branch method, one branch was purposely sprayed with a 2% solution to simulate accidental drift. In blanket spray, the entire bush was deliberately sprayed over the top. The development of injury symptoms were observed every 30 days for 180 days.

RESULTS AND DISCUSSION

Control of *Imperata cylindrica*

Table 1 summarizes the results of the rate refinement trials in India. Glyphosate applied at 1.80 kg ae ha^{-1} provided 94% control of *Imperata cylindrica* six months after application. Neither of the lower rates (1.08 and 0.72 kg ae ha^{-1}) provided acceptable long term control of *Imperata cylindrica*.

In Sri Lanka, the effective rate of glyphosate for long term control of *Imperata cylindrica* was 3.60 kg ae ha^{-1} (Table 2). While 2.88 kg ae ha^{-1} of glyphosate provided good control in 1980, control in 1979 was unacceptable when plants were growing under moisture stress. Generally, plants growing under stress conditions such as drought, insect damage recent slashing, or dust on foliage will not respond properly to glyphosate. The use of a higher rate will provide more consistent control of *Imperata cylindrica* over a broader range of environmental conditions.

The difference in rates rquired to control *Imperata cylindrica* in India versus Sri Lanka is undoubtedly due to physiological differences in the plants caused by varying environmental and cultural practices. Similar rate responses to glyphosate have been observed with other weed species throughout the world. These differences point out the need to conduct extensive field trials within a country prior to making weed control recommendations.

Control of *Panicum repens*

Table 3 summarizes the results of rate refinement trials with glyphosate to control *Panicum repens* in Sri Lanka. Glyphosate at 2.16 kg ae ha^{-1} provided 95% control of *Panicum repens* upto 270 days afterapplication with no regrowth. Performance of the 1.8 kg ae ha^{-1} application was better in 1980 compared to 1979. Again, the difference in

Table 1 : Control of *Imperata cylindrica* in tea with glyphosate, Assam (North Bank) India 1978 and 1979.

Herbicide	Rate (kg æ ha^{-1})	Percent *Imperata cylindrica* Control *		
		1978	1979	Mean
Glyphosate	0.72	62	66	64
Glyphosate	1.08	80	85	82.5
Glyphosate	1.80	92	96	94

* One hundred and fifty days after glyphosate application.

Table 2: Control of *Imperata cylindrica* in tea with glyphosate, Sri Lanka, 1979 and 1980.

Herbicide	Rate (kg æ ha^{-1})	Per cent *Imperata cylindrica* Control *		
		1978	1979	Mean
Glyphosate	2.16	60	83	72
Glyphosate	2.88	82	90	86
Glyphosate	3.60	93	92	92

* Two hundred and ten days after glyphosate application.

Table 3: Control of *Panicum repens* in tea with glyphosate, Sri Lanka, 1979 and 1980.

Herbicide	Rate (kg æ ha^{-1})	Per cent *Panicum repens* Control *		
		1979	1980	Mean
Glyphosate	1.44	70	82	76
Glyphosate	1.80	81	91	86
Glyphosate	2.16	91	95	95

* Two hundred and seventy days after application.

Table 4 : Recovery of tea bushes following post directed and simulate over-spraying of glyphosate (2% solution) to one year old plants, Sri Lanka.

Days after application	Application Method *		
	Normal	Sidebranch	Blanket
30	No injury	Scorching	Scorching
60	No injury	Scorching	Die-back
90	No injury	Multiple bud	Die-back
120	No injury	Recovering	Multiple bud
150	No injury	Recovering	Recovering
180	No injury	Recovering	Recovering

* Normal application; post directed spray, minimal contact of bush; Side branch, one branch sprayed; Blanket, entire bush sprayed.

control may be due to the drier conditions which existed in 1979 compared to 1980. The results of these trials confirm the results obtained in 1974 by the Tea Research Institute in Sri Lanka.

Crop Safety of Glyphosate in Tea

Glyphosate at 2% solution (6.69 kg ae/$^{-1}$) or two or three times the anticipated use rate when used as a directed spray around the tea bush did not induce any phytotoxicity to the tea plant (Table 4). However, when the same concentration was sprayed on one branch, scorching and drying of the leaves developed. The tea bushes that received over the top application with a 2% glyphosate solution also exhibited scorching and drying that resulted in die-back of the tips. When the tea plants begin to recover from glyphosate injury, multiple buds were produced. The multiple buds will drop and die and this will be replaced with long, narrow leaves. This is an indication that the plant has recovered. The plants that were sprayed on one branch only completely recovered after 150 days while the plants that were blanket sprayed, recovered after 180 days.

CONCLUSION

Glyphosate applied at the correct dosage provided excellent long term control of *Imperata cylindrica* and *Panicum repens* growing in tea. In India, 1.8 kg ae ha^{-1} of glyphosate was the optimum rate for effective long term control while in Sri Lanka, 3.6 ae ka ha^{-1} was required to obtain the same level of *Imperata cylindrica* control. In Sri Lanka, glyphosate applied at 2.16 kg ae ha^{-1} provided excellent long term control of *Panicum repens.* Crop tolerance studies demonstrated that tea is tolerant to high doses of glyphosate applied as a post directed application in the crop.

ACKNOWLEDGEMENTS

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ANNUAL AND PERENNIAL GRASS WEEd CONTROL IN ASIA-PACIFIC REGION WITH FLUAZIFOP-BUTYL

A. K. SETH and D. W. R. HEADFORD
Far East and Pacific Region, ICI Plant Protection Division, Fernhurst and
Weed Science Section, Jealott's Hill Research Station,
ICI Plant Protection Division, Bracknell, U.K., respectively.

ABSTRACT

Fluazifop-butyl (coded PP009) a new broad leaved crop selective herbicide has been widely evaluated in Asia-Pacific Region for the control of annual and perennial grasses. This compound has been found to be highly active against most grasses particularly when applied post-emergence. It is very safe to all non-graminaceous crops. Annual and seedling perennial grasses are well-controlled by rates ranging between 0.125-0.5 kg/ha. The rates required for the control of established perennial grasses range between 0.5-2.0 kg/ha ai. Cultivation resulting in fragmentation of the perennating organs invariably reduce the rate required for effective control.

INTRODUCTION

Fluazifop-butyl is a new selective herbicide for the control of both annual and perennial grasses in non-graminaceous crops. General information on this compound and preliminary field results primarily from the temperate region were presented by Plowman *et al.* (1980) and Finney and Sutton (1980). This paper reviews the findings of some of the Asia-Pacific Region highlighting the important characteristics of this herbicide.

MATERIAL AND METHODS

The experimental details of the trals discussed in this paper are presented in Table 1. In all trials a 25% emulsifiable concentrate formulation of fluazifop-butyl was used. A surfactant Agral 90 at the strength of 0.1% in the final spray solution was used in all trials. Appropriate commercially available products were used as standards.

RESULTS AND DISCUSSION

Crop selectivity: A wide range of non-germinaceous crops will tolerate fluazifop-butyl at rates 2-4 times those required for effective weed control. Table 2 lists the crops which have been shown to be tolerant to post-emergence sprays of this chemical.

Annual Grass Control: Results from two trials comparing pre- and post-emergence activity of fluazifop-butyl against annual grasses are given in Table 3. The results show this compound to be much more active when applied post-emergence, although it also possesses useful pre-emergence activity. A list of additional tropical and mediterranean climate weeds known to be susceptible to post-emergence application of fluazifop-butyl is given in Table 4. The rates indicated are needed for 80% or more weed control.

Perennial grass control: The results from a trial carried out in Bangalore, India against established stands of *Cynodon dactylon, Panicum repens* and *Pennisetum clandestinum* are presented in Table 5. Fluazifop-butyl at 1 kg gave very good control for two months. Thereafter, the

Table 1 : Experimental Details.

Country	India	Malaysia	Australia
Site	Bangalore	Malacca	Griffith, NSW
Crop	No crop	No crop	No crop
Plot size	2 m x 1 m	2 m x 3 m	1 m x 3 m
Replication	2	4	2
Sprayer	Pressure vessel with CO_2 as propellant	Oxford precision with Arcton as propellant	Oxford precision sprayer with propane as propellant
Nozzle	Allmans '00'	Allmans '00'	2 T-jet No. 730231
Volume l/ha	500	400	250
Pressure (bar)	2.1	2.1	2.1
Assessment	Visual assessment % kill over whole of the plot.	Visual assessment % kill over whole of the plot.	Visual assessment % kill over whole of the plot.

Table 2: Crops shown to be tolerant to post-emergence sprays of fluazifop-butyl.

Apple	Groundnut	Raspberry
Apricot	Jute	Redcurrant
Banana	Kale	Redgram
Blackgram	Lettuce	Soybean
Broad bean	Linseed	Spinach
Brussel sprout	Lucerne	Squash
Bulbs	Lupin	Strawberry
Cabbage	Melon	Sugarbeet
Carrot	Mungbean	Sunflower
Cassava*	Oil palm	Swede
Cauliflower	Oil seed rape	Tea
Cherry	Onion	Tomato
Clover	Parsely	Turnip
Cocoa	Parsnip	Vine
Coffee	Pea	Watercress
Cotton	Peach	Whitebean
Flax	Pineapple	Legume cover crops
French bean	Potato	(Pueraria, Centrosema, Calopogonium)
Garlic	Radish	

* Basal spray only

weeds started to regrow. When compared to the standard glyphosate, PP009 appeared to be more active particularly against *Cynodon*.

Work carried out in Malaysia against another perennial weed *Paspalum conjugatum* has also shown this herbicide to be very effective against the established stands of this species even at 0.5 kg/ha. Typical results are presented in Table 6.

Perennial grass control: Effect of fragmentation of the perennating organ on the level of control.

Table 7 presents results from a trial carried out in Australia against *Cynodon dactylon*. In this trial post-emergence applications were made either to re-growth following fragmentation of rhizomes or to an established stand without fragmentation. Fluazifop-butyl was much more active when applied following fragmentation with 1.0 kg/ha rate giving good control. Without fragmentation 2.0 kg/ha rate was needed to give similar control.

Table 3: Control of annual grasses using fluazifop-butyl (Bangalore, India 1979/80).

Application	Chemical treatment	Rate	% Kill									
			1980 Rabi Season *						1979 Kharif Season **			
				Phalaris minor	*Echinochloa crus-galli*	*Avena fatua*	*Triticum aestivum*	*Poa annua*	*Echinochloa colonum*	*Digitaria marginalis*	*Dactyloctenium aegyptium*	*Chloris barbata*
Pre-emergence	Fluazifop-butyl	0.25	30	10	0	0	10	0	–	–	–	–
		0.5	60	20	20	30	60	0	100	100	100	100
		1.0	95	90	80	55	8[illegible]	0	100	100	100	100
	Propyzamide	0.5	50	0	40	5	5	100				
		1.0	95	0	75	20	20	100				
	Metribuzin	0.5							85	85	100	95
		1.0							100	100	100	100
Post-emergence	Fluazifop-butyl	0.0625	5	5	20	0	0	0	–	–	–	–
		0.125	5	10	60	15	40	0	–	–	–	–
		0.25	60	95	90	90	100	20	100	100	100	100
		0.50	90	100	100	100	100	25	100	100	100	100
	Propyzamide	0.5	0	0	40	0	0	35				
		1.0	80	0	95	55	50	55				
	Alloxydim-Na	0.25							65	40	50	55
		0.50							95	75	90	80
		1.0							100	100	100	100

* *Rabi* (cool) season: Pre-emergence treatments: Assessed at 40 days after treatment (DAT), Post-emergence treatments: Sprayed when weeds 4-5 leaf stage & assessed at 30 DAT, ** *Kharif* (summer) Season: Pre-emergence treatments: Assessed at 45 DAT, Post-emergence treatments: sprayed at 4-5 leaf stage & assessed at 25 DAT.

Table 4: List of susceptible weeds to post-emergence application of fluazifop-butyl. The rates indicated are needed to achieve 80% or more weed control.

Very sensitive species (0.125-0.25 kg a.i./ha)(1)	
Brachiaria platyphylla	*Hordeum vulgare (barley)*
Cenchrus echinatus	*Panicum maximum – seedling*
Eleusine indica	*Zea mays* (maize)
Hordeum murinum	
Sensitive species (0.25-0.5 kg a.i./ha)	
Brachiaria plantaginea	*Rottbœllia exaltata*
Cynodon dactylon – seedling	*Saccharum officinarum* (sugarcane)
Digitaria sanguinalis	*Setaria glauca (lutescens)*
Lolium rigidum	*Setaria viridis*
Panicum dichotomiflorum	*Sorghum bicolor*
Panicum texanum	*Sorghum halepense* – seedling
Panicum virgatum	*Sorghum vulgare* (sorghum)
Susceptible species (0.5–1.0 kg a.i./ha)	
Axonopus compressus	*Phalaris minor*
Bromus sterilis	*Poa trivialis*
Corchorus olitorius (jute)	*Setaria anceps*
Lolium perenne	*Setaria faverri*
Moderately resistant species (greater than 1 kg a.i./ha)	
Festuca ovina, Festuca rubra	*Poa annua*

Table 5 : Control of established stands of *Cynodon dactylon, Panicum repens* and *Pennisetum clandestinum* using fluazifop-butyl – Bangalore, India.

Chemical	Rate kg a.i./ha	Days after treatment	% kill		
			C. dactylon	*P. repens*	*P. clandestinum*
Fluazifop-butyl	1.0	7	30	10	20
		20	100	65	80
		40	95	90	92
		70	80	60	80
		90	75	50	75
	2.0	7	20	10	25
		20	100	50	75
		40	95	95	100
		70	85	75	90
		90	85	70	85
Glyphosate	2.0	7	47	55	75
		20	95	98	100
		40	87	100	100
		70	25	75	70

Table 6 : Control of an established stand of *Paspalum conjugatum* using fluazifop-butyl, Malacca, Malaysia.

Chemical	Rate kg a.i./ha	Days after Treatment	% Kill
Fluazifop-butyl	0.25	7	5
		21	13
		42	47
		70	33
	0.50	7	7
		21	15
		42	80
		70	92
Glyphosate	0.50	1	12
		21	37
		42	78
		70	52
		91	

Table 7 : *Cynodon dactylon* control : Effect of fragmentation of rhizomes on the level of control following post-emergence application of fluazifop-butyl Griffith, Australia.

Chemical	Rate	Days after Treat-ment	% Kill	
			Frag-mented	Non-frag-mented
Fluazifop-butyl	0.25	7	12	–
		14	63	–
		28	23	–
		56	8	–
		84	30	–
	0.5	7	13	5
		14	53	40
		28	28	55
		56	58	15
		84	55	10
	1.0	7	15	10
		14	73	53
		28	83	55
		56	97	28
		84	78	3
	2.0	7	–	23
		14	–	60
		28	–	84
		56	–	89
		84	–	70

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HOE 30374 – A NEW HERBICIDE FOR TRANSPLANTED PADDY RICE

P. LANGELUDDEKE, G. SALBECK, H. BIERINGER, H. KASSEBEER and H. UNGLAUB
Hoechst Aktiengesellschaft, Postfach 80 03 20,
6230 Frankfurt/M. 80.

ABSTRACT

Hoe 30374, a new chemical of low toxicity belonging to the phophoric esters group, is a herbicide which is especially effective on annual grasses and sedges, and selective in transplanted rice. It has been tested under tropical as well as under subtropical or warm temperate conditions. The dosage rate is 0.3 kg/ha a.i. in form of an EC, or 0.45 kg/ha a.i. when used as a granule; it can be applied up to the 2 or 2.5 leaf stage of *Echinochloa crus-galli*. Under tropical conditions of Southeast Asia combinations with 2,4-D controlled a broad spectrum of annual weeds and can be used from 6 to 10 days after transplanting. In the soil, the active material is decomposed relatively quickly and it is leached to a very low degree.

INTRODUCTION

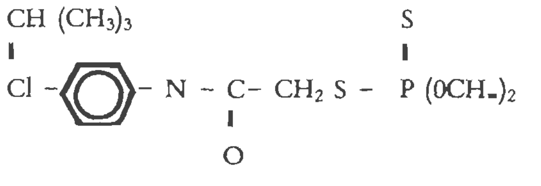
Chemical weed control in rice is well established in Japan and of increasing importance in the tropical rice growing countries. Noda (1980) mentioned that *Echinochloa* species, especially *Echinochloa crus-galli* Beauv. are of great importance in Japan and in South East Asian countries as well; other annual species such as *Cyperus difformis* L., *Cyperusiria* L., *Monochoria vaginalis* (Burm.) C. Presl. and *Sphenochlea, zeylanica* Gærtn. were reported as also being important weeds in paddy fields. A new herbicide, which effectively controls a numberof these important annual weeds,has been discovered in the laboratories of Hœchst AG in Frankfurt. This material with the Code-No. Hœ 30374 has been intensively tested under different conditions during the last years. The results of this experiment have been reported in this paper.

CHEMICAL AND PHYSICAL PROPERTIES

Code: Hœ 30374

Chemical Name: S-[N-(4-chlorophenyl-) -N-isopropyl-carbamoylmethyl-]-0, 0-dimethyl-dithiophosate

Structural formula:



Common name: anilofos (proposed)
Water solubility: 13.6 mg/l (at 22°C)
Formulations: a) grangule with 1,5 % a.i.
b) EC with 300 g/1 a.i.
c) EC with 150 g/l Hœ 30374
+ 150 g/l 2,4-D isobutylester

Toxicology of technically active material

Acute oral toxicity rat	(male)	LD_{50}	830 mg/kg bodyweight
	(female)	LD_{50}	472 mg/kg bodyweight
Acute dermal toxicity rat	(female)	LD_{50}	> 2000 mg/kg bodyweight
Fish toxicity: TLM-value (96 h)	gold fish	4.6 ppm	
	trout	2.8 ppm	

According to our present knowledge, Hœ3.374 has no mutagenic effects.

MATERIAL AND METHODS

Pot and field trials

Pot trials were carried out in Japan (in Kawagœ, Satiama prefecture) under open conditions in plastic pots (60 by 17 by 14 cm). In all pots the water level was kept at 1 to 2 cm throughout the trial. A normal paddy soil was used.

All field trials in Japan were carried out near Kawagœ in small plots with 0.8 m^2 plot size with 3 replicates in a randomized block design. Most of thse trials were carried out at 2 transplanting times (early transplanting mid/end May, late transplanting mid/end June or beginning July) in order to get information on the performance of the product under different conditions. The plot size of the field trials conducted in the Philippines, most of them in the Laguna province, was usually 4 m^2 and in some trials 15 m^2, and the number of replicates 4. Visual crop tolerance evaluations were made by using figures between 0 and 100 %; the weed control evaluations were made by counting the weeds in the central 3 m^2 of the 4 m^2 plot, or in 3 by 1 m^2 sub plots when the plot size was 15 m^2. Two seedling types were used for transplanting: usual wetbed seedlings, or dapog seedlings, i.e. rice plants which are cultivated without soil on banana leaves, plastic material or similar, and which are transplanted 8 to 12 days after seeding.

RESULTS

Basic results

Growth stage: In a pot trial EC formulations of Hœ 30374 and benthiocarb were dissolved in water and carefully poured into the irrigation water at 5 different application times. The results of this trial are given in Table 1. They show that control of *Echinochloa* with Hœ 30374 at 0.45 kg/ha was excellent up to the relatively late 2.5 to 3.5 leaf stage. A later application at the 3.5 to 5.0 leaf stage, however, was not sufficiently active. Benthiocarb with 3.0 kg/ha was equally effective as Hœ 30374 at 0.45 kg/ha. A half dose of benthiocarb was slightly weaker than a half dose of Hœ 30374.

Soil type: In preliminary tests only slight differences between the herbicidal effect of Hœ 3037 on different soil types could be found if the product was applied in granular form into the irrigation water.

Leaching: In a special leaching trial Hœ 30374 was leached into 1 to 2 cm at 0.6 kg/ha and into 2 to 4 cm at 0.8 kg/ha.

Symptoms on weeds: Following treatment with Hœ 30374, weed growth is inhibited. The plant colour turns dark green or sometimes an unspecified discoloration takes place. Weeds remain stunted and finally die off.

Mode of action: Hœ 30374 is primarily absorbed by the plant through the roots and to some extent through newly emerging shoots and young leaves. The physiology of weed mortality is not yet known.

Persistence: Specific trials are not yet finished. Observations under field conditions indicate, however, that rates of 0.45 kg/ha are decomposed within 20 or 30 days higher rates (0.9 kg/ha) within 40 days.

Table 1 : Echinochloa control of 2 rice herbicides at 5 application times in a pot trial
Control figures based on fresh weight in gr. per pot, 3 replicates (47 days after seeding)

Treatments	(a.i. kg/ha)	application time (leaf stage) 0.5-1.0	1.0-1.5	1.5-2.5	2.5-3.5	3.5-5.0
Hœ 30374	0.450	–	–	98	99	81
	0.225	99	100	94	90	45
	0.112	89	58	53	74	23
Benthiocarb	3.0	–	–	99	97	77
	1.5	93	88	90	75	50
	0.75	62	71	68	57	25

Table 2 : Phytotoxicity (dapog seedlings) and weed control of 2 granular herbicides at 3 application trials (means of 5 trials)

Plant species	applic. DAT	number of trials	Hœ 30374 + 2,4-D 0.45 + 0.45	butachlor 1.25
Crop (rice) (35 DAT)	6	(5)	5.3	3.7
	8	(5)	2.9	2.6
	10	(5)	3.6	3.8
Echinochloa spp. weed	6	(5)	98.9	91.6
	8	(5)	95.6	87.7
	10	(5)	89.3	71.1
Cyperus difformis + *C. iria*	6	(4)	99.5	100
	8	(4)	100	100
	10	(5)	99.9	99.6
Scirpus supinos	6	(3)	96.4	98.7
	8	(2)	89.6	93.4
	10	(3)	86.7	86.0
Monochoria vaginalis	6	(5)	98.8	96.6
	8	(5)	98.1	89.1
	10	(5)	82.0	62.6
Spenochlea zeylanica	6	(2)	90,2	92,9
	8	(5)	88,0	90,1
	10	(2)	92,4	80,6
Fimbristylis spp.	6	(2)	98.5	99.5
	8	(4)	100	96,5
	10	(3)	100	90,8

Field trials with Hœ 30374

In trials conducted in 1979 and 1980 in Japan it has been found that *Echinochloa crus-galli* and *Cyperus difformis* were completely controlled, when Hœ 30374 at 0.45 kg/ha ai was applied early (up to 2.5 leaf stage of *Echinochloa*. At later application stages (up to 4 leaves) the grass control was good, but not complete. Especially at this stage Hœ 30374 was more effective than the standard benthiocarb. No phytotoxicity was observed.

In the Philippines a large number of trials under different soil and climatic conditions were conducted in 1978 and 1979. Their results show that annual grasses and sedges are controlled by relatively low rates of Hœ 30374: *Echinochloa spp. mostly E. crus-pavonis* (H.B.K.) Schult. or *E. crus-galli, Ischæmum rugosum, Cyperus difformis, C., iria and Fimbristylis littoralis* Gaudich. were sufficiently controlled over a relatively long application period: 4 to 8 DAT (days after transplanting) in case of granular application (0.45 kg a.i/ha), 3 to 8 DAT when applied as EC (0.3 kg a.i/ha). The effect of butachlor, especially of granular butachlor on *Echinochloa* was weaker. *Scirpus, supinos* (Gimel) T. Koyama, however, was better controlled with butachlor than with Hœ 30374. Broadleaved weeds such as *Monochoria vaginalis, Sphenochlea zeylanica* or *Ludwigia octovalvis* (Jacq.) Reaven were not sufficiently controlled by Hœ 30374, although very young stages of these weeds were sometimes damaged.

The crop tolerance of Hœ 30374 on dapog seedlings was generally good or acceptable and similar to that of butachlor; initial damage was grown away from usually within 3 to 4 weeks and had no influence on tiller numbers or yields. This initial damage could be observed sometimes when dapog seedlings were used; normal wetbed seedlings were tolerant to Hœ 30374 at even higher application rates. In more detailed studies on the influence of application times we found, that very early applications (3 to 5 DAT) sometimes damaged the dapog seedlings too severely. In similar trials in direct seeded rice the crop tolerance of Hœ 30374 was not sufficient at applications up to 10 to 14 days after seeding (Table 2).

In trials conducted in the first crop season in Taiwan under extremely cool conditions no phytotoxic symptoms could be found and the weed control results were very similar to those obtained in the Philippines and in Japan.

Some special trials on the influence of water management were conducted in the Philippines. Hœ 30374 granules were applied into water of different depth: 1, 3 and 6 cm and these water levels were maintained for 4 to 5 days after application. In some trials no influence on weed control was observed. In others there was a tendency for a somewhat reduced efficacy at the high water level. In another trial series, Hœ 30374 EC or a Hœ 30374 +2,4-D tank mixture was sprayed on water saturated soil or into the irrigation water; the weed control was much better when the plots were drained at time of application and not reflooded until 24 hr later.

Field trials with combinations

In japan, different combinations of Hœ 30374 with other herbicides have been tested in order to cover a broader spectrum of annual and perennial weeds.

Thus, e.g. combinations Hœ 30374 + simetryne + MCPB or Hœ 30374 + naproanilide were included into trials in the field and in concrete pots for testing their weed control. These combinations control annual and perennial weeds, including *Sagittaria pygmæa* Miq. and, at least partly, perennial sedges. The experimentation with these products, however, is not yet finished.

In the Philippines the further experimentation was concentrated on combina-

Table 3 : Weed control of 3 EC herbicides at 3 application times (means of 2 trials, seedling type : wet bed.

Weed	applic. DAT	Hoe 30374 + 2,4-D 0.3 + 0.3	Piperophos + 2,4-D 0.67 + 0.33	Butachlor 1.0
Echinochloa sp.	6	99.3	96.0	98.5
	8	97.5	96.1	82.5
	10	98.3	96.7	85.8
C. difformis + C. iria	6	100.0	97.4	100.0
	8	94.5	100.0	100.0
	10	100.0	97.5	98.4
S. supinos	6	71.6	67.3	98.6
	8	87.5	86.9	96.7
	10	93.2	95.5	93.4
M. vaginalis	6	88.9	89.8	96.5
	8	98.4	91.6	93.8
	10	97.4	95.6	79.2
S. zeylanica	6	88.3	66.4	42.4
	8	95.9	93.4	39.5
	10	94.3	97.7	71.8

tions Hœ 30374 +2,4-D. The main objective was to find the optimal ratio of components and to exactly define the period during which such a mixture can be used. According to these results a 1 : 1 ratio of both components is acceptable for practical use. In (Table 2), the results of 5 trials are summarized where the products were applied as granular formulations, and where the combination Hœ 30374 + 2,4-D at 0.45 + 0.45 kg/ha gave good or excellent control of *Echinochloa sp., C. difformis, C. iria, S. suspinos, M. vaginalis, Fimbristylis sp.* and *S. zeylanica* from 6 to 10 DAT, with a very few exceptions (*M. vaginalis* at 10 DAT). Butachlor at 1.25 kg/ha a.i. was weaker on *Echinochloa, Monochoria* and *Spenochlea*, especially at the latter application dates. The initial crop damage, however, was somewhat greater with the Hœ 30374 + 2,4-D combinations.

In the Table 3 a similar comparison is made between Hœ 30374 + 2,4-D EC at 0.3 + 0.3 and butachlor EC at 1.0 kg/ha a.i.; another commercially available mixture, piperophos + 2,4-D at 0.67 + 0.33 kg/ha a.i., was included. The Hœ 30374 + 2,4-D mixture generally performed well controlling the same weeds.as the competitive products and showing only some weakness at the earlier applications on *S. supinos.* Later applications controlled practically all occurring weeds. The piperophos + 2,4-D mixture showed a similar tendency, whereas butachlor performed best at the earlier applications, but failed to control *Sphenochlea.* Other weeds which occur in these trials more sporadically were *F. littoralis and L. octovalvis.* They were equally controlled by the combination Hœ 30374 + 2,4-D with both granule and EC formulations.

DISCUSSION

The new material Hœ 30374 is an interesting herbicide for use in transplanted rice. Annual grass weeds and sedges are controlled at relatively low rates : 0.3 kg a.i/ ha as EC, or 0.45 kg a.i/ha as a granule. Growth stages of *Echinochloa sp.* which are controlled by these rates, range from 0.5 to 2, 5 leaves at time of application. The total weed spectrum covered by Hœ 30374 included *E. crus-galli, E. cruspavonis, I. rugosum, L. chi-*

nennsis (L.) Nees., *C. difformis, C. iria* and *F. littoralis.* Weaker effects could be observed on *S. supinos, E. acicularis* Rœm. et Schult. and sometimes even on *S. juncoides* Roxb. & S. wallachi Nees.

The crop tolerance for young dapog seedlings is good. Only under cooler conditions of the dry season in the Philippines some initial phytotoxicity may be observed at applications up to 5 to 6 DAT. Other seedling types such as wetbed seedlings or seedlings for machine transplanting which are more developed at time of transplanting are tolerant under extremly cool (Taiwan 15 to 20°C and under hot conditions (Japan and Philippines 30 to 35°C) as well.

According to our present results the influence of soil type on the biological performance is limited. In paddy soil the active material is leached only to a slight or moderate extent, and the product is decomposed within 20 to 40 days under field conditions.

Combinations, however, are necessary for a complete weed control where perennial weeds such as *S. pygmæa* or perennial sedges occurs, combinations with Simetryne + MCPB or with Naproanilide, e.g., resulted in interesting effects which deserve further intensive work.

For the tropical regions of South East Asia, however, we found that a combination Hœ 30374 + 2,4-D is a good solution for situations, where annual weeds including grasses and sedges are predominant. An EC formulation containing 150 g/l Hœ 30374 + 150 g/l 2,4-D isobutylester has been developed which controls effectively all important annual weeds.

All trials carried out so far gave the best results when this combination was applied 6 to 10 DAT, whereas an established product such as butachlor is recommended for earlier application (3 to 5 DAT). Consequently the advantage of the new product Hœ 30374 + 2,4-D is a greater flexibility as far as application time is concerned. During this period the first application of and insecticide for whorl maggot *(H. philippina)* control has to be carried out and in this case the product can be tankmixed with an insecticide such as triazophos. Even when the combination was used in granular form we observed a good efficacy throughout this period of 6 to 10 DAT, however, the rate of active material required was higher.

LITERATURE CITED

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INTERACTIONS OF PRE-EMERGENCE HERBICIDES, SOIL APPLIED ALIDICARB INSECTICIDE AND SUCCINIC ACID ON COTTON AND THEIR EFFECT ON GROWTH, YIELD ATTRIBUTES AND YIELD

P. RETHINAM[1] and S. SANKARAN[2]
[1] CPCRI, Field Station, Irinjalakuda-680 121.
[2] Department of Agronomy, TNAU, Coimbatore-641 003, India.

ABSTRACT

A field experiment was conducted for two years at the Tamil Nadu Agricultural University, Coimbatore to study the interaction effect of four pre-emergence herbicides, alachlor, fluometuron, fluchloralin and dinitramine respectively at 1.5, 1.0, 1.0 and 0.48 kg ha^{-1}. The results showed that the germination of cotton was not affected due to the interaction effect. Reduction of root length at 15 days was observed in all herbicides-aldicarb combinations but the plant height was not affected. Dry matter production of crop was not affected due to the interaction effect at 15 and 45 days. Number of sympodial branches per plant was reduced due to the interactions of alachlor-aldicarb (14.7), alachlor-succinic acid (14.5) and their combination (14.8). Dinitramine-aldicarb interaction influenced the number of fruiting points positively (32.5) over dinitramine alone (28.3). Increased number of bolls per plant was observed in alachlor-aldicarb and fluometuron-succinic acid, while it was decreased in dinitramine-aldicarb. Seed cotton weight per boll was increased in fluometuron-succinic acid (4.93 g), while fluometuron-aldicarb-succinic acid combination decreased the same (4.68 g). Seed cotton yield was lower in herbicide-aldicarb. Fluometuron-succinic acid combination yielded 22.86 q ha^{-1}, while fluometuron-aldicarb yielded 20.24 q ha^{-1}. Fluchloralin-aldicarb (19.69 a, ha) and dinitramine-aldicarb (21.78 q ha^{-1}) yielded lower than fluchloralin (21.22 q ha^{-1}) or dinitramine alone (21.78 q ha^{-1}). Seed cotton yields in the hand weeding and unweeded control were 19.82 and 15.36 q ha^{-1} respectively.

INTRODUCTION

Cotton (*Gossypium hisautum* L.), in recent years, is an important commercial crop contributing to the sustenance of a large industry and labour force in India. Herbicides, insecticides and growth promoting chemicals are often to be applied simultaneously or serially to the crop within a short period of time for increased returns. Although herbicides, insecticides and growth promoters may perform the function, for which they are applied, the effect of interactions from the combinations of these chemicals have not yet been clearly understood. In a few cases, these interactions have increased the crop productivity as in the case of phorate which helped to overcome the inhibitory effect of trifluralin on secondary root development in cotton seedlings (Arle, 1968). In other cases increased crop injury like the toxicity of urea herbicides to cotton due to the presence of carbamate insecticides in the mixture occurred (Hacskaylo *et al.* 1964). Several field and laboratory studies have shown that systemic insecticide can delay or reduce seedling emergence, reduce seedling growth and visibly damage the leaves of cotton plants (Parencia *et al.* 1957; and Reynolds *et al.* 1957). Based on the above, a study was undertaken in order to find out the interaction effect of herbicides, insecticides and growth promoting chemical on cotton. In this paper the effect on the growth, yield attributes and yield are discussed.

MATERIAL AND METHODS

A field experiment was conducted for two years at the Tamil Nadu Agricultural University campus in a split plot design with three replications, in a clay-loam soil with low available N and P_2O_5 with gross and net plot sizes of 6.00 m by 3.60 m and 4.50 m by 3.27 m respectively. The main plot treatments comprised (1) alachlor (2-chloro-2', 6' diethyl-N-(methoxy methyl) -acetanilide) at 1.5 kg ha^{-1} (2) fluometuron (N^1-(3-trifluoro methyl) phenyl-N, N-dimethyl urea) at 1.0 kg ha^{-1}, (3) fluchloralin [N-propyl -N (2^2 chloro ethyl)-2, 6-dinitro n-n trifluomethyl aniline] at 1.0 kg ha^{-1}, (4) dinitramine (N^3 N^3 -diethyl-2, 4-dinitro n-n trifluomethyl aniline) at 0.48 kg ha^{-1} a.i., (all as pre-emerence) (5) hand hoeing and weeding at 20 and 45 days and (6) unweeded control. The sub-plot treatments comprised (1) soil application of aldicarb granules [2 methyl -2 (methyl thio) propionaldehyde -O-methyl carbamyl oxine] at 1.0 kg ha^{-1} a.i, (2) seed treatment with two percent succinic acid and soil application of succinic acid at 0.5 kg ha^{-1}, (3) combination of sub-plot treatments (1) and (2) and (4) untreated control.

The herbicides were sprayed uniformly with Back-pak sprayer, three days after sowing and a light irrigation followed 12 hr after spraying. The delinted cotton seeds were soaked in two per cent succinic acid for six hr. In addition, soil application at 0.5 kg ha^{-1} was done along the seedline after sowing. Aldicarb granules were applied along the seed row at 1 kg ha^{-1} immediately after sowing. Handweeding and hoeing was done on 20 and 45 days as per the treatments and an earthing up was given to all plots at 45 days. The observations on germination, growth characters and yield attributes were recorded besides collecting the yield data. The pooled data analysis for two years alone have been given for all characters except the yield data for which the year-wise as well as pooled data are given.

RESULTS

Growth characters: The results showed that the germination of cotton was not affected due to interaction effect (Table 1). Reduction in root length at 15 days was observed in all herbicide-aldicarb treatments and it was the least in alachlor-aldicarb, followed by alachlor-aldicarb-succinic acid combination. The plant height at 15 days was influenced by alachlor-aldicarb interactions. The plant height was the highest in fluometuron-aldicarb interaction and was the lowest in alachlor-aldicarb-succinic acid combination at 45 days. Pooled data revealed that alachlor interacted with aldicarb and influenced the growth of plant whereas with succinic acid it reduced the plant height. Fluometuron-succinic acid interaction also reduced the plant height. Dinitramine-aldicarb influenced the plant height positively but it was on par with dinitramine alone. The dry matter of the crop was not affected due to the interaction effect at 15 and 45 days.

Yield characters: The number of sympodial branches plant was not influenced by the interaction of herbicides except alachlor (Table 1). Alachlor alone gave the highest number of sympodial branches but its interaction with aldicarb

Table 1 : Effect of treatments on germination, growth and yield characters.

	M^1	M^2	M^3	M^4	M^5	M^6	Mean	S.E.D./C.D. (P = 0.05)
(a) Germination in percentage								
T_1	96.6	95.4	95.3	95.0	95.0	95.2	95.4	M : 0.46/N.S.
T_2	95.2	96.9	96.6	96.7	97.0	97.0	96.5	T : 0.28/N.S.
T_3	96.0	95.3	96.0	96.4	97.0	96.1	96.1	MT : 0.70/N.S.
T_4	96.8	95.4	95.8	96.4	95.5	96.1	96.0	TM : 0.76/N.S.
Mean	96.1	95.7	96.9	96.1	96.1	96.1		
(b) Root length at 15 days in mm								
T^1	5.98	7.33	5.95	7.71	7.40	6.96	6.89	M : 0.12/0.24*
T_2	6.51	8.38	7.35	8.76	8.15	8.10	7.89	T : 0.06/0.12*
T_3	6.00	8.05	7.51	8.03	7.41	7.56	7.43	MT : 0.15/0.30*
T_4	7.06	8.06	7.88	7.81	7.95	7.66	7.74	TM : 0.17/0.36*
Mean	6.39	7.95	7.17	8.08	7.72	7.52		
(c) Plant height at 15 days, in cm								
T_1	10.8	11.1	10.6	10.6	10.6	10.7	10.6	M : 0.12/0.3*
T_2	8.8	10.3	10.1	10.0	9.8	9.9	9.8	T : 0.08/0.4*
T_3	8.3	10.1	9.2	9.6	10.1	10.1	9.6	MT : 0.21/0.4*
T_4	8.9	10.0	10.3	10.4	10.7	10.0	10.1	MT : 0.21/0.4*
Mean	9.0	10.4	10.1	10.1	10.1	10.3		
(d) Plant height at 45 days, in cm								
T_1	25.7	23.8	25.2	27.5	25.2	26.7	25.7	M : 0.38/0.8*
T_2	20.0	21.0	22.6	24.1	21.7	25.0	22.4	T : 0.56/1.1*
T_3	20.7	23.5	23.3	23.8	22.3	24.9	23.1	MT : 1.39/2.7*
T_4	22.4	23.9	24.4	25.4	24.2	25.9	24.4	TM : 1.26/2.5*
Mean	22.2	23.1	23.9	25.2	23.3	25.6		
(e) Dry matter of crops at 15 days, kg ha^{-1}								
T_1	8.6	10.1	10.3	10.2	9.7	7.8	9.5	M : 0.17/0.3*
T_2	9.5	10.0	9.5	9.8	9.9	7.1	9.3	T : 0.23/N.S.
T_3	9.2	10.2	9.9	9.8	10.3	7.9	9.5	Mt : 0.56/N.S.
T_4	8.9	10.1	9.4	10.2	9.8	7.8	9.4	TM : 0.51/N.S.
Mean	9.0	10.1	9.8	10.0	9.9	7.7		

(f) Dry matter of crops at 45 days, in kg ha^{-1}

T_1	467	517	474	573	518	378	498	M : 12.5/26*
T_2	427	476	433	534	490	333	449	T : 7.5/15*
T_3	483	553	505	544	574	387	508	MT : 28.0/N.S.
T_4	415	479	447	524	502	315	447	TM : 20.2/N.S.
Mean	448	506	465	543	536	353		

(h) Number of sympodia per plant

T_1	14.7	14.2	14.7	14.5	14.9	12.8	14.3	M : 0.28/0.6*
T_2	14.5	15.0	14.6	14.4	15.1	13.4	14.5	T : 0.19/N.S.
T_3	14.8	14.7	14.5	15.3	14.4	13.1	14.5	MT : 0.46/0.9
T_4	15.9	14.0	14.1	15.5	14.5	13.6	14.5	TM : 0.49/1.0
Mean	15.0	14.5	14.5	14.9	14.7	13.2		

(i) Number of fruiting points per plant

T_1	29.7	31.0	29.4	29.3	27.2	28.5	29.4	M : 0.73/1.5*
T_2	28.9	30.9	27.0	30.2	30.7	25.2	28.8	T : 0.43/0.1*
T_3	30.8	30.3	28.5	32.5	30.6	28.3	29.8	MT : 1.06/2.1*
T_4	30.3	29.2	27.2	28.3	31.9	24.3	28.5	TM : 1.17/2.4*
Mean	30.2	30.4	28.0	30.1	30.1	26.1		

(j) Number of bolls per plant

T_1	18.2	17.4	16.8	17.7	17.9	15.8	17.3	M : 0.08/0.1*
T_2	17.3	19.7	17.0	18.0	18.5	18.5	17.6	T : 0.11/0.2*
T_3	17.4	17.7	16.8	17.3	18.3	15.5	17.7	MT : 0.27/0.5*
T_4	17.5	16.9	16.0	18.1	17.0	14.6	16.7	TM : 0.25/0.5*
Mean	17.6	17.9	16.7	17.8	17.9	15.2		

(k) Weight of seed cotton per boll in g

T_1	4.77	4.90	4.66	4.82	4.69	4.19	4.67	M : 0.02/0.05*
T_2	4.74	4.93	4.68	4.99	4.66	4.17	4.69	T : 0.09/N.S.
T_3	4.48	4.67	4.80	4.76	4.40	4.15	4.56	MT : 0.24/N.S.
T_4	5.06	4.96	4.57	4.74	4.62	4.10	4.67	TM : 0.21/N.S.
Mean	4.75	4.86	4.72	4.83	4.59	4.15		

M_1 : Alachlor M_2 : Fluometuron M_3 : Fluchloralin M_4 : Dinitramine M_5 : Hand weeding M_6 : Unweeded control T_1 : Aldicarb T_2 : Succinic acid T_3 : Aldicarb + Succinic acid T_4 : No chemical N.S. Not significant

Table 2 : Effect of treatments on total seed cotton yield, q ha[-1] First crop.

	M_1	M_2	M_3	M_4	M_5	M_6	Mean	S.E.D./C.D. (P = 0.05)
T_1	26.11	23.24	23.38	24.35	23.98	18.75	23.30	M : 0.56/1.23
T_2	23.87	28.05	24.44	24.86	25.37	19.95	24.40	T : 0.28/0.55
T_3	22.45	24.40	22.27	24.31	26.44	19.21	23.19	MT : 0.69/1.35
T_4	25.83	26.62	25.60	25.46	25.46	19.68	24.77	TM : 0.14/0.31
Mean	24.58	25.55	23.94	24.77	25.32	19.40	23.93	
Second crop								
T_1	16.99	17.27	16.02	17.13	16.48	11.01	15.83	M : 0.05/0.11
T_2	17.36	17.64	16.53	17.31	16.76	11.39	16.16	T : 0.04/0.07
T_3	16.71	16.80	15.42	16.80	16.34	10.74	15.46	MT : 0.09/0.17
T_4	17.69	17.96	16.80	18.10	17.22	12.22	16.67	MT : 0.09/0.17
Mean	17.17	17.41	16.20	17.31	16.21	11.34	15.42	
Pooled data								
T_1	21.56	20.24	19.69	20.73	20.24	14.86	19.55	Y : 0.16/0.34
T_2	20.61	22.86	20.50	21.10	21.06	15.67	20.30	M : 0.28/0.59
								YM : 0.40/N.S.
T_3	19.58	20.60	18.84	20.54	21.39	14.97	19.32	T : 0.14/0.29
								MT : 0.35/0.70
T_4	21.78	22.29	21.22	21.78	21.35	15.94	20.72	TM : 0.41/0.84
								YT : 0.20/0.40
Mean	20.88	21.50	20.06	21.04	21.01	15.36	19.97	

succinic acid reduced the same. In the case of fruiting points/dinitramine interacted with aldicarb and succinic acid positively which was significantly superior to dinitramine alone. Among the herbicide-insecticide-succinic acid interactions, the fluchloraline-succinic acid gave the lowest number of fruiting points.

Increased number of bolls per plant was observed in alchlor-aldicarb interaction. Fluometuron-succinic acid gave the highest number of bolls and the lowest was in fluometuron alone. Dinitramine-aldicarb combination or combination with succinic acid reduced the boll numbers.

Yield: Interaction effect was significant in both the years (Table 2). In the first year, alachlor-aldicarb interaction had higher seed cotton yield of 26.11 q/ha[-1] whereas aldicarb-succinic acid combination gave 22.45 q ha[-1] only. Fluometuron in combination with succinic acid registered a higher yield of 28.05 q ha[-1], whereas fluometuron alone had an yield of 26.62 q ha[-1]. This was followed by aldicarb-succinic acid combination with an yield of 24.40 q ha[-1]. Fluchloralin with aldicarb-succinic acid interaction had the lowest yield of 22.27 q ha^{-1}, while the highest was in fluchloralin alone (25.60 q ha^{-1}). Dinitramine alone had higher seed cotton yield of 25.46 q ha^{-1} which was on par with succinic acid combination (24.31 q ha^{-1}). In hand weeding aldicarb-succinic acid combination gave a higher yield of 26.44 q ha^{-1}, while the lowest was in aldicarb (23.98 q ha^{-1}).

In the second year, interaction of herbicides with aldicarb and aldicarb-succinic acid combination decreased the seed cotton yield.

Pooled analysis showed that alachlor alone and alachlor with aldicarb were on par and superior to succinic acid and aldicarb-succinic acid combination. Fluometuron interaction with succinic acid was on par with fluometuron alone. Fluchloralin with aldicarb and aldicarb-succinic acid had lower yields than succinic acid alone or no chemical treatments. Dinitramine interaction with aldicarb were lower in yield (20.73 q ha^{-1}) than dinitramine alone (21.78) or with succinic acid (21.10). However, in handweeding aldicarb gave the lowest yield of seed cotton, whereas succinic acid, aldicarb-succinic acid and no chemical treatments were on par but superior to aldicarb. In unweeded control also no chemical treatment (15.94) and succinic acid were on par.

DISCUSSION

The germination of seed cotton was not affected by the interaction of herbicides – aldicarb and succinic acid combinations. This might be probably due to hard seed coat through which the chemicals could not penetrate to the endosperm and change the hormonal balance within germinating position. Walker *et al.* (1963) also reported that single application, at a given rate, of herbicides (diuron or monuron) and systemic insecticides (phorate or disulfoton) did not adversely affect the emergence and subsequent growth of cotton seedlings. Though the root length was affected due to aldicarb-herbicides interaction, the plant height was positively influenced. Savage and Ivy (1973) reported that phytotoxic effects at high rates of pre-emergence fluometuron was decreased by granular application of disulfoton. This is evinced by the increased height of cotton plants under fluometuron-aldicarb interaction. Since the height of the plants was not reduced by aldicarb-herbicides, the dry matter production of crop was not affected. The number of bolls per plant was increased by 1.2 per cent in aldicarb and alachlor combination, while reduction to the extent of 6.2, 2.8 and 1.2 per cent were observed in fluchloralin, fluometuron and dinitramine respectively over hand weeding. However, the weight of seed cotton per boll was increased by 4.8, 2.8 and 1.7 per cent in fluometuron, dinitramine respectively but a decrease in weight by 0.7 per cent was observed in fluochloralin. This has been reflected in the yield of seed cotton also. The seed cotton yield increase in fluometuron-succinic acid was due to increased number of bolls per plant (19.7) and seed cotton weight per boll (4.93 g) which were 9.4 and 5.8 per cent higher over hand weeding treatments. However, aldicarb-succinic acid combination with herbicides reduced the yields considerably. This might be due to the lower number of bolls per plant and seed cotton weight per boll. Helmer *et al.* (1969) with systemic insecticide aldicarb and trifluralin herbicide showed no detrimental effect on cotton. Likewise, Ivy (1971) found no decrease in seed cotton yield due to interaction of urea herbicides as well as dinitro anilines. In the present study also alachlor, fluometuron and dinitramine herbicides with aldicarb insecticides did not reduce the yield when compared to hand weeding.

CONCLUSION

Soil application of herbicides – aldicarb and succinic acid combination had no effect on the germination of cotton. Although the root length was reduced by aldicarb and its combination with succinic acid, the plant height was not affected. A positive interaction effect resulted in higher number of bolls in alachlor-aldicarb, fluometuron-succinic acid combination. Fluometuron-succinic acid combination gave the highest yield. Aldicarb with all herbicides ranked third only in the yield, first being no chemical, second being succinic acid.

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STUDIES ON INTERACTIONS OF HERBICIDES WITH INSECTICIDES IN RICE CROP

S. K. MUKHOPADHYAY and A. K. SEN
College of Agriculture (PSS), Visva-Bharati University, Sriniketan
West Bengal, India.

ABSTRACT

The herbicides nitrofen, bentazon, butachlor and propanil were individually mixed with either phorate or carbofuran granular insecticides and applied on rice crop (Cv. Ratna) grown in transplanted and direct seeded rice culture in *kharif* (warm rainy season) and *boro* (dry summer season). In *kharif* season broadleaved semi-aquatic weeds, namely, *Ludwigia parviflora* and *Marsilea quadrifolia* and grassweed *Echinochloa colonum* were common. In *boro* season weed species like *E. colonum, Alternanthera sessiles* and *Fimbristylis mileacea* were predominant. Rice crop grown in *kharif* season suffered much more attack of insects than *boro* season rice. Propanil + phorate and propanil + carbofuran showed phytotoxic injury to rice crop in both the seasons showing yellowing and burning of leaves but the crop recoverd about five weeks after application. Among all the treatments, butachlor + carbofuran insecticide was most effective in killing grasses, sedges and broadleaved weeds and stemborer insects. Butachlor mixed with phorate showed similar control of all categories of weeds but leaf hopper insects were more checked than stem borer. Other mixtures of herbicides, *viz.*, butachlor, nitrofen and bentazon separately with phorate or carbofuran were quite compatible at the doses used and at the time of application in these experiments showing no symptoms of injury to rice plants.

INTRODUCTION

Losses in the yield of rice crop due to weeds and insect are quite severe. Biological control is at present perhaps impractical for large scale use to combat these pests. Large number of investigations have been made on the use of herbicides to control weeds and insecticides. But very few investigations have been made on the combined use of herbicides and insecticides in rice crop. Very often weeds and insects infest the rice crop at the same time (Gifford, 1973; Smith and Seaman, 1973). Hence, herbicides and insecticides are needed at about the same time and one application of these combined pesticides will help to reduce the cost of operation. The work of Smith and Tugwell (1975) revealed the interaction of propanil herbicide with carbofuran insecticide but in recent time large number of other effective herbicides and insecticides are available for use in rice fields and there is great necessity to study in detail the interaction of these herbicides and insecticides combinations.

With these ideas in view, the present investigation was conducted from 1975 to 1977 with new herbicides in addition to propanil to see their interaction with common insecticides used in rice crop in different seasons and under different rice culture in the agro-ecological conditions of traditional rice belt in Eastern India.

MATERIAL AND METHODS

Three experiments were conducted from December 1975 to June 1977 (one transplanted in wet *kharif* season 1975 and one direct seeded puddled rice in *kharif* 1976 and the other in dry *boro* sea-

Table 1: Treatment effect on the stand of rice crop.

Treatments	Rice plant population/m^2					
	Initial (15 DAT)			Final (90 DAT)		
	1975	1976	1976-77	1975	1976	1976-77
Nitrofen 2 kg + Phorate 1.6 kg	51.00	76.66	72.77	52.00	82.75	76.00
Nitrofen 2 kg fb Phorate 1.6 kg	51.00	84.25	81.50	53.00	88.91	84.55
Nitrofen 2 kg + Carbofuran 0.5 kg	50.66	85.00	81.10	51.33	86.75	85.11
Nitrofen 2 kg fb Carbofuran 0.5 kg	53.33	82.00	86.22	54.66	84.41	88.15
Bentazon 3 kg + Phorate 1.6 kg	50.00	75.91	76.53	50.33	79.50	79.73
Bentazon 3 kg + Carbofuran 0.5 kg	51.33	82.25	79.88	51.00	84.50	82.33
Butachlor 2 kg + Carbofuran 0.5 kg	54.00	84.12	89.11	55.33	86.40	91.00
Butachlor 2 kg fb Carbofuran 0.5 kg	53.33	85.33	86.42	55.33	86.40	91.00
Butachlor 2 kg + Phorate 1.6 kg	51.66	73.00	75.51	52.00	78.58	78.66
Butachlor 2 kg fb Phorate 1.6 kg	49.66	79.33	80.22	50.33	82.41	84.00
Propanil 3 kg + Carbofuran 0.5 kg	51.00	78.75	79.00	51.33	82.00	82.33
Propanil 3 kg + Phorate 1.6 kg	50.00	76.91	76.93	51.00	80.25	79.00
Untreated control	54.00	84.00	85.33	50.00	74.22	69.00
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

DAT – Days after transplanting; DAS – Days after seeding.

son of 1976-77 also as direct seeded puddled rice). Soil in all the experimental fields was fine sandy loam lateritic soil with pH 5.8 with medium nitrogen and potash and low phosphate content. The rice variety in dry *boro* season was Ratna (TKM 6 x IR-8) and in *kharif* season was Pankaj (Peta x Tongkai Ratan). The experiments were conducted under Randomised Block Design with 13 treatments replicated thrice. Herbicides nitrofen and butachlor granules were used just at pre-emergence to weeds, i.e., six days after transplanting of rice seedlings (transplanted crop) or seeding (direct seeded crop). The herbicides bentazon and propanil (EC) were used as post-emergence at twenty one days after transplanting rice seedling. The insecticides phorate and carbofuran were used as mixture with granular herbicides and in case of treatments having liquid herbicides, the insecticides were broadcasted first followed immediately by spraying of liquid herbicides.

Observations were made on the crop stand, yield components and yield of rice grain, total weed density and major insects.

RESULTS AND DISCUSSION

Effect on crop stand

The chemicals did not significantly reduce the number of crop plants by completely killing the crops at the early or mature stage (Table 1). But it needs to be pointed out that when propanil was sprayed on the same day after carbofuran

Table 2: Treatment effect on the yield attributes and grain yield.

Treatments	Grains/panicle			1000-grain weight(g)			Panicles			Grain yield (kg/ha)		
	1975	1976	76-77	1975	1976	76-77	1975	1976	76-77	1975	1976	76-77
Nitrofen 2 kg + Phorate 1.6 kg	72.63	61.81	44.45	20.33	24.56	20.02	8.71	2.41	2.97	2384	2750	3113
Nitrofen 2 kg fb Phorate 1.6 kg	73.66	114.66	74.34	20.84	25.59	21.26	9.40	5.00	4.48	3120	4143	5033
Nitrofen 2 kg + Carbofuran 0.5 kg	73.96	102.82	73.30	21.07	25.31	21.21	9.00	3.68	4.46	3108	3777	4683
Nitrofen 2 kg fb Carbofuran 0.5 kg	80.43	114.41	78.00	21.59	25.55	21.47	9.42	4.11	4.78	3504	4138	5755
Bentazon 3 kg + Phorate 1.6 kg	76.93	65.60	56.34	21.06	24.83	20.43	9.00	3.59	3.06	2512	3233	3308
Bentazon 3 kg + Carbofuran 0.5 kg	76.96	101.11	69.71	20.86	25.10	21.04	9.30	4.00	3.55	2904	3653	4363
Butachlor 2 kg + Carbofuran 0.5 kg	92.83	132.00	80.50	22.28	25.90	22.33	9.52	5.28	5.58	3760	5167	5963
Butachlor 2 kg fb Carbofuran 0.5 kg	83.70	119.22	80.39	21.79	25.77	21.89	9.51	4.89	4.83	3584	4538	5953
Butachlor 2 kg + Phorate 1.6 kg	72.73	93.16	61.55	20.90	24.97	20.75	9.01	3.47	3.29	2586	3583	3580
Butachlor 2 kg fb Phorate 1.6 kg	68.80	104.16	71.70	20.77	25.10	21.12	9.02	2.79	3.78	3036	3667	4555
Propanil 3 kg + Carbofuran 0.5 kg	72.53	98.66	66.70	20.41	25.00	20.97	9.00	4.63	3.47	2890	3650	3925
Propanil 3 kg + Phorate 1.6 kg	71.63	69.73	58.66	20.91	24.88	20.44	9.21	3.61	3.07	2560	3333	3575
Untreated control	65.90	50.17	39.38	19.90	23.57	19.87	8.70	1.80	2.55	2310	932	588
LSD (0.05)	N.S.	40.27	20.22	N.S.	N.S.	N.S.	N.S.	0.58	0.66	N.S.	908	1604

or phorate application, there was complete yellowing of leaves and leaf-burn of rice plants even though there was no mortality of the crop. Somewhat similar results were obtained by Bowling and Hudgins (1966).

Effect of treatments on yield attributes and grain yield of the crop

In case of transplanted rice, the treatments did not have any significant beneficial effect on any yield attributing characters in this experimental situation (Table 2). However, in case of direct seeded rice crops in both the seasons the treatment showed significant effect on all the yield components except thousand grain weight. As regards the effect of treatments on the number of grains per panicle, butachlor + carbofuran, butachlor followed by carbofuran, nitrofen followed by phorate, nitrofen followed by carbofuran showed more effectiveness as compared to other treatments. The same trend was observed on effective tillers per plant.

As regards yield of grain, in case of transplanted rice, none of the treatments could show any significant effect on the yield of grain over unweeded control as well as between themselves perhaps due to low weed density in transplanted rice. In direct seeded rice crops (*kharif* and *boro*) where weed population was higher (1976 and 1976-77), it is evident from the data that all the treatments were significantly superior to the unweeded control. Among the treatments, butachlor + carbofuran was found to be the best in both the experiments conducted in different

Table 3 : Effect of treatments on total weed density/ m².

Treatments	45 DAT/DAS			90 DAT/DAS		
	1975	1976	1976-77	1975	1976	1976-77
Nitrofen 2 kg + Phorate 1.6 kg	110.3	275.3	131.6	154.6	296.6	142.3
Nitrofen 2 kg fb Phorate 1.6 kg	22.3	23.0	10.6	25.6	44.0	20.3
Nitrofen 2 kg + Carbofuran 0.5 kg	45.0	125.0	88.6	61.6	166.0	83.6
Nitrofen 2 kg fb Carbofuran 0.5 kg	40.0	83.6	74.3	51.0	157.6	75.3
Bentazon 3 kg + Phorate 1.6 kg	95.0	205.7	112.3	145.0	276.3	109.6
Bentazon 3 kg + Carbofuran 0.5 kg	54.3	148.0	100.6	70.3	214.3	99.0
Butachlor 2 kg + Carbofuran 0.5 kg	19.0	57.6	16.3	22.0	135.6	64.6
Butachlor 2 kg fb Carbofuran 0.5 kg	41.6	74.6	59.3	40.3	156.0	69.6
Butachlor 2 kg + Phorate 1.6 kg	77.6	188.0	109.0	87.3	258.6	102.0
Butachlor 2 kg fb Phorate 1.6 kg	51.6	145.6	97.6	69.0	196.3	95.0
Propanil 3 kg + Carbofuran 0.5 kg	55.6	162.3	103.0	116.3	247.6	100.0
Propanil 3 kg + Phorate 1.6 kg	82.6	196.3	110.3	114.0	268.6	105.6
Untreated control	115.0	341.6	204.6	170.3	476.0	219.6
LSD (0.05)	39.1	148.0	37.4	91.3	169.7	29.3

seasons (*kharif* and *boro*). Superior treatments next order were butachlor followed by carbofuran, nitrofen followed by carbofuran treatments and nitrofen followed by phorate. Even though all the treatments showed better performance in increasing the yield of the grains, the herbicides bentazon and propanil in combination with carbofuran and phorate were inferior to butachlor in combination with the insecticides.

Herbicide-Insecticide treatment effects on weeds: In the transplanted rice (1975 *kharif*), the weed problem was quite low. In fact, the infestation of grass weed was very less which were found to be most damaging in case of direct seeded rice crops (1976 *kharif* and 1976-77 *boro*). This was obviously due to the effect of much more standing water in this season as well as initial higher age of rice plants (seedlings) than weeds in transplanted crop. De Datta (1974) is also of opinion that flooding rice to a depth of 10 cm to 20 cm when it is in the seedling stage helps control of barn yard grass. From the data in Table 3, though it is revealed that nitrofen, butachlor, bentazon and propanil herbicides in combination with the systemic insecticides (carbofuran granules and phorate granules) gave significant control of weed population over the untreated check, the yield increase is not statistically significant due to low population of weeds in the transplanted rice fields.

In the direct seeded rice fields, under the present investigation, it was found that the weed problem unlike the transplanted field was of very serious nature which showed an average loss of yield of the crop to the extent of 86.2%. Due to simultaneous germination of the weed and crop seeds with no possibility of any

Table 4: Effect of treatments on insects at ninety days after transplanting or seeding (Mean of three years).

Treatments	Stem borer	leaf hopper	Gall midge
Nitrofen 2 kg + Phorate 1.6 kg	8.73	38.33	21.78
Nitrofen 2 kg fb Phorate 1.6 kg	8.99	34.89	20.22
Nitrofen 2 kg + Carbofuran 0.5 kg	6.61	41.55	15.78
Nitrofen 2 kg fb Carbofuran 0.5 kg	6.39	38.11	15.22
Bentazon 3 kg + Phorate 1.6 kg	9.05	35.77	21.22
Bentazon 3 kg + Carbofuran 0.5 kg	6.69	39.22	16.89
Butachlor 2 kg + Carbofuran 0.5 kg	6.36	45.89	17.89
Butachlor 2 kg fb Carbofuran 0.5 kg	4.49	42.33	15.55
Butachlor 2 kg + Phorate 1.6 kg	8.66	38.66	22.33
Butachlor 2 kg fb Phorate 1.6 kg	8.26	33.11	20.11
Propanil 3 kg + Carbofuran 0.5 kg	7.13	41.89	17.89
Propanil 3 kg + Phorate 1.6 kg	8.90	35.21	20.55
Untreated control	13.40	79.66	32.99

shading by the crop plants over the weeds in the beginning of weed growth, as it was in the case of the transplanted rice crop. Many weeds were found in the direct seeded rice fields. Among the grassy weeds *E. colonum* was most predominant. From this investigation, it was quite clear that under the situation of heavy infestation of weeds in direct seeded rice fields, chemical or cultural, resulted in remarkable increase of rice yield.

Bentazon and propanil herbicides in combination with carbofuran and phorate were not as good as the pre-emergence herbicides *viz.*, butachlor or nitrofen in combination or followed by insecticides used in this investigation but they provided significant check of weed population over the unweeded control. Among these two post-emergence herbicides, propanil was found better in controlling grass weed while bentazon resulted in controlling sedge weeds.

Effect of chemical on Insects

Since carbofuran and phorate sprays are generally ineffective against most of the common rice insects in the tropics, granular formulations of insecticide can be applied in the rice field.

Butachlor herbicide followed by carbofuran insecticide was found to be the best giving sizeable reduction of stem borer and gallmidge and increasing yield to the extent of 155% over unweeded control (Table 4). However, when the effect of this treatment was considered on leaf hopper infestation, it was inferior to butachlor herbicide followed by phorate insecticide the latter treatment resulted maximum mortality of leaf hopper insects. Again, nitrofen followed by carbofuron showed better performance in both the season in checking the gallmidge incidents. In general, it was observed that the treatments where carbofuran was included, maximum control of stem borer and gallmidge was obtained. Highest suppression of leaf hopper was observed when phorate insecticide was included.

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DISSIPATION OF BUTACHLOR AND PROPANIL HERBICIDES IN RICE CROP

GITA KULSHRESTHA, N. T. YADURAJU and V. S. MANI
Indian Agricultural Research Institute, New Delhi - 110 012, India

ABSTRACT

Butachlor (N-(butoxymethyl)-2-chloro-2', 6'-diethyl acetanilide) as pre-emergence at 1.0 kg/ha and propanil (3', 4'-dichloropropionanilide) as post-emergence at 0.5 l/ha were separately applied to transplanted rice (*Oryza sativa*). Dissipation of the two herbicides in soil, rice crop and water under field conditions was investigated by analysing microquantities of butachlor and propanil by electron capture gas chromatographic technique. Butachlor and propanil did not persist for more than 38 and 26 days respectively in either of the three systems. The half-life of butachlor ranged between 9 to 18 days and of propanil varied from 5 to 9 days. Rice grains, however, contained 0.11 and 0.08 ppmw of butachlor and propanil residues, respectively, at harvest.

INTRODUCTION

Butachlor and propanil are recommended for selective weed control in rice crop (Gupta *et al.* 1979 and Arceo *et al.* 1979).

Chela and Gill (1980) reported on the basis of field bioassay that none of the two anilides applied in rice left any phytotoxic residues in soil to be adversely effective on rotational crops *viz.* wheat, and linseed planted after transplanted rice. The anilides are hydrolysed in soil and plants to the halogenated anilines and the corresponding acids. The halogenated aniline translocated to rice grains have been found to be toxic in nature (Still *et al.* 1980).

This study was designed to evaluate persistence of butachlor and propanil in soil when applied as pre-emergence and post-emergence herbicides, respectively to rice for weed control, their translocation within the plant and to grains and their removal and dissipation in water.

MATERIAL AND METHODS

Field studies: A field experiment was conducted with transplanted rice (var. Pusa-33) in *rabi* 1977 in randomized block design. The soil contained 62.2% sand, 19.8% clay, 18.0% silt and 0.60% organic matter and had a pH of 7.8.

Butachlor(Machete, 5% granules) was applied as a pre-emergence treatment at 20 kg/ha and propanil (Stam F-34, 25% E. C.) 2 l/ha in 1000 l water was sprayed as a post-emergent treatment. These chemical treatments were compared with untreated and hand weeded checks. All the treatments were quadruplicated. Plant, soil (0 to 15 cm depth) and water samples were collected immediately following application and then at intervals of 5 days for determination of herbicide residues. Grain samples of rice were also collected at harvest.

Laboratory studies: Plant and grain samples were extracted with chloroform and cleaned up by eluting the herbicides from the columns containing florisil and celite mixture (1:1) with methylene chloride. Soil and water samples were extracted with methylene chloride. Butachlor and propanil in the extracts were analyzed by gas chromatographic method and their concentrations were

Table 1: Recovery of herbicides from fortified samples of soil, plant, grain and water.

Herbicide/ Material	AA* (ppmw)	AF** (ppmw)	% Recovery
Butachlor			
Soil	0.5	0.42	84.0
	1.0	0.87	87.0
	2.0	1.80	90.0
Water	0.5	0.46	46.0
	1.0	0.91	91.0
	2.0	1.90	95.0
Plant	0.5	0.43	86.0
	1.0	0.80	80.0
	2.0	1.70	85.0
Grain	0.5	0.40	80.0
	1.0	0.81	81.0
	2.0	1.75	87.5
Propanil			
Soil	0.5	0.43	86.0
	0.1	0.85	85.0
	2.0	1.75	87.5
Water	0.5	0.44	88.0
	1.0	0.88	88.0
	2.0	1.90	95.0
Plant	0.5	0.40	80.0
	1.0	0.80	80.0
	2.0	1.80	90.0
Grain	0.5	0.40	80.0
	1.0	0.82	82.0
	2.0	1.60	80.0

AA* = Amount added; AF** = Amount found.

expressed as µg of herbicide per g /ml of sample.

Gas chromatography was performed on a Tracor MT-220 fitted with Ni^{63} electron capture detector and packed with 3% OV-17 on chromosorb W 80/100 mesh and was run at 225°C at a flow rate of 60 ml/min of N_2 carrier gas. The injection port was maintained at 225°C and the detector at 275°C. The retention times of butachlor and propanil were 120 and 72 secs respectively. The amount of herbicide was calculated by comparing the peak height of the sample to that of the standard.

RESULTS AND DISCUSSION

The sensitivity of the gas chromatographic technique was 0.5 µg for butachlor and 0.4 µg for propanil.

Recoveries of known amounts of herbicides added to soil, water, plant and grain samples ranged between 80 to 95 per cent (Table 1).

Persistence of butachlor and propanil: Results of chemical analyses of soil, plant and water samples are presented in Table 2 and 3. Herbicide persistence followed

Table 2: Dissipation of butachlor in rice plants, soil and water.

System	Residues (ppmw) Days after spraying 0	5	10	15	20	26	32	38	% Dissipation
Plant	2.5	1.9	1.5	0.9	0.3	ND	–	–	100
Soil	2.6	2.1	1.7	1.4	1.2	1.0	0.4	ND	100
Water	19.0	10.0	4.0	1.0	0.7	0.4	0.4	ND	100

Table 3: Dissipation of propanil in rice plants, soil and water.

System	Residues (ppmw) Days after spraying 0	5	11	16	26	% Dissipation
Plant	1.0	0.8	0.4	0.2	N.D.	100
Soil	1.6	1.0	0.5	0.2	N.D.	100
Water	2.4	1.3	0.6	0.2	N.D.	100

Table 4: Effect of herbicides on grain yield of rice

Treatments	Grain yield (q/ha)
Butachlor pre-em	39.37
Propanil post-em	38.99
Weed free check	41.60
Unweeded control	34.62
C. D. at 5%	1.25

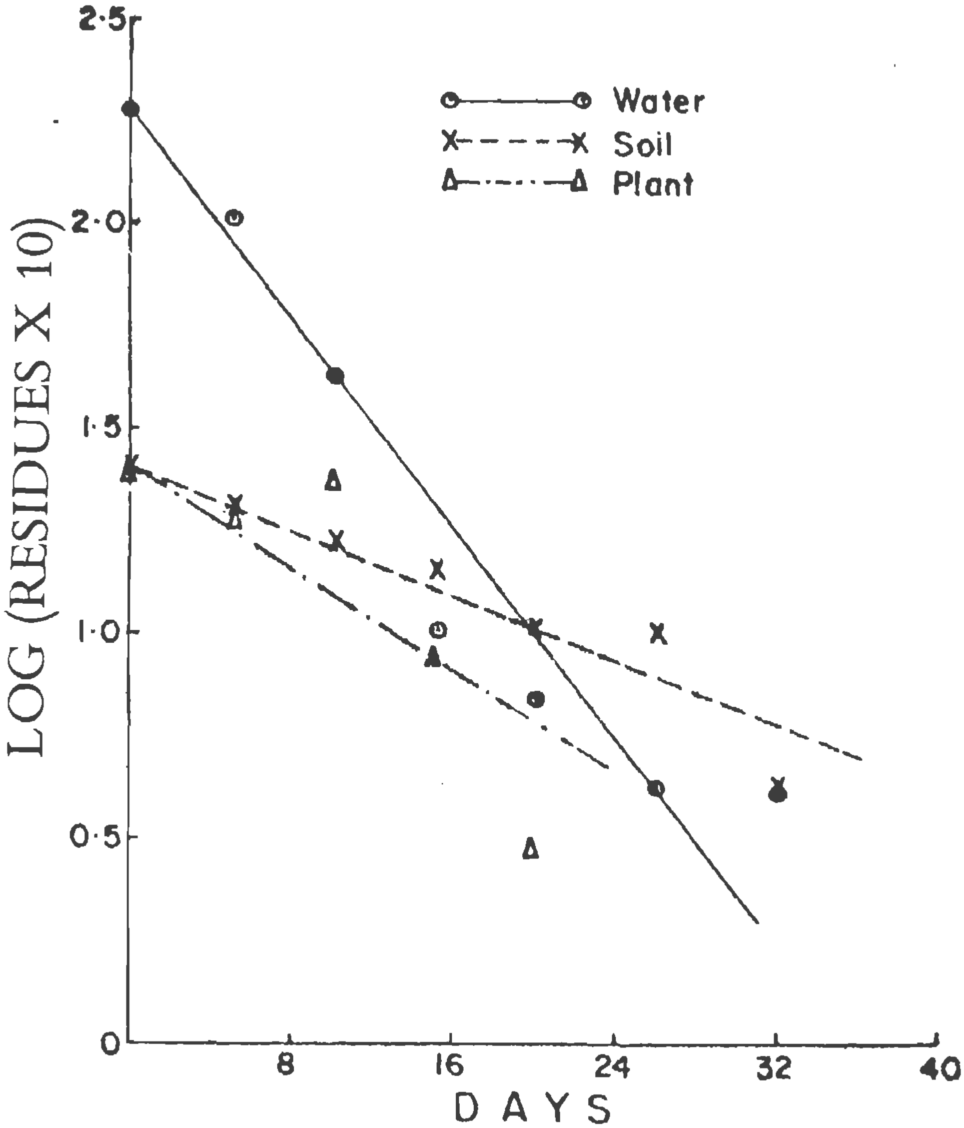

Fig. 1 : Linear plot for the first order reaction of butachlor under field conditions.

first order kinetics as shown in semi log plots of the data (Fig 1 and 2). Residues of butachlor and propanil reached non-detectable levels within 38 and 26 days respectively of their application emphasizing thereby that butachlor persisted longer than propanil. The slopes of the curves revealed that dissipation of the herbicides especially butachlor was much rapid in water as compared to soil and plants. the estimated half-life of butachlor was 18, 10 and 9 days and of propanil was 6, 8.5 and 5.2 days in soil, plant and water respectively.

Residues of herbicides in rice grains: Rice grains at harvest contained 0.08 and 0.11 ppmw of propanil and butachlor residues respectively. This indicated that

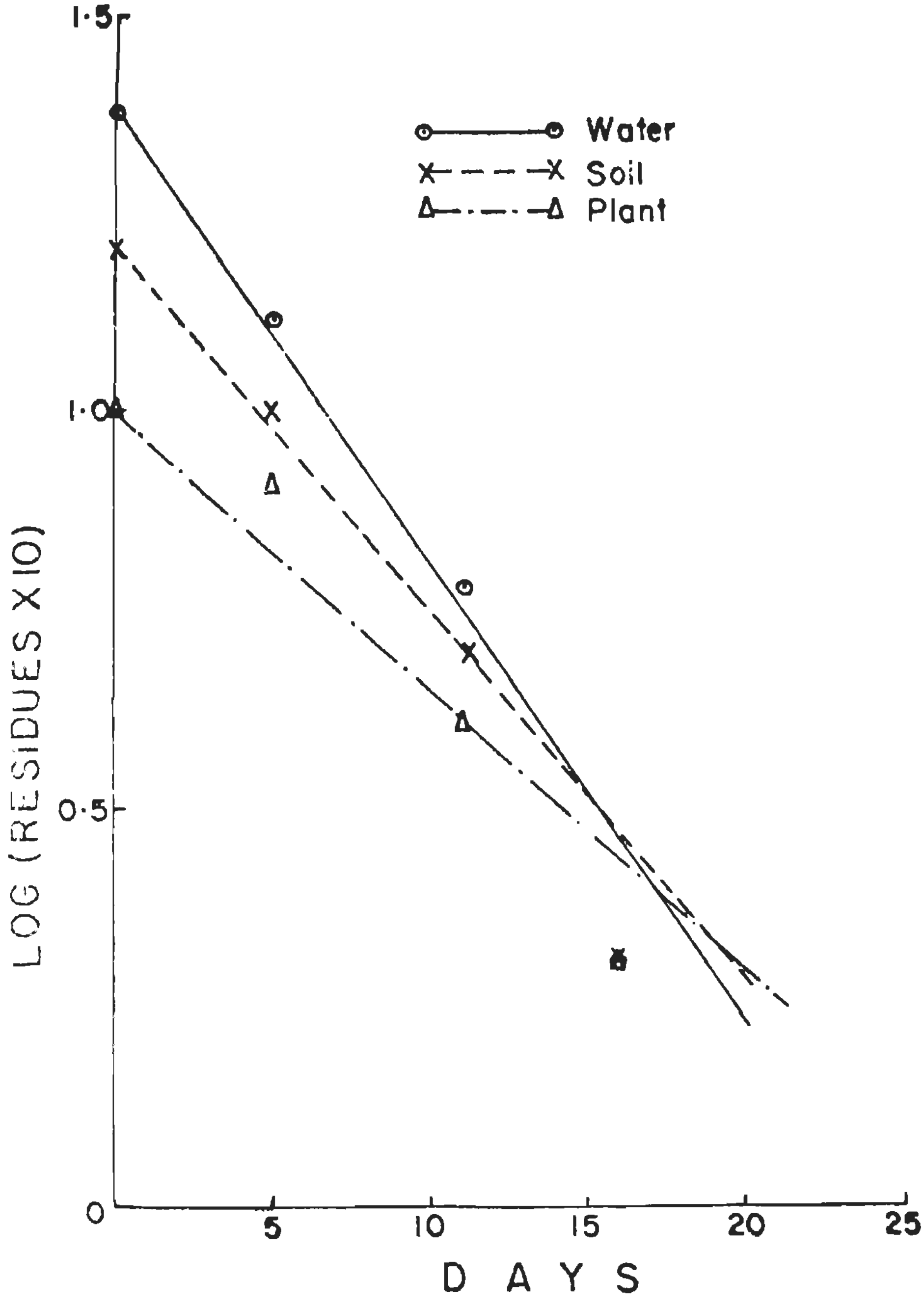

Fig. 2. LINEAR PLOT FOR THE FIRST ORDER REACTION OF PROPANIL UNDER FIELD CONDITIONS.

the herbicides were absorbed and translocated within plants. These residues, however, are within the limits of tolerance levels of 0.5 ppmw of these herbicides in raw rice as suggested by EPA.

Selectivity of herbicides to crops: The yield data are summarized in Table 4. The herbicide treatments gave as good yield as the hand weeding treatment. These results are in tune with the results of Schiller and Indhaphun (1979) in pointing out the fact that both butachlor and propanil are alternatives to handweeding when applied under optimum conditions.

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PERSISTENCE AND MOVEMENT OF HEXAZINONE IN SOME NEW ZEALAND SOILS

A. RAHMAN
Ruakura Soil and Plant Research Station, Ministry of Agriculture and Fisheries, Hamilton New Zealand.

ABSTRACT

The residual activity of hexazinone [3-cyclohexyl-6-dimethylamino-1-methyl-1,3,5-triazine-2, 4 (1H, 3H)-dione] in cultivated soils was investigated at six trial sites varying widely in their soil properties and climatic conditions. Soil samples were collected at monthly intervals from 0-10 cm depth and bioassayed in the glasshouse using radish *(Raphanus sativus)* and german millet *(Setaria italica)* as test species. Results showed that the residual life of hexazinone varied between 4 to 8 months for 1 kg/ha rate, and 8 to 11 months for 3 kg/ha rate depending on the test species, soil type and the climatic conditions. The phytotoxic residues lasted longer in cold and dry weather than under warm and wet conditions. Differences in soil texture and sil organic matter levels appeared to be important for the persistence of hexazinone mainly within regions of similar rainfall and temperatures. The movement of hexazinone was greater in a sandy loam soil than in a silt loam soil.

INTRODUCTION

Hexazinone is a very active herbicide both as a foliar spray or when applied to the soil and controls a wide range of perennial grasses and broadleaf weeds including a number of shrubs and tree species. Initially introduced in 1971-73 as an industrial herbicide, its development for weed control in arable situations did not take place until later on, mainly because of its long period of persistence and somewhat limited crop tolerance (Richardson and Parker, 1977). It has shown promise for selective uses in forestry and in crops such as sugar cane, rubber, asparagus, lucerne and blueberries (Cameron and Stokes, 1978; Rochecouste, 1976).

No work on the residual activity of hexazinone has been reported in New Zealand soils, although a few observations have been mentioned on the length of residual weed control in forestry situations (Cameron and Stokes, 1978; Coackley and Moore, 1977). The rates used in arable situations will be lower than those in forestry, but the indications are that the persistence of hexazinone will be similar to certain other triazines such as atrazine and simazine. Limited overseas research also supports its moderate to long persistence in the soil.

Miles and Santelmann (1978) from Oklahoma noted significant reductions in the yield of cotton following a lucerne crop treated with 1.7 kg ha^{-1} of hexazinone. Bioassays showed no evidence of residual effects 45 weeks after treatment. Richardson and Parker (1977) found that using kale as a bioassay species, the 0.45 kg ha^{-1} dose was still persistng 38 weeks after spraying. Research work by the proprietors of this product suggests that its half-life ranges from 1 to 6 months depending on soil type and location (Anon 1977; Rhodes, 1980).

As residual activity of hexazinone will be an important consideration for its use in arable farming, this work was initiated to study its movement and persistence under different soil and climatic conditions in New Zealand.

MATERIAL AND METHODS

Field trials were laid down on established *Medicago sativa* L., lucerne, during the

Table 1. Some soil properties of the trial sites.

Site no.	Soil type	Sand (%)	Clay (%)	Organic carbon (%)	pH	C.E.C. (MEq/100 g)
1	Horotiu sandy loam	55	16	9.1	5.8	37.2
2	Himatangi sand	86	6	4.0	6.0	11.3
3	Templeton silt loam	45	21	4.4	5.4	15.8
4	Selwyn sandy loam	70	11	3.3	6.8	11.6
5	Timaru silt loam	48	19	4.6	5.2	17.0
6	Kauru silt loam	35	21	3.5	5.7	17.2

Table 2. Rainfall and temperature records of trial sites.

	Rainfall (mm)				Mean soil temp. (° C)*		
Site no.	0 – 3 months	3 – 6 months	6 – 9 months	Yearly total	January	June	Year
1	470	205	311	1326	18.7	7.7	13.2
2	240	248	224	923	18.3	7.0	12.7
3	168	341	244	914	16.3	3.8	9.6
4	161	334	252	908	16.3	3.8	9.6
5	98	172	197	727	16.4	3.9	9.8
6	90	158	176	672	15.9	3.0	8.8

* At 10 cm depth, recorded at 9 am.

1979-80 growing season on six soil types located in different parts of the country. Some physical and chemical properties of the soils at different locations are listed in Table 1. Methods for determining these properties have been described earlier (Rahman, 1977). Rainfall and soil temperature records for various trial sites are presented in Table 2. Work on movement of hexazinone was carried out on sites 3 and 4 which were located within 5 km of each other.

Hexazinone was applied to the lucerne crop at rates of 1, 1.5, 2 or 3 kg ha^{-1} between July and August 1979 (mid to late winter). Individual plots were 10 m x 2 m and treatments were arranged in a randomised block design with four replications. The herbicide was applied in a spray volume of 290 l ha^{-1} at a pressure of 200 kPa.

Soil samples for bioassay of herbicide activity were obtained from each plot at monthly intervals from the date of spraying until residues fell below the level of detection. Samples for persistence studies were collected to a depth of 10 cm and for movement studies from depths of 0-10, 10-20 and 20-30 cm. The soil was bioassayed in the glasshouse using the procedure described by Rahman and Cox (1975). A series of 'standards' was run simultaneously with each soil type by employing a range of concentrations of hexazinone and determining the effect on dry matter weights of shoots.

The bioassay species used for measuring the residual activity were *Raphanus sativus* L., radish, and *Setaria italica* (L.) Beauv., german millet. Initially *Brassica rapa* L., turnips, *Brassica nigra* L., black mustard and *Avena sativa* L., oats, were also tested in the glasshouse to find the most suitable plant species for bioassay of hexazinone residues. Turnips and black mustard were slightly more sensitive than radishes while oats were the least susceptible species to hexazinone.

Table 3. Effect of hexazinone on bioassay species in the glasshouse.

hexazinone (ppmw)	Dry shoot wt – % of control		
	Radish	Turnip	German millet
0	100 a*	100 a	100 a
0.05	84 ab	75 b	98 a
0.10	68 b	56 c	85 ab
0.15	39 c	23 d	73 b
0.20	4 d	0 e	62 bc
0.25	0 d		44 c
0.30			25 d
0.35			10 de
0.40			0 e
CV%	12.4	8.3	17.5

*Duncan's multiple range test ($P<0.05$).

However, radish and german millet were selected as the most suitable for bioassay due to their rapid foliage production and their consistent and uniform growth throughout the year.

RESULTS

Data from 'standards' established on a sandy loam soil with 9.1% organic carbon (site 1) show that the minimum detectable concentration of hexazinone was about 0.10 ppmw (parts per million by weight of oven-dry soil) for radish and 0.15 ppmw for german millet (Table 3). The detectable concentration of the herbicide varied between different trial sites.

The lengths of time required for hexazinone residues to fall below phytotoxic levels in the top 10 cm of the soil of six trial sites are given in Table 4. Residues were considered nonphytotoxic when reduction in dry matter weights of radish was not significantly different from the untreated controls. As german millet was more tolerant to hexazinone, residue levels became nontoxic to this species about 2 months sooner than to radishes. However, response trends for the german millet bioassy followed a similar pattern to that of radishes (Table 4).

Table 4. Months after application when residues fell below phytotoxic levels to radishes.

Site no.	Hexazinone (kg ha^{-1})			
	1	1.5	2	3
1	5	7	7	8
2	6	7	8	10
3	7	9	10	11
4	7	8	9	11
5	7	8	9	11
6	8	9	10	12

Table 5. Pattern of dissipation of hexazinone residues.

Site no.	Radish shoot wt – % of control* Months after application							
	3	4	5	6	7	8	9	10
				1 kg ha^{-1}				
1		12	58					
2		0	36	71				
3		0	4	29	64			
4		0	15	46	73			
5		0	21	41	67			
6		0	9	24	45	70		
				2 kg ha^{-1}				
1	0	12	37	62				
2	0	3	20	54	75			
3	0	0	0	24	42	61	76	
4	0	0	7	31	47	72		
5	0	0	16	29	43	61		
6	0	0	0	0	22	34	52	69

*Figures in this table are all significantly different from untreated controls (= 100), $P = 0.05$, pooled S.E. ±5.6 for 1 kg ha^{-1} and ±6.3 for 2 kg ha^{-1}. Blank spaces indicate no significant difference recorded.

The pattern of dissipation of hexazinone residues in the top 10 cm of the soil from 1 and 2 kg ha^{-1} rates is presented in Table 5. Similar trends and differences between rates were also apparent in the results from 1.5 and 3.0 kg ha^{-1} rates.

The movement of hexazinone was greater in the sandy loam soil (site 4) than in

Table 6. Movement of hexazinone (2 kg ha^{-1}) in two soil types.

Site no.	Soil type	Sampling depth(cm)	Radish shoot wt - % of control (= 100) Months after application		
			3	6	9
3	Silt loam	0-10	0 a*	30 a	75 a
		10-20	102 b	98 b	95 b
		20-30	100 b	103 b	100 b
4	Sandy loam	0-10	0 a	37 a	87 a
		10-20	100 b	84 b	64 b
		20-30	104 b	100 b	90 a

Duncan's multiple range test (P = 0.05)

the silt loam soil (site 3) as evidenced by greater phytotoxicity to radish plants in the lower depths, especially 9 months after application, in site 4 (Table 6). Data from other treatments showed trends similar to those observed for the 2 kg ha^{-1} rate. As was the case with persistence studies, data for german millet supported the results obtained by the radish bioassay.

DISCUSSION

An examination of the soil properties and climatic data for trial sites in Tables 1 and 2 shows a strong relationship of these factors with the residual activity of hexazinone reported in Tables 4 and 5. Statistical analyses of the data pooled over all the rates of application revealed that rainfall and soil temperatures were the factors most highly related to the herbicide persistence ($r = 0.86^{***}$ and 0.81^{***} respectively) followed by the sand content ($r = 0.69^{**}$) and the organic carbon content of the soil ($r = 0.48^{*}$). The correlation values for other soil properties were not significant.

As rainfall and soil temperatures for these trial sites were strongly related to each other ($r = 0.86^{***}$), it is very difficult to differentiate between the effects of these two factors on the persistence. It can be said, however, that hexazinone persists longer under dry and cold conditions than under wet and warm conditions. Differences in the soil texture and the organic carbon content of the soil appear to be important mainly within regions of similar rainfall and temperatures.

Results from all field trials indicate that the rate of dissipation of hexazinone was dependent on the initial rate applied to the soil. Thus the length of residual activity increased as the initial rate was increased, but not to the same degree. Similar observations have been made by other workers (Rochecouste, 1976). These data on the persistence of hexazinone in cultivated soils are also partially supported by observations made on the length of residual weed control in forestry situations in New Zealand (Coackley and Moore, 1977).

Data on movement of hexazinone indicate that its residues leach to greater depths in light-textured soils than in heavy soils. This is not surprising in view of its very high water solubility. Thus once the top 5-10 cm of the soil is 'safe' from the residue point of view, the lower depths may still pose threat of damage to susceptible crops in some light soils. Although these trials provide no information on the lateral movement of hexazinone in the soil, current work in progress suggests some lateral movement of this herbicide where heavy rainfall follows within a few days of application, especially if sprayed on a wet soil.

The assessment of residual activity presented in Tables 4 and 5 is based on the dry weight of radish plants, which is a very susceptible species to hexazinone. As mentioned earlier, german millet as a less susceptible bioassay species produced a similar response curve 2 months sooner than radishes. Thus an area could be 'safe' for less susceptible crops, following in rotation somewhat earlier than expected from the data presented here.

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INTERACTIONS OF PRE-EMERGENCE HERBICIDES, SOIL APPLIED ALDICARB INSECTICIDE AND SUCCINIC ACID ON THE QUALITY OF COTTON

P. RETHINAM[1] and S. SANKARAN[2]
[1] CPCRI, Field Station, Irinzalakuda-680 121, India.
[2] Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, India.

ABSTRACT

A field experiment was conducted for two years at TNAU, Coimbatore, to study the interactions of four pre-emergence herbicides *viz.*, alachlor 1.5 kg a.i./ha fluometuron at 1.0 kg a.i./ha, fluochloralin at 1.0 kg a.i./h and dinitramine 0.48 kg a.i./ha with aldicarb insecticide 1.0 kg a.i./ha and succinic acid two per cent solution for seed treatment and 0.5 kg/ha for soil application.

Interactions of fluometuron with succinic acid gave higher ginning per cent (34.03). Fluchloralin-aldicarb-succinic acid combination (32.97) and dinitramine-aldicarb-succinic acid combinations (32.83) reduced the ginning per cent, lint and seed indices were not influenced by the interaction effect of pre-emergence herbicide, aldicarb insecticides and succinic acid. Fibre fineness was positively influenced by the interaction effect of dinitramine-aldicarb combinations (3.17) as well as by fluchloralin-aldicarb-succinic acid combination (3.16). Fibre length was reduced due to the interaction effect of dinitramine succinic acid combination (30.16) while the same was increased with aldicarb-succinic acid combination (31.32). Interactions of alachlor, fluometuron, fluchloralin with aldicarb reduced the fibre length. Bundle strength was positively influenced due to the interaction effect of alachlor, fluometuron and fluchloralin herbicides with aldicarb. Bartlett index and maturity co-efficient were not influenced by the interation of herbicide with insecticide or succinic acid.

INTRODUCTION

In an interest to increase the cotton (*gossypium hirsutum* L.) production per unit area to meet the increasing demands of growing population, we use all package of practices like improved varieties, proper fertilizer application, weed control by herbicides, insect control by insecticides and also growth promoting chemicals. This results in the simultaneous presence of two or more pesticides in the micro environment of the plant. In cotton field, use of pre-emergence herbicides and soil applied insecticides like carbofuron and aldicarb are used either simultaneously or serially to control weeds and pests. The interactions of these chemicals sometimes cause delay in maturity (Corbin and bradley, 1970), seedling injury (Walker *et al.* 1963), phytotoxic effect (Nash, 1967), increased seedling growth (Arle, 1968) or no detrimental effect (Helmer *et al.* 1969) or no reduction in yield (Deryabin and Karimov, 1974). Based on these, a field study was conducted with herbicides, insecticides and hormone and their interaction effect on the quality of cotton was studied besides yield.

MATERIAL AND METHODS

A field experiment was conducted for

Table 1: ffect of treatment on quality parameters.

	M_1	M_2	M_3	M_4	M_5	M_6	Mean	SEd±/C.D. (P = 0.05)
(1) Ginning percentage								
T_1	31.97	32.03	32.23	32.30	32.68	32.82	32.94	M: 0.06/N.S.
T_2	32.72	32.80	32.17	32.64	32.11	32.03	32.41	T: 0.06/0.12*
T_3	32.62	32.34	32.21	32.11	31.83	31.80	32.15	MT: 0.15/0.29*
T_4	32.65	32.12	32.19	32.25	32.51	31.95	32.21	TM: 0.15/0.29*
Mean	32.39	32.32	32.20	32.32	32.28	31.95		
(2) Lint index								
T_1	5.68	5.69	5.69	5.72	5.73	5.28	5.63	M: 0.03/07*
T_2	5.75	5.89	5.83	5.89	5.86	5.40	5.77	T: 0.25/0.05*
T_3	5.55	5.68	5.64	5.78	5.74	5.22	5.57	MT: 0.06/N.S.
T_4	5.89	5.76	5.84	5.97	6.02	5.23	5.83	TM: 0.06/N.S.
Mean	5.72	5.75	5.75	5.79	5.84	5.32		
(3) Seed index								
T_1	12.13	12.25	11.99	12.22	12.17	11.27	12.00	M: 0.03/0.1*
T_2	12.17	12.29	12.18	12.27	12.22	11.44	12.10	T: 0.03/0.1*
T_3	12.04	12.10	11.82	11.88	12.18	11.16	11.86	MT: 0.08/0.2*
T_4	12.33	12.28	12.19	12.24	12.39	12.77	12.20	TM: 0.08/0.2*
Mean	12.17	12.23	12.04	12.15	12.24	11.41		
(4) Fibre fineness micronaire (10^{-6} g/inch)								
T_1	3.10	3.03	3.03	3.21	3.08	3.03	3.08	M: 0.01/0.02
T_2	3.08	3.18	3.14	3.09	3.14	3.13	3.13	T: 0.01/0.02
T_3	3.01	3.06	3.17	3.06	3.01	3.01	3.04	MT: 0.03/0.06
T_4	3.09	3.11	3.12	3.04	3.13	3.13	3.07	TM: 0.03/0.06
Mean	3.07	3.09	3.11	3.10	3.09	3.09	3.08	
(5) Fibre length, mm								
T_1	30.42	30.50	30.62	31.37	30.85	30.40	30.71	M: 0.06/0.13*
T_2	3ß.83	31.48	30.82	31.27	30.87	31.02	31.05	T: 0.08/0.15*
T_3	31.32	31.20	30.45	30.17	30.73	30.45	30.72	MT: 0.19/0.37*
T_4	31.13	31.55	31.55	31.52	31.38	30.22	31.23	TM: 0.18/0.35*
Mean	30.93	31.20	30.86	31.08	30.96	30.52	30.23	
(6) Bundle strength (Tenacity 'o' gauge)								
T_1	46.68	45.92	46.70	45.50	45.38	44.58	45.71	M: 0.12/0.24*
T_2	46.25	44.78	44.67	45.30	44.30	44.42	45.12	T: 0.12/0.23*
T_3	45.38	44.42	45.30	45.67	44.77	44.32	44.98	MT: 0.28/0.57*
T_4	45.68	44.42	45.03	45.90	45.30	45.80	45.25	TM: 0.27/0.55*
Mean	46.00	44.88	45.29	45.59	45.19	44.63	45.26	

(7) Bartlett's index								
T_1	0.64	0.64	0.66	0.65	0.66	0.65	0.65	M : 0.006/NS
T_2	0.65	0.66	0.65	0.66	0.65	0.67	0.65	T : 0.011/NS
T_3	0.64	0.64	0.65	0.65	0.66	0.65	0.65	MT : 0.027/NS
T_4	0.63	0.66	0.65	0.66	0.65	0.66	0.65	TM : 0.024/NS
Mean	0.64	0.65	0.65	0.66	0.66	0.66		
(8) Maturity Co-efficient								
T_1	0.657	0.653	0.655	0.670	0.652	0.642	0.655	M : 0. 0030/0.009
T_2	0.658	0.635	0.667	0.650	0.648	0.655	0.652	T : 0.0044/N.S.
T_3	0.638	0.653	0.657	0.643	0.648	0.640	0.647	MT : 00108/0.022
T_4	0.662	0.647	0.642	0.657	0.658	0.643	0.651	TM : 0.0099/N.S.
Mean	0.654	0.647	0.655	0.655	0.652	0.645		

M_1 – alachlor T_1 – aldicarb M_2 – Fluometuron T_2 – Succinic acid M_3 – Fluchloralin T_3 – aldicarb + succinic acid M_4 – dinitramine T_4 – no chemical M_5 – handweeding M_6 – unweeded control N. S. significant.

two years at the Tamil Nadu Agricultural University, Coimbatore as detailed in the earlier paper by the same authors included in the proceedings.

After the harvest of the seed cotton the quality characters like ginning percentage, lint index, seed index, fibre fineness, fibre length, bundle strength, Bartlett index and maturity co-efficient were studied. The pooled analysis data for the two years alone are discussed in this paper.

RESULTS

The results on the quality characters are presented in Table 1. Interaction of fluometuron-succinic acid had higher ginning percentage (32.80), followed by alachlor-succinic acid (32.72). Alachlor-aldicarb interaction showed the lowest ginning percentage (31.97). In the interaction of herbicide, aldicarb-succinic acid lowered the ginning per cent.

The lint index (Table 1) was not affected by the interaction of herbicide-aldicarb or herbicide-aldicarb-succinic acid. Interaction of all herbicides with aldicarb and succinic acid combinations generally reduced the seed index (11.86), followed by herbicides-aladicarb interactions (12.00).

Fibre fineness was influenced positively by the dinitramine-aldicarb interaction (3.21). Herbicides - aldicarb-succinic acid interactions had lower micronnaire values (3.04) except fluchloralin values (3.04) except fluchloralin-aldicarb-succinic acid (3.17). Fluometuron-succinic acid showed higher fibre fineness (3.18) compared to aldicarb (3.03) or aldicarb-succinic acid combinations (3.06) or no chemical (3.11).

The mean fibre length was generally influenced by herbicides-succinic acid (31.05) combinations. Alachlor-aldicarb-succinic acid interaction influenced the fibre length positively (31.32), while alachlor-aldicarb was the lowest (30.42), followed by alachlor-succinic acid (30.83). Fluometuron-aldicarb also showed lower fibre length (30.50), compared to either fluometuron alone (31.55) or fluometuron-succinic acid (31.48). Fluchloralin alone had a fibre fineness of 31.55 mm, and all the other combinations with aldicarb and succinic acid showed lower fibre length. Dinitramine-alachlor-succinic acid interactions also reduced the fibre length (30.17).

Interactions of alachlor, fluometuron and fluchloralin with aldicarb significantly increased the bundle strength to 46.68, 45.91 and 46.16 respectively.

Bartlett's index was not influenced by the interaction of herbicides, aldicarb or aldicarb-succinic acid combinations. Maturity co-efficient also showed similar trend.

DISCUSSION

The ginning percentage was influenced by the interactions of herbicides–succinic acid. Hamilton and Arle (1976) showed that urea and dinitro aniline (trifluralin) herbicides did not affect the ginning percentage. In the same way Raghupathy (1976) reported that ginning percentage was not affected by aldicarb at 1.00 kg a.i. ha^{-1}. In the present study the combinations of alachlor-aldicarb lowered the ginning percentage. The reduction was however only two per cent over alachlor alone. Lint index was not affected by interaction of aldicarb or succinic acid with herbicides. Smith (1971) reported that lint index was not affected by herbicide treatments. In this study pre-emergence herbicide with soil applied aldicarb or succinic acid did not affect the same.

As the seed index is the weight of 100 seeds, a weed-free environment might have enhanced the growth and vigour of the crop and had contributed to the better seed development. Interactions of herbicides, aldicarb-succinic acid combinations alone showed low seed index when compared to herbicides–aldicarb, herbicides-succinic acid combinations.

Fibre fineness which is a measure of the fibre weight in kg per unit length of fibre, was influenced positively by dinitramine-aldicarb (3.21) while dinitramine-aldicarb-succinic acid reduced it (3.01). Hamilton and Arle (1976) also observed that trifluralin, nitralin, diuron, monuron, prometryne and fluometuron had no effect on fibre properties including fibre fineness. In the present study, compared to handweeding treatments herbicides and soil applied chemicals did not reduce the fibre fineness.

The fibre length, another desirable quality of cotton was not much influenced by the interaction effect when compared to handweeding treatment. Bundle strength which is the ratio of breaking strength of a bundle of fibre to its weight, was positively influenced by herbicides alachlor interactions.Barlett' index which is the earliness index and maturity co-efficient were not affected by the interaction of herbicide and soil applied chemicals.

CONCLUSION

Lint index, Barlett's index and maturity co-efficient were not affected by the interaction of herbicide – soil applied chemicals. Interactions of herbicides aldicarb and succinic acid combinations reduced the seed index as well as fibre fineness. Dinitramine-alachlor-succinic acid interactions reduced fibre length. Interactions of alachlor, fluometuron and fluchloralin with aldicarb influenced the bundle strength positively.

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SOIL DISSIPATION OF THREE HERBICIDES

DESH R. DUSEJA
Tennessee State University, Nashville, Tennessee 37203, U.S.A.

ABSTRACT

Three herbicides, trifluralin, (α, α, α-trifluoro-2, 6-dinitro-N, N-dipropyl-*p*-toluidine), profluralin [*N*-(cyclopropylmethyl)-α, α, α -trifluoro-2, 6-dinitro-*N*-propyl-*p*-toluidine], and dinitramine (N^4, N^4-diethyl-α,α, α -trifluoro-3, 5-dinitrotoluene-2, 4-diamine) were incubated in an Etowah silt loam soil under laboratory conditions. The herbicides were incubated at 0.5 ppmw herbicide concentrations at 73 and 95°F, and for a time period ranging from 7 to 17 days. Three pH levels (5.3, 6.4 and 7.5) and three moisture contents (0, 50 and 100% FC) were generally used.

Maximum disappearance of each herbicide occurred at the intermediate pH of 6.4. The herbicide losses were enhanced by increasing moisture contents and increasing temperature, and time. At 7 days incubation, at 50% FC moisture and soil pH of 6.4, herbicide dissipation at 73°F was in the order: Profluralin (~30%) > Trifluralin ≈ Dinitramine (~20%).

INTRODUCTION

Deleterious effects of combinations of pesticides may result from increased phytotoxicity, increased persistence or inactivation of one pesticide by another; however, beneficial interactions may result from increased phytotoxicity, lowered undesirable plant species or increased degradation. Kaufman (1966) found that the microbial degradation of dalapon was suppressed in the presence of amitrole.

Tank-mix applications of trifluralin with profluralin and dinitramine have recently begun to be applied. Although a number of studies (Hardcastle, 1974 and Jones *et al.* 1974) have dealt with crop tolerance, crop performance and yield as a result of atrazine and metribuzin combinations with trifluralin, the persistence in soil of dinitroanilines as admixture has not been reported in the literature.

This study reports the influence of soil pH, moisture, temperature and time on the persistence of an admixture of trifluralin, profluralin and dinitramine in Etowah silt loam soil in laboratory incubation studies.

Experimental section

Soil from the 15 cm depth of Etowah silt loam was collected at the Tennessee State University farm. Soil was air dried, ground, passed through a 2 mm sieve. Some of the physicochemical properties of this soil are given in Table 2. Fortification of soil (spiking) was done with known amounts of technical grade herbicide (trifluralin, profluralin and dinitramine) solutions prepared in hexane. Concentrations in soil of 0.5 ppmw each of trifluralin, profluralin and dinitramine (hereinafter referred to as dinitroanilines) were obtained. The studies were conducted in a growth chamber (Warren Shearer Model) at constant temperatures of 73 and 95°F. Two moisture contents were used (50 and 100% of soil field capacity), the soil being sampled at two time intervals of 7 and 17 days. Three pH levels (pH 5.3, 6.4 and 7.5) were used. The natural soil pH was 6.4. Forty grams of soil were incubated in styrofoam cups of about 600 ml capacity. The moisture in the cups was replenished every 24 hr.

The entire soil mass was removed from the styrofoam cup by a spatula at appropriate time intervals, allowed to air-dry at room temperature in a dark room for 24 hr, crushed and passed through a 2 mm sieve. Ten grams of soil prepared as above were extracted with 20 ml of methanol.

To the direct extract, five ml iso-octane was added. A varian Aerograph gas chromatograph, Model 2440, equipped with scandium tritide (Sc^3H) electron capture detector was used for analysis.

RESULTS

Regardless of the soil moisture content (50% or 100% of FC), soil temperature (73 or 95°F) or the time of incubation (7 and 17 days), soil persistence of all the three dinitroanilines was the least at the natural pH of 6.4, compared to the other two pHs studied (Table 1). The differences were generally highly significant (P = 0.01) for all the three herbicides. The differences in herbicides persistence at the same time intervals and the same temperature varied from 7 to 32% of the original herbicide concentration (0.5 ppmw) depending on the herbicide.

More herbicides dissipated at 100% FC moisture than 50% FC moisture at 7 or 17 days intervals, and at all the three pHs studied (Table 2). To illustrate, one example at the natural pH, herbicide persistence was 57.6 and 24.2%, respectively, for trifluralin; 60.3 to 25.4%, respectively, for profluralin and 42.4 and 21.2%, respectively for dinitramine; at 50 and 100% moisture at 7 days incubation.

The higher temperature of 95°F resulted in higher dissipation of each dinitroaniline (7 days), regardless of soil pH (Table 1). At pH 5.3 for instance, the soil persistence at 73 and 95°F was 87.3 and 69.7% respectively, for trifluralin; 80 and 73% respectively, for profluralin and 89.7 and 57.6% respectively, for dinitramine.

The increase in soil incubation time from 7 to 17 days resulted in increased herbicide dissipation; for example, at the highest pH of 7.5, 100% FC moisture and 95°F, the herbicide persistence was 48.5 and 30.3% respectively, for trifluralin; 47.6 and 30.3% for profluralin; and 42.4 to 29.1% for dinitramine; at 7 and 17 days intervals.

DISCUSSION

Effect of soil pH

Savage (1973) found the degradation of trifluralin in soil to be lower at pH by 4.8 compared to that of pH 6.8. His results, therefore, corroborate ours. Savage appears to attribute this to greater herbicide absorption and reduced microbial activity at the lower pH. His observations on greater absorption at lower pHs are, however, in disagreement with Mengers and Hubbard (1970), who found the GR 50 of trifluralin to a number of plant species to be lower in Harlinger Clay (62% clay, 1.7% O.M. and a pH of 8.0) than in three other soils with lower clay and O.M. contents and at lower or the same pH (with the exception of one soil of pH 8.7). We also found in our laboratory (Table 3) that the maximum difference in

Table 1 : Some physio-chemical properties of Etowah silt loam soil.

Soil depth	pH	Organic matter	Mechanical analysis Sand %	Silt %	Texture Clay %		% Field capacity
0-6 "	6.4	1.79	48.8	30.9	17.9	Loam	64
6-12"	6.9	1.96	43.3	34.8	22.0	Loam	53
12-18"	7.0	1.40	38.3	34.0	27.7	Clay Loam	53

Table 2: Soil dissipation of three dinitroaniline herbicides under laboratory incubation conditions, as affected by moisture, temperature and time. Original concentration of each herbicide was 0.5 ppmw.

Soil pH	Amount remaining (% of original)				
	50% Moisture			100% Moisture	
	73°F	95°F		95°F	
	7 Days	7 Days	17 Days	7 Days	17 Days
			Trifluralin		
5.3	87.3a	69.7a*	34.7a	34.8a	25.5a
6.4	80.0b	57.6b	24.2b	24.2b	20.0b
7.5	89.7c	74.3a	37.9c	48.5c	30.3c
			Profluralin		
5.3	80.0a	73.0a	34.7a	36.5a	26.7a
6.4	70.3b	60.3b	27.3b	25.4b	20.2b
7.5	82.4c	76.2c	48.5c	47.6c	30.3c
			Dinitramine		
5.2	89.7a	57.6a	36.4a	28.8a	24.2a
6.4	80.0b	42.4b	17.3b	21.2b	13.9b
7.5	89.7a	74.3c	45.5c	42.4c	29.1c

*Means followed by the same letter within the same herbicide and same time interval are not significantly different at 1% level according to the Duncan multiple range test.

Table 3: Absorption of profluralin on Etowah silt loam soil from an aquous profluralin suspension of 4.92 ppm at room temperature.

Soil pH	% of Original concentration absorbed
5.3	99.17
6.4	98.90
7.5	99.15

absorption of profluralin on Etowah soil from 4.92 ppm initial herbicide concentration, was 0.27%, at pH 5.3 and 6.4; evidently not enough to explain the differences in degradation noted for this herbicide at the two pHs.

Effect of soil moisture

As the soil moisture increased in both the experiments, from 0 to 100% FC, there was continuous increase in the loss of the three dinitroanilines (Table 2). Many researchers have found the same trend (Zimdahl and Gwynn, 1977, and Hollist and Foy, 1971). Bardsley *et al.* (1968) found that trifluralin losses from soil were greater when the soil was saturated rather than at field capacity, presumably because more free water was available to vaporize itself and to dissolve more trifluralin. Probst *et al.* (1967) reported a more rapid rate of degradation of dinitroanilines at 200% FC (anærobic conditions) than at moisture levels of 0, 50 and 100% FC. Hollist and Foy (1971) attributed the increased rate of trifluralin degradation to the blocking of the active absorption sites on the soil by the increasing moisture content.

At 0% FC in our experiments, trifluralin degradation was very little (Table 2). This results from strong soil absorption of herbicide molecules (Burnside, 1974; Harris, 1967). However, microbial activity in dry soil is also drastically reduced (Burnside, 1974). Harris (1967) also reported that triazine herbicides in dry soils are not easily degraded or lost by non-biological agents such as volatilization and photodecomposition because of retarded herbicide movement to the surface.

CONCLUSION

The most prominent finding of this study, not widely reported in the literature, was concerning the effect of pH on herbicide dissipation—a pH of 6.4 being most conducive to herbicide disappearance compared with higher or lower pH's used. The mechanism of this effect could not be found.

The herbicide disappearance progressively increased with moisture content (0 to 100% FC) and temperature (73 to 95°F).

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