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... CONFERENCE OF

... PACIFIC WEED SCIENCE SOCIETY

... 1987

THE ELEVENTH CONFERENCE OF
THE ASIAN–PACIFIC WEED SCIENCE SOCIETY

PROCEEDINGS OF THE ELEVENTH
ASIAN–PACIFIC WEED SCIENCE SOCIETY
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1987

WEED SCIENCE SOCIETY OF
THE REPUBLIC OF CHINA

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CONFERENCE 1985 - 1987

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Weed Control

OPENING REMARKS

Chairman of The Organizing Committee

Yuh-Lin Chen

Honourable Guest, Dr. You-Tsao Wang, the Chairman of the Council of Agriculture, Dr. Yuh-Hsien Yu, the Commissioner of the Department of Agriculture and Forestry, Taiwan Provincial Government, Distinguished Speakers, Esteemed Fellow Members of the Asian-Pacific Weed Science Society, Ladies and Gentlemen:

As Chairman of the Organizing Committee of the 11th Asian-Pacific Weed Science Society Conference, I am deeply honoured to have this opportunity to say a few words to such a distinguished gathering. First of all, I wish to thank my colleagues who have made the efforts to come from far and near to Taipei to attend this Conference. For it is your participation that will make this Conference a success.

On behalf of the Organizing Committee and my colleagues, I wish to convey my sincere thanks to our guest of honour, Dr. Y. T. Wang, the Chairman of the Council of Agriculture, Dr. Y. H. Yu, the Commissioner of the Department of the Agriculture and Forestry, Taiwan Provincial Government, Dr. C. Sun, President of the National Taiwan University, Dr. K. S. Kung, President of the National Chung Hsing University, and distinguished guests from the Council of Agriculture, National Science Council, Department of Agriculture and Forestry, Taiwan Provincial Government, and many other organizations, who honour us with their presence today. I wish also to take this opportunity to thank all members of the Society who have contributed in one way or another and wish to congratulate the previous officers in charge for the tremendous efforts they put in and for the achievement they accomplished. To our distinguished speakers and chairpersons of the sessions and authors I extend my sincere appreciation. My deepest gratitude is extended to our government as well as the many private companies for their continuous support and assistance to make this Conference possible. As a token of our appreciation, the names of these organizations and companies are listed in the Final Program and the Abstracts, and also will be published in the Proceedings II after the Conference.

I sincerely hope that this Conference will prove to be an ideal forum for the weed scientists from countries not only from the Asian-Pacific region but also from all parts of the world to discuss and exchange views on the common problems pertaining to weed science as well as to foster international collaboration.

With the theme of this Conference "Weeds and their Control in Vegetable Production" in mind, we gather here today to discuss and exchange our knowledge and the achievements we made so far.

I am pleased to inform you that the Organizing Committee has arranged extremently interesting and stimulating social programs and tours around our beautiful island with a chance to visit fascinating places. I hope you will use this opportunity to experience the delights our country has to offer from our famous Chinese cuisine to art and culture, which I believe will make your visit here a truly memorable experience. It's also an excellent opportunity to promote friendship and renew old acquaintances.

Lastly, I like to wish each and everyone a most pleasant stay here in Taiwan, and may I extend my best wishes to you all.

Thank you very much.

WELCOME MESSAGE

Chairman, Council of Agriculture

Y. T. Wang

Honorable guests, distinguished speakers, ladies and gentlemen:

It gives me great pleasure to welcome all participants, on behalf of the Republic of China, to the 11th Conference of the Asian-Pacific Weed Science Society. The Republic of China takes great pride in hosting this Conference, and we hope very much that your stay with us will be both an interesting and an enjoyable one.

I should first like to thank the Organizing Committee on the wonderful job they have done in assembling experts from all over the world for this meeting. I should also like to express my thanks to the sponsors of this Conference, the Weed Science Society of the Republic of China, The Asian Vegetable Research and Development Center, and the Food and Fertilizer Technology Center. By supporting this meeting, these three organizations have made an important contribution to the advancement of weed science.

Weeds have always been one of the farmer's most destructive enemies. They compete with his crops for sunlight, water and food; they also serve as hosts or shelters for a range of pests. Ever since farming began, weeds have endangered yields wherever crops are grown,but they have been particularly serious in the humid tropics, where vegetation grows fast and the growing season lasts all year round. For centuries, farmers have been trying to control weeds as best they can by simple methods; primarily by hand weeding, supplemented by periodic burning or flooding of the soil where this was possible.

This century has seen a revolution in weed control, with the introduction of chemical herbicides. For the first time, the farmer has had a quick and effective means available of eliminating weeds, all the more valuable because industrialization has meant a widespread farm labor shortage. However, as we are all aware, the chemical herbicides also have their drawbacks. They can affect a wide range of species and damage the ecological balance, while there is also the danger of toxic residues in food crops and drinking water. Weed science research is now at a very active and exciting stage, as experts work to develop new, less toxic chemical herbicides, and non-chemical methods of protecting crops from weeds. The most recent research on these topics will be discussed at this conference, and also valuable new information on the incidence and effect of weeds, factors affecting the performance of various herbicides in the field, safety aspects or herbicide use, and weed management in integrated crop protection. I hope this meeting will give all of you working in weed science new insights and inspiration for your work, and that you will return home with fresh ideas on how to help the farmers achieve safe, cost-effective weed control.

I hope very much that you will enjoy your stay in Taipei, which provides an interesting combination of traditional and modern Chinese culture. Forty years ago Taipei was hardly more than a village; now it is one of Asia's most prosperous and exciting cities. I hope you will have time while you are here to enjoy the warm hospitality of the Chinese people, and see something of this beautiful island of Taiwan. Finally, I hope that this important meeting will prove to be a successful and fruitful one that will be of benefit to you all, and to the farmers your work has done so much to help. Thank you.

ADDRESS

President, International Weed Science Society

Keith Moody

Mr. Chairman, the President of the Asian-Pacific Weed Science Society, distinguished Guests, Delegates to the 11th Asian-Pacific Weed Science Society Conference, ladies and gentlemen:

On behalf of the International Weed Science Society, I would like to welcome you to this Conference which I regard as being one of the most important weed science conferences in the world.

Since we last met in Chiangmai, Thailand in November 1985 several important events have occurred in the region. Among these are:

I. the establishment of (a) the Southeast Asian Weed Information Center at Biotrop in Bogor, Indonesia, (b) the Tropical Weeds Research Center in Charters Towers, Australia, and (c) the Pakistan Weed Science Society, and

II. the holding of (a) the International Conference on Pesticides in Tropical Agriculture in Kuala Lumpur, Malaysia and (b) the 11th International Congress of Plant Protection in Manila, Philippines-the first time that this prestigious conferencse has been held in a developing country.

I would like to extend my congratulations and best wishes to all those people involved in these and other projects which I have not specifically mentioned and wish them every success in the future.

Unfortunately, the International Weed Scsience Society has not been as active. I hope that this will soon be remedied. A meeting to determine the future of the International Weed Science Society will be held one evening during this conference and all of you who are interested are welcome to attend. I look forward to the day when the International Weed Science Society will play a more active role in this and other regional weed science society conferences.

I would like to extend my appreciation to the organizing committee of this conference for all the time and effort they have spent on developing such an interesting program.

Congratulations on a job well done.

I am sure that this will be a very successful meeting.

Thank you.

A HISTORICAL REVIEW OF THE DEVELOPMENT OF RICE HERBICIDES IN JAPAN

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ABSTRACT

In 1948 the first efficacy test of modernized rice herbicide in Japan was performed using 2,4-D at Hyogo Prefectural Agricultural Experiment Station. After the improvement of 2,4-D formulations and the introduction of MCPA and derivatives, PCP granules, which registered in 1957, were widely utilized to control barnyardgrass and other early weeds. In early 1960s, however, the fish toxicity of PCP advanced new herbicides. Diphenylethers, such as nitrofen and chloronitrofen (CNP), for early application were followed by the simetryn combination with thiobencarb or molinate for middle stage weeds. From early 1970s, butachlor, chlomethoxynil, oxadiazone, and a combination of piperophos and dimethametryn appeared in the market. Now the second generations of herbicides followed to the original ones, for instance, naproanilide to phenoxy herbicides, bifenox to chlomethoxynil, pretilachlor to butachlor, pyrozoxifen and benzofenap to pyrazolate, dimepiperate, isopropylate or SC-2957 to thiobencarb. One of the sulfonylurea herbicides, bensulfuron-methyl, has joined to the rice herbicide group very recently with extremely low dosage and lower toxicity to animals producing many combinations with other herbicides. The characteristics of utilization of rice herbicides in Japan are summarized as follows: (1) They were developed mainly for transplanted cultivation. (2) Almost all formulated products are granular ones. (3) Over half of the formulated products are combinations of two or three active ingredients. These combinations enlarged the weed spectrum to be controlled. In order to control all weeds, the herbicides have been applied two or three times at intervals. Now one shot application of such combinations is being recommended to save the application labor and for other purposes. During these periods, there occurred many troubles mainly as to the herbicide injury to rice plants. However these problems were solved by the technical countermeasures developed in this country. Each example will be explained in this paper from the standpoints of improvement of formulations, development of alternative herbicides, utilization of safeners, thorough distribution of safe application guide and others.

FOREWORD

In Japan herbicide use contributed so much to save the labour cost in rice cultivation as will be described in details later. In this paper the author will try to review the development and use of rice herbicides in this country, explaining the changes in kinds of herbicide along with occurred problems and their solutions and also the economic analysis of the impacts.

CULTIVATION METHODS OF RICE PLANTS

The cultivation methods of rice plants are classified into four categories, such as transplanting by machine and by hands, dry-direct seeding and wet (or water) direct seeding. And the mechanical transplanting includes the use of young and middle seedlings. In the case of hand transplanting larger seedlings are used. Until 20 years ago, Japanese farmers were transplanting by hands in their long history. However, now almost all seedlings are transplanted by machine, and only five percent done still by hands. Direct seeding methods occupy only 0.6%.

APPLICATION OF HERBICIDES: TIMES AND SCHEDULE

Before 1949 all weeding had been done by man power itself. At present the paddy field are treated by herbicide at least one time. The number of application of herbicides is as follows: one time 17.5%, two times 63.6% and three and four 18.9% in 1982, showing that the two times application is dominant.

Application dates are devided into three: early one is done before or just after the transplanting, the middle 10 days or two weeks after transplanting, and later one 20 to 30 days after the transplanting or later mainly to control the broad leaved weeds.

Fig. 1 shows the historical changes of weeding schedule for transplanted rice.

In early 1950's three time puddings, an intertillage, two time hand weedings and 2,4-D application followed by one more handweeding were habitual practice. In early 1960's PCP was introduced to control barnyardgrass (*Echinochloa oryzicola* Vassing # ECHOR) (Letters following this symbol are WSSA/WSSJ. approved computer code from "Important Weeds of the World" published by the Agrochemical Division of Bayer AG, Leverkusen, F. R. Germany.) just after transplanting and followed by phenoxy herbicides (2,4-D or MCPA) application. In early 1970's many herbicides were introduced into the market and serial or sequential application systems of herbicides were established. From later 1970's to early 1980's, this decade, application before transplanting was added into serial application system. Now so-called "one shot application" is being recommended.

ONE SHOT APPLICATION OF HERBICIDES

The serial or sequential application systems of two, three or even four herbicides have a very firm weeding efficacy, while they also have adverse effects such as increase in application labour, costs of herbicides and environmental effects. Then the one shot application is now being recommended.

Table 1 shows several examples of herbicide combinations for one shot application. They should have both wide weed control spectrum and relatively longer residual activity. In 1986, one shot applications were done in about 870 thousands ha.

Table 2 shows the answers from 665 extension workers for a questionaire about "one shot application" which was collected in 1982 by Japan Association for Advancement of Phyto-Regulators (JAPR or Shokucho). At the item (2), reasons for YES-answer, labour saving and economic reasons were dominant as the advantages of one shot application. At the item (5), in practice, the extension workers understood that 38% and 5% needs one more or other application, respectively. This is not a true one shot application. And as shown in item (4) the possible area for one shot application may be assumed

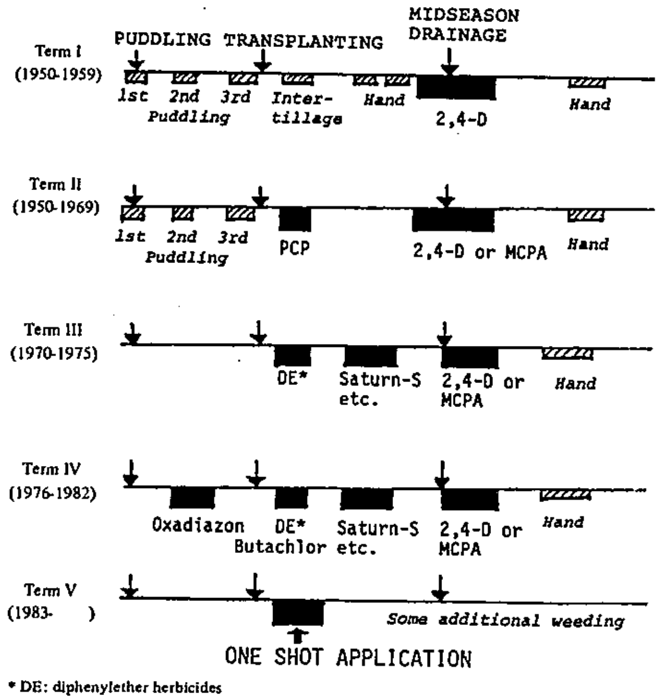

Fig. 1. Changes in weeding schedule for transplanted rice from 1950 in Japan.

Table 1. Herbicides for "One Shot" application.

	Trade name		Component	Applied area in 1986 (1000ha)
(1)	Kusakarin	25G 35G	Pyrazolate (6.0) + Butachlor (2.5) Pyrazolate (8.0) + Butachlor (3.5)	557
(2)	One All	G 8G	Pyrazoxyfen (6.0) + Pretilachlor (1.5) Pyrazoxyfen (8.0) + Pretilachlor (1.5)	115
(3)	Ohza G		Naproanilide (7.0) + Butachlor (3.5)	93
(4)	Kusahope G		Pyrazolate (6.0) + Pretilachlor (1.5)	59
(5)	Wider G		Bentazon (10.0) + Piperophos (4.4) + Dimetnametryn (1.1)	22
(6)	Yohtol G		Naproanilide (7.0) + Pretilachlor (2.0)	18
(7)	Shirubenon	G	Thiobencarb (7.0) + Pyrazolate (7.0)	7
	Total			871 (37%)

Table 2. Answers from 665 extension workers for a questionaire about "One Shot" application of herbicide for transplanted rice.

(1)		Farmers will use	97%	(4)		Possible Area	
		not use	3%			1.2 Million ha	
						(58%)	
(2)		Reasons for YES					
	(a)	Labor-saving	96%	(5)		In Practice	
	(b)	Environmental	5		(a)	Only One Shot	58%
	(c)	Economic	26		(b)	One More Application	38
	(d)	Others	3		(c)	Others	
(3)		Reasons for NO					
	(a)	Soil & Water Managements	8%				
	(b)	Less Perennial Weeds	14				
	(c)	Serial Application is better	36				
	(d)	Herbicide Cost	36				
	(e)	Others	21				

to be 1.2 million ha corresponding to 58% of total acreage of rice cultivation in Japan.

APPLICATION TYPES OF HERBICIDES

From another viewpoint, Fig. 2 shows the changes in the treated areas by different types of herbicides and in the cultivated areas. The black lower part shows the early or soil application under flooded condition. Small spotted part shows the middle or folilar and soil application also under flooded condition. Top vertical striped part shows later or foliar application mainly to broad leaves control. White part means post harvesting treatment with paraquat to control the regrown weeds. White circles show the cultivated paddy areas, then this figure means that, after 1975, at least two time applications of herbicides have been done in average in Japan.

CHANGES IN THE USE OF INDIVIDUAL HERBICIDES DURING 40 YEARS

Phenoxy and foliar application herbicides As shown in Fig. 3, 2,4-D and MCPA began to be used in 1950 and 1954, respectively. From 1960 until 1975 the acreages of 2,4-D and MCPA utilization were around 600 and 300 thousands ha, respectively, and after then both went down to 200 thousands ha. 2,4-D is suitable to the southern areas and MCPA the northern.

From 1975 bentazon was marketed and used in 100 thousands ha to control the perennial weeds, and now the granule form is applied under drained or shallow water conditions to make the activity stable. The 2,4-D-aminotriazole mixture formulation had been used for ten years from 1966 to control slender spikerush (*Eleocharis acicularis* R. et S. var. *longiseta* Svenson # ELOAL), however this herbicide has been replaced with other new herbicides effective to this weed.

Soil application herbicides in early stage Soil application, that is early application just before or after transplantation, was initiated by PCP in 1959, followed by PCP combinations and diphenylethers with lower fish toxicity. From early 1970's, oxadiazon, thiocarbamates (thiobencarb and molinate), butachlor and pyrazolate appeared in the market.

PCP and its combination with other herbicides (Fig. 4) In later 1940's PCP was tested to control a shell-fish, *Katayama nosphora*, a carrier of a human pathogene *Schistosoma japonicum*, in paddy fields by a help of the Allied Occupation Forces. and the same time it was found to be effective to barnyard-grass which could not be controlled by 2,4-D. The improvement of the formulation of PCP into granular one made it so safe to rice as described later. Then from 1962 PCP mixture with allyl ester of MCPA and MCPB were used, the former showed half million ha share in the northern areas. However in 1962 after a heavy rain, the PCP flooded out from paddy fields to shallow lakes or seas, showed a very severe toxicity to fish and shell-fish. Then the usage went to down suddenly. After 1977 PCP use in aquatic area was prohibited.

Low fish toxicity herbicides (Fig. 5) As the alternatives of PCP herbicides, in 1963 MCPCA [2'-chloro-2-(4-chloro-*o*-tolyloxy) acetanilide] and nitrofen were registered, and then chlornitrofen, chlornitrofen-MCPA combination, chlomethoxynil, and chlornitrofen-dymron combination followed to them. Nitrofen became not only to be the pioneer of low fish toxicity herbicides but also opened a new area of mode of herbicidal action. Now the mode of action of diphenylethers or related herbicides including oxadiazou or chlorophthalim [*N*-(s-chlorophenyl)-3, 4, 5, 6-tetrahydrophthalamide] are being

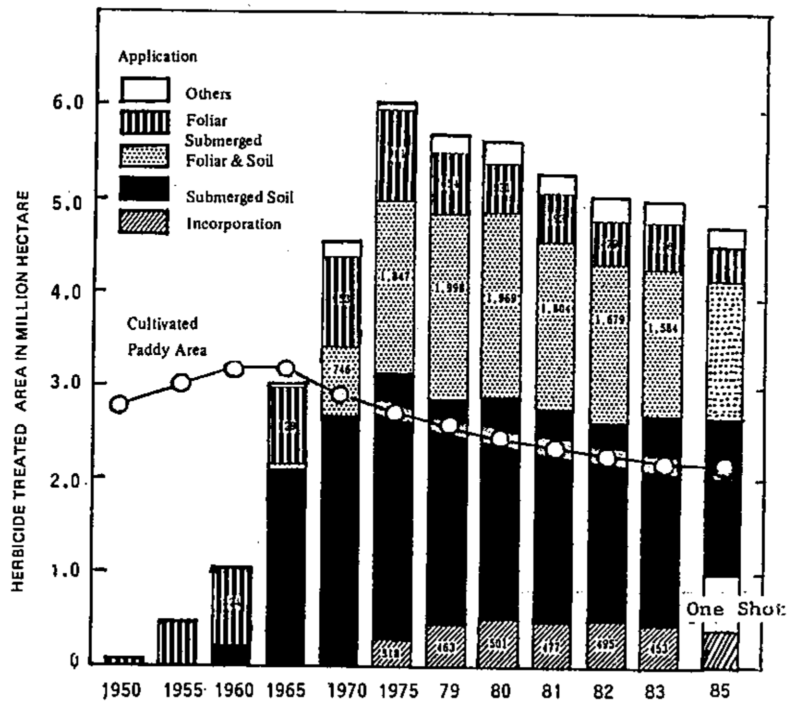

Fig. 2. Changes in herbicide-treated area of paddy field in Japan.

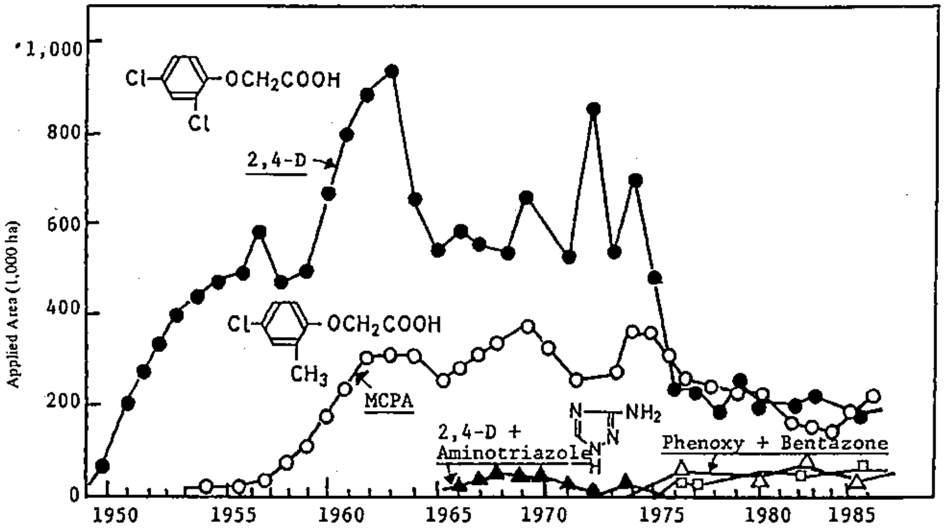

Fig. 3. Applied area of foliar application herbicides.

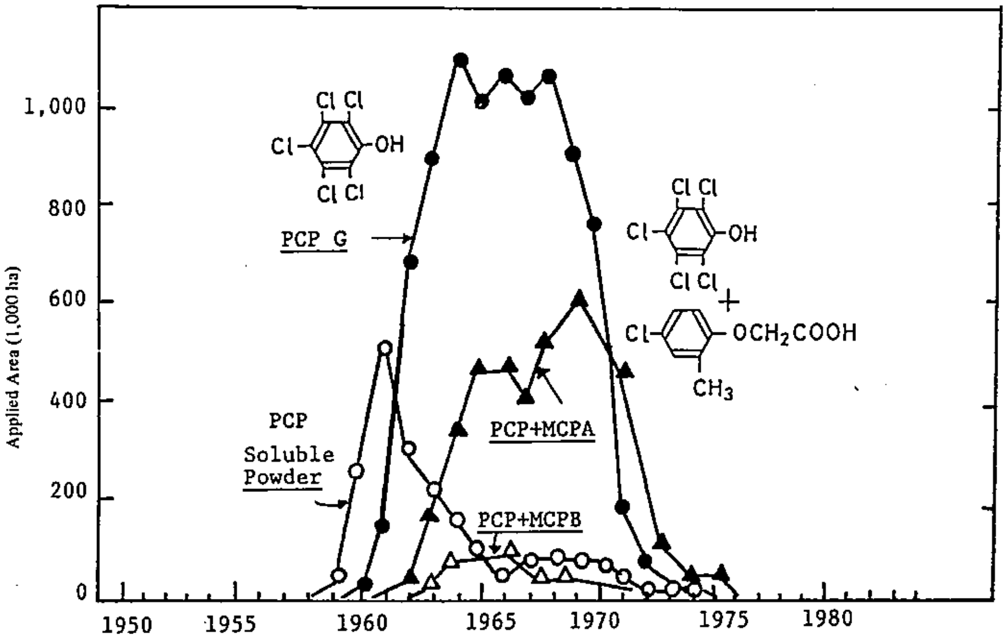

Fig. 4. Applied area of soil application herbicides (PCP and its mixtures).

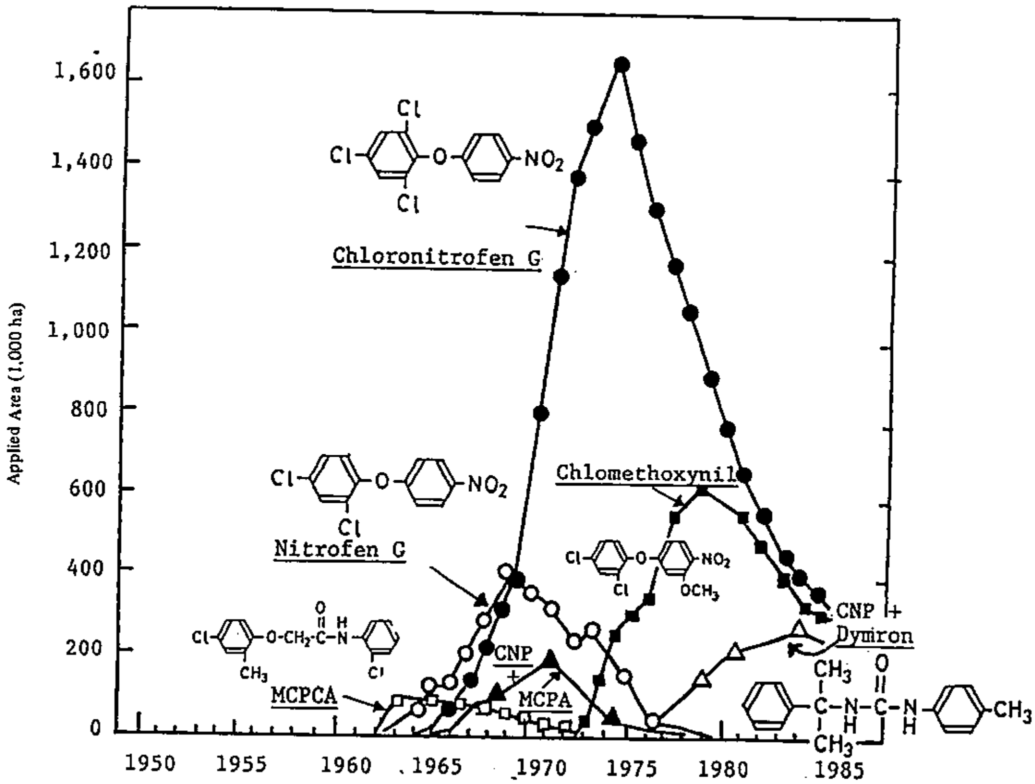

Fig. 5. Application area of soil application herbicides with low fish-toxicity.

surveyed at least eight laboratories all over the world. These compounds required for light to kill weeds and show no activities under the dark condition, and cause the peroxidation of the membrane of important organella of weeds.

Chlornitrofen granule in 1974 reached to be used in 1.65 million ha, which showed the maximum acreage as a single herbicide formulation, but gradually replaced with newly developed ones. Chlornitrofen-dymron combined granule is effective also to sedges, then is keeping 250 thousands ha share.

Soil incorporation herbicides Although oxadiazon granule showed some toxicity to transplanted rice, the improvement of the formulation into emulsifiable concentrate (EC) and the change of the application method made it very effective and safe in the early stage application. Oxadiazon EC can be applied directly to the muddy water just after puddlings from three small holes of Coca-Cola type bottle by hand. The herbicide may be absorbed with suspending soil particles which sunk down later upon the soil surface to make thin herbicide-soil layer. The herbicide in the layer attacks just emerged weeds very effectively, then the share showed about half million ha during the latter half of 1970's (Fig. 6). From 1981 the use of oxadiazon-butachlor mixture effective also to sedges increased and it is replacing the share of oxadiazon itself.

Other early stage herbicides The intensive use of PCP or chlornitrofen caused the succession of weeds from the annuals to the perennials, then from early 1970's effective soil application herbicides began to be used. These are shown in Fig. 7. Thiobencarb-chlornitrofen mixture was effective to slender spikerush, but showed lower activity to urikawa (*Sagittaria pygmaea* Miq. # SAGPY), then their use decreased gradually from 1980.

Butachlor, which is a dominant herbicide in Korea now, appeared in the market in 1973 in Japan and gradually increased its share because this herbicide is effective not only annual weeds but also perennial sedges such as Japanese bulrush [*Scirpus juncoides* Roxb. var. *hotarui* (Ohwi) T. Koyama # SCPJU] and safe to transplanted rice especially in the lower temperature zone. In 1984 its share became 600 thousands ha.

Pretilachlor, which structure and efficacy are resemble to butachlor, began to be marketed in 1984 and is increasing its share.

Pyrazolate granule showed nice efficacy to both annual and perennial weeds, especially to *S. pigmaea*, in the southern areas from 1980, and is used safely in water-seeding culture into the soil with CaO_2-coated rice seeds.

Above described one shot application herbicides may belong to this group. These herbicides are granules consisting of two or three active ingredient as shown in Table 1.

Folilar and soil treatment herbicides under submerged condition This category is a special one which applied under submerged or flooded condition. When the weeds became to be somewhat adults ten days to two weeks after transplantation, the herbicides of this type can attack both the weed shoots in the water and just emerging weed buds from the soils.

Swep-MCPA combined granule (SWEP-M) appeared in the market in 1969 as a herbicide formulation of this type at first, followed by the mixture of thiobencarb-simetryn (Saturn-S) in 1970 and molinate-simetryn (Mamet) in 1972. Since swep-MCPA caused some injury by organo-phosphorous and carbamate insecticides because of the inhibition of swep detoxification enzyme which is the same as propanil-hydrolyzing enzyme (rice aryl acylamidase I, EC 3.5.1.13), its application became to be limited in the northern areas in Japan (Fig. 8).

The share of thiobencarb-simetryn mixture reached to 1.36 million ha at once in 1974, but became to be replaced with thiobencarb-chlornitrofen mixture because of the rice injury caused by abnormally absorbed simetryn under high temperature which will be explained later.

In 1970's other perennial weeds succesion than slender spikerush became very severe, then in order to encounter this problem new herbicides were searched for.

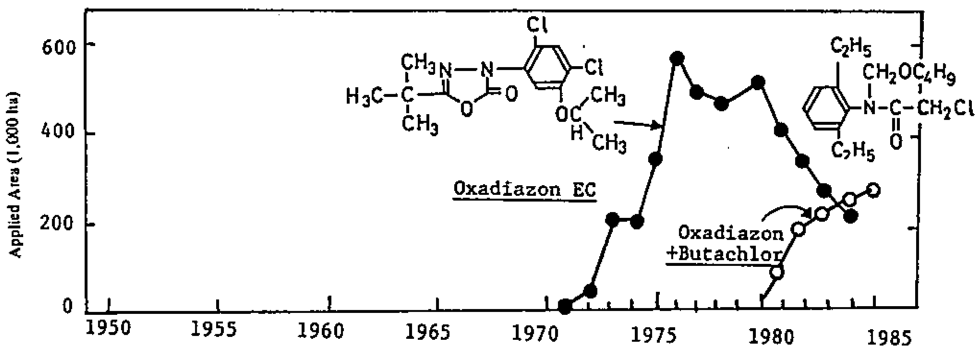

Fig. 6. Applied area of soil incorporation herbicides.

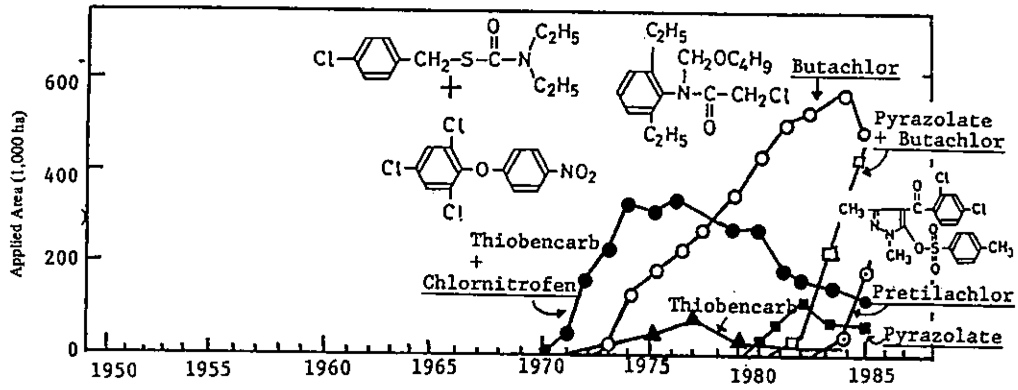

Fig. 7. Applied area of soil application herbicides (Thiocarbamates and others).

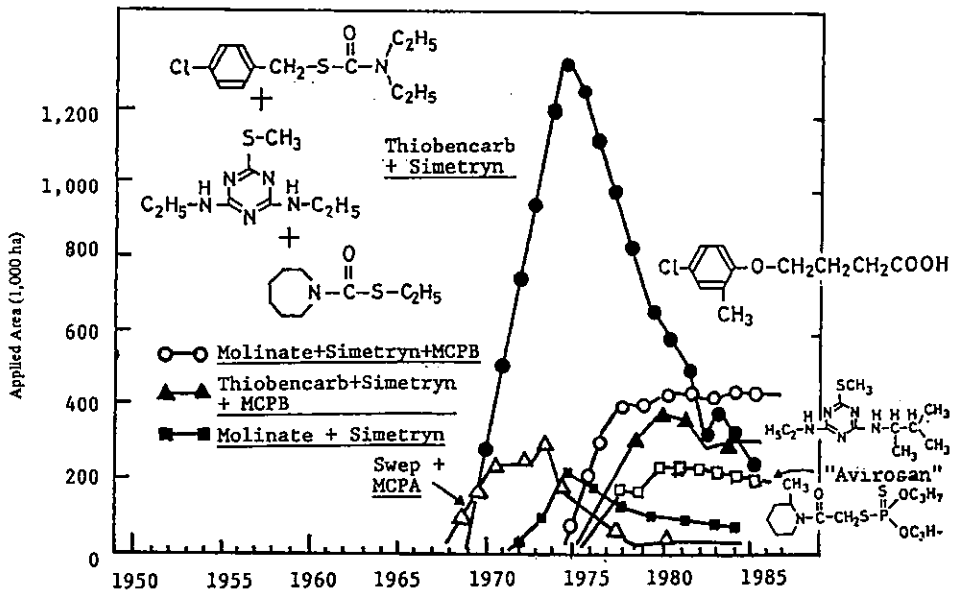

Fig. 8. Applied area of foliar and soil application herbicides.

In 1975, molinate-simetryn-MCPB mixture (Mamet-SM) was marketed, and followed by thiobencarb-simetryn-MCPB (Kumilead-SM) in 1976. Both herbicide formulations reached a share of 400 thousands ha, respectively, and are keeping large share still now. During these wider uses, molinate caused the carp toxicity problem, and thiobencarb did the dwarfing of rice plants. Both problems will be explained in the next parts.

Dimethametryn-piperophos mixture (Avirosan) was marketed in 1976, and keeping the share of 200 thousands ha share in the northern areas without no problems showing nice efficacy to Japanese bulrush.

Table 3 shows main herbicides in rice culture in 1985 in Japan.

Table 3. Main herbicides for rice culture in Japan (1985).

Components	Trade name	Treated Area (1,000 ha)	
Incorporation		421	
Oxadiazon + Butachlor	Delcut EC		255
Oxadiazon	Ronstar EC		166
One shot application		579	
Pyrazolate + Butachlor	Kusakarin G		474
Naproanilide + Butachlor	Ohza G		105
Soil application		1,686	
Butachlor	Machete G		444
Chlornitrofein	NO G		340
Chlomethoxnil	X-Gohni G		311
Chlornitrofen + Dymron	Shohron-M G		236
Pretilachlor	Solnet G		173
Thiobencarb + Chlornitrofen	Saturn-M G		110
Pyrazolate	Sunbird G		72
Submerged foliar & soil appln.		1,302	
Molinate + Simetryn 3 MCPB	Mamet-SM G		426
Thiobencarb + Simetryn + MCPB	Kumilead-SM G		292
Thiobencarb + Simetryn	Saturn-S G		241
Piperophos + Dimethametryn	Avirosan G		191
Molinate + Simetryn	Mamet G		60
Simetryn + Phenothiol	Grakinl G		53
Bentazon	Basagran G		39
Foliar application		206	
MCPB G			137
2, 4-D G			69

At present, along with severe competition each other a lot of new herbicides have appeared in the test or in the market. Here we can find out the second generations of the classical herbicides as follows: pretilachlor to butachlor, bifenox to chlomethoxynil, pyrazoxyfen and benzofenap to pyrazolate, dimepiperate and isopropylate to thiobencarb and molinate, and NC-311 to bensulfuron methyl.

As the completely new rice herbicides, we can cite mefenacet, bromobutide and chlomeprop. These new herbicides make their combinations, the number of which can be counted as like as bensulfuron methyl 8, pyrazolate 5, pyrazoxyfen 3, mefenacet 5, and bromobutide 4. It will be so complicated one to select the most suitable herbicide formulation by farmers to apply it to their paddy field.

PROBLEMS OCCURRED DURING THESE 40 YEARS AND THEIR SOLUTIONS

During these history, as shown in Table 4, there occurred several problems, and they were solved by researches and technical improvements, respectively.

Table 4. Problems and solutions in herbicides use in Japan.

	Herbicide	Problems	Solutions
(1)	2,4-D	Drift injury to mulberry tree and others	Ester-granular form and submerged application
(2)	PCP	Selectivity	Granular formulation
(3)	PCP	Fish toxicity	New herbicides
(4)	Simetryn	Rice injury under high temperature after long rainy days	Replacement with chlornitrofen
(5)	Thiobencarb	Dechlorination	Safeners (Inhibition) of dechlorination)
(6)	Molinate	Toxicity to Japanese carp	Area limitation
(7)	Thiocarba-mates	Distillation with paddy water and injury to vegetables	Caution to farmers with technical advice
(8)	Early herbi-cides	Selectivity to short and young seedling for machine transplanting	More selective herbicides or safeners

The first one was the adverse effect by the drift of phenoxyherbicides on broad-leaved crop plants, especially mulberry trees near to paddy fields. This problem was solved by making them granular formulation of ethyl esters and using them under the flooding or submerged condition.

The second trouble was the injury of PCP on transplanted rice. As described above during the course of chemical control test of schistosomiasis carrier shell-fish, PCP was found to kill barnyardgrass. However the solution of PCP-Na applied to paddy field showed some extent of injury to rice plants. This problem was solved by making PCP granular form and using them in the afternoon when there found no water on rice leaves. This selective use was the beginning of utilization of granules in flooded paddy fields to make them selective with location difference mechanism.

The third one was the fish toxocity of PCP. The expanded use of PCP was found in early 1960's as shown in Fig. 4, and when a heavy rain fall came. A lot of soil particles absorbing PCP was flowed out of paddy field and went to lakes and seas, where they were shallow, PCP attacked fish and shell-fish. This is found to come from the common mode of action, the uncoupling of oxidative phosphorylation of both weeds and fish. Then although some derivatives of PCP were synthesized and tested both herbicidal activity to barnyardgrass and fish toxicity, the both activities were found to be parallel, the more effective to the weeds the more toxic to fish. Then the use of PCP was abandoned.

During this one decade of 1960's, the farmers were so accustomed to use the herbicide PCP to control barnyardgrass, the development of new alternative herbicides became to be urgent. At that time the developing ability of Japanese industry were raising up, then several alternatives with low fish toxicity had been timely developed and registered. They were nitrofen, MCPCA, chlornitrofen (CNP), dichlobenil (DBN), chlothiamid (DCBN), and propanil (DCPA). Among them only chlornitrofen survived in the large use until present time.

The fourth problem was the rice injury by simetryn. After the introduction of thiobencarb-simetryn mixture in 1970, simetryn showed rice injury under the high temperature following to the long rainy days in Kyushu area, the southern part of Japan, in 1971. It was caused by abnormal absorption of simetryn accompanied by active transpiration under such high temperature. This problem was solved by the alternation from such combination to thiobencarb-chlornitrofen mixture (Saturn-M).

The fifth problem was the dechlorination of thiobencarb. After the wide use of this herbicide some extent of dwarfing injury of transplanted rice plants became to be found in the limited area around in 1975. This phenomenon was surveyed and found to come from the dechlorinated thiobencarb produced by special microorganism(s) under so reduced soil condition with heavy application of organic matters, especially the rice straws. The straws had been produced in paddy fields by the utilization of small combine machine for harvesting.

The scientists of Kumiai Chemical Industries were urged to search the counter measure to solve this problems, and after the efficacy tests of combined formulation of thiobencarb with other herbicides, methoxyphenone (Fig. 9) was found to decrease the dwarfing injury of rice plants. It became clear that methoxyphenone prevents the dechlorination of thiobencarb even under the above-mentioned special condition. Then, in two years both in 1982 and 1983, the combined formulation of thiobencarb with methoxyphenone was practically utilized in such special areas. And an active search work for such chemicals having the inhibitory activity of dechlorination as methoxyphenone, that is a kind of herbicide safener, was initiated; and a new safener, 4-bromophenyl chlormethyl sulfone (BCS, Fig. 9) was found. Now the latter safener, BCS, seems to be combined with thiobencarb herbicides to prevent the dechlorination. If that is true, BCS is assumed to be one of the big safeners for herbicides under practical use all over the world, and this developing ability should be evaluated so much. Now no dwarfing problem is reported in Japan.

The sixth one is the effect of molinate on carp fish. Cultivated Japanese carp was found to suffer from anemia, that is the shortage of blood, by the escaped molinate from paddy fields. This problem was solved by the limitation of using area of this herbicide.

After the wide use of both thiocarbamates, thiobencarb and molinate, distillated herbicide component with paddy water under high temperature caused damage on vegetables next to the treated paddy fields. Since this phenomenon was found to be limited to small basin under the conditions of high temperature and no wind, such caution with technical information to the farmers solved this seventh problem.

The eighth one was related to the young seedlings which used in the machine transplanting. As described above, when the transplanting of rice seedlings became mechanical one, the leaf stage of seedlings became to be younger. This meant the increase of the susceptibility of the seedlings to the herbicides. Then more selective herbicides have been developed to solve this problem.

Sometimes so sophisticated technology may be applied as shown as follows: One of the most novel herbicides registered for rice cultivation in Japan is bensulfuron-methyl (Londax) (Fig. 10). This herbicide has the useful properties of sulfonylureas, both extremely low dosage and lower toxicity to animals. Although bensulfuron-methyl is fundamentally a selective herbicide for rice plants, under excess dosage or special condition it shows some slight injury to the plant. Usually rice plants are tolerant to this herbicide by the detoxification mechanism. It is *O*-demethylation on pyrimidin ring, probably by monooxygenase system. And this detoxification process can be intensified by the co-existence of thiocarbamates such as thiobencarb, dimepiperate (MY-93), isopropylate (CH-83) or SC-2957). These thiocarbamates make the weed control spectrum wider and become a kind of safener to bensulfuron-methyl.

From above-described experiences as to the problems and solutions, we have learned many valuable lessons to which a great amount of tuition fees had been paid. And these experiences should be reused in the future and the problems should not be repeated any more.

ECONOMICAL ANALYSIS OF HERBICIDES USE IN RICE CULTURE IN JAPAN

Fig. 11 shows the historical changes in the average labour hours per ha in rice culture in Japan. The total labour hours became about 28% of that in 1949 during these 35 years. The results of labour saving effects are very significant mainly by mechanization in each technical process and herbicide use in weeding. Even though there found such significant labour saving, rice grain yield increased from three tons per ha to five.

In weeding, it was initiated by the introduction of herbicides.

The cost relating to weeding may be calculated as follows:

Income in handweeding = YP - LW; Income in chemical weeding = Y'P - (C + SW); Benefit in chemical weeding than handweedings = (L - S) W - C - (Y - Y') P.

Here, Y = grain yield in handweeding (ton/ha); P = price of brown rice (US $/ton); L = labour in handweeding (hr/ha); W = wage (US $/hr); Y' = grain yield in chemical weeding (ton/ha); C =

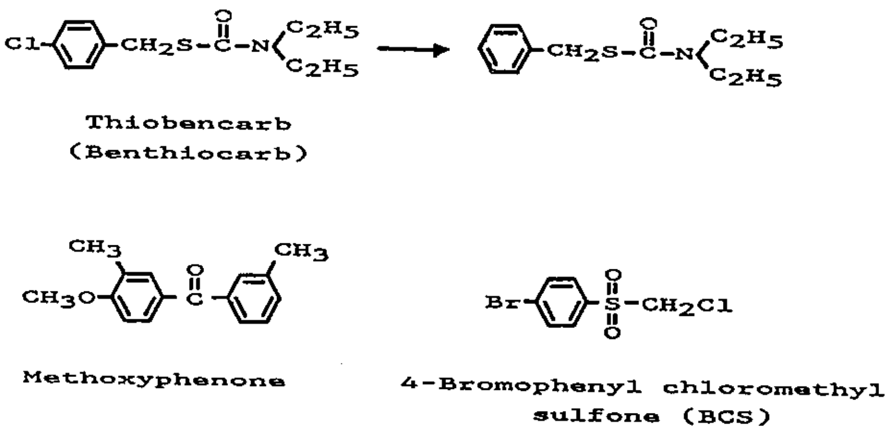

Fig 9. Dechlornation of thiobencarb and its safeners.

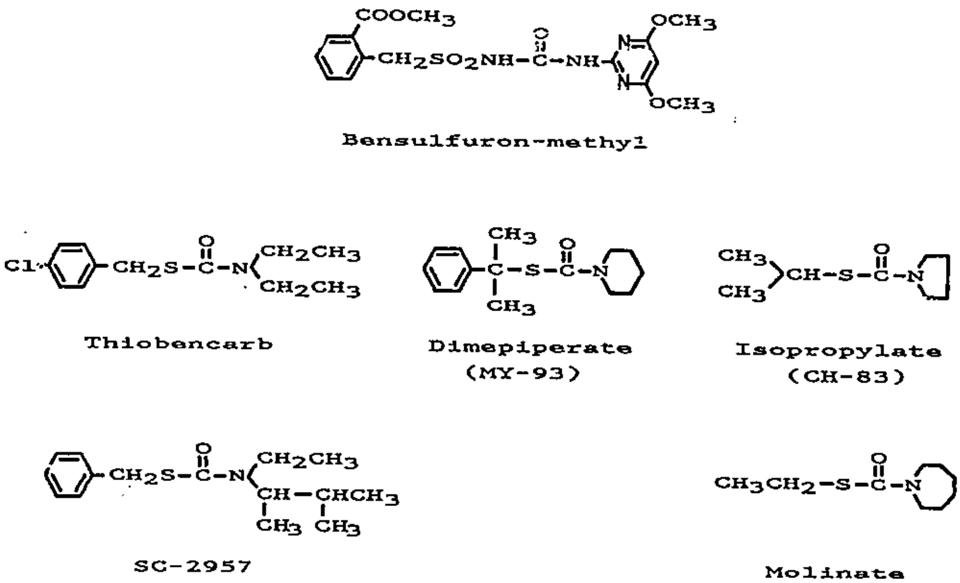

Fig. 10. Besulfuron-methyl and its safeners.

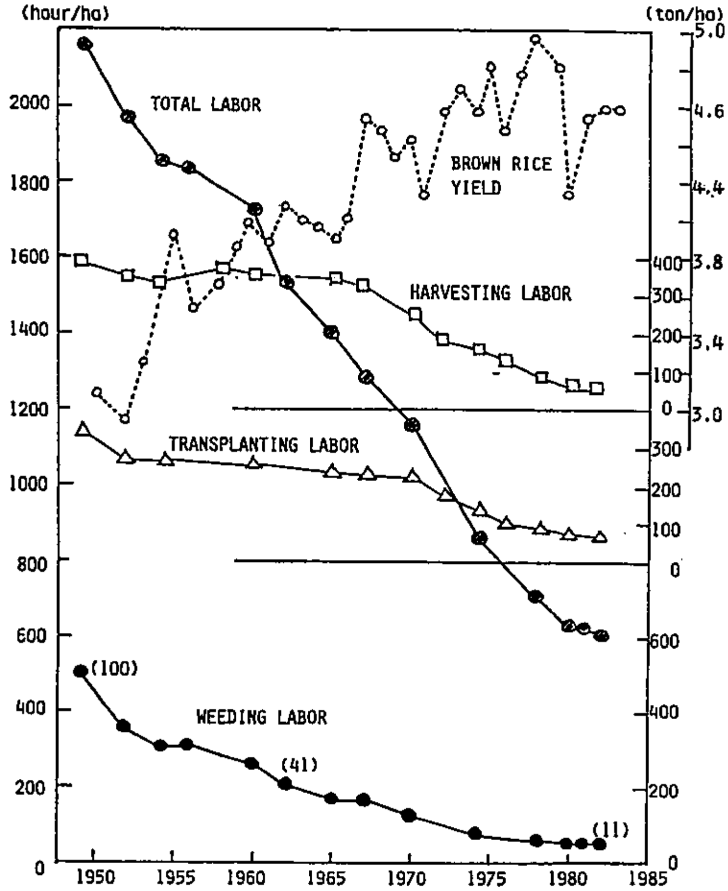

Fig. 11. Changes in labor times for rice culture and brown rice yields.

price of herbicides (US $/ha); S = herbicide application labour (hr/ha).
Usually present herbicides have almost no effect on grain yields, then (Y - Y') seems to be zero. Here the benefit in chemical weeding will correspond only to (L -S) W - C. If L will be large and S and C are small, respectively, the benefit will become to be large.

If we try to use the actual average values in 1984 as like as follows, practical benefit can be calculated: L = 506 hr/ha (in 1949 without any herbicide), S = 47 hr/ha (in 1984), W = US $ 6.4 (Yen 960), C = US $ 200 (Yen 30,000). The benefit (L-S) W-C can be accounted to be US $ 2,737 per ha. Then in total in Japan, it reaches to 6.27 billion U.S. dollars for 2.29 million ha.

Now the policy as to rice production and price which have been supported by the government, that is by tax, is going to be changed by the international agricultural situation. Then it is assessed that the use and market of herbicide will have somewhat different status from the past history.

Anyhow herbicides brought a great benefit to rice cultivation not only from the monetary standpoints but also the liberation from the inhumanitic physical and mental pains of farmers during serious labours of weeding in hot, humid and muddy paddy fields. On the other hand a great deal of care have been paid on the environmental effects of herbicides and this should be continued in future.

These history has been established in Japan by the nice cooperative efforts mainly by the persons belonging to the following organization and the related international ones:

Ministry of Agriculture, Forestry and Fishery, Local Governmental Experimental Station and Extension

Workers Bureau, Universities, The Weed Science Society of Japan and other Societies, The Japan Association for Advancement of Phyto-Regulators and Herbicide Industries.

ACKNOWLEDGEMENTS

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FOOD PRODUCTION, PESTICIDE USES, AND ADJUVANTS CONTRIBUTION IN DEVELOPING COUNTRIES

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ABSTRACT

A growing world population demands an increased food supply. Increased food production requires effective crop management and protection. Agrochemicals have a critical role in protection. Pesticides have played an important part in promotion of crop production, in minimization of crop losses, and in reduction of crop production costs. However, due to environmental concerns about pesticides and rising costs of pesticides, research on the use of adjuvants to reduce pesticide requirements, while attaining good pest control is of tremendous importance, especially in developing countries.

WORLD OVER–POPULATION AND LOSS OF ARABLE LAND

Our world is undergoing a population explosion! On July 11, 1987 (6:35 PM, CDT), the world population reached a level of 5 billion (see a picture of a new-born baby in Yugoslavia). The United Nations population fund estimates that the world population is growing at about 150 per minute or 220,000 a day. The fund is attempting to draw world attention to the growth in global population, which will reach 6 billion by the year 2000. If we use the population in 1970 as a basis, it can be seen (Table 1) that the population of the developed countries has increased by 8% by 1980, but the population of developing countries increased by 24%, three times the percentage increases of the developed countries. More people will live in Asia by the year 2000 than in all other developing regions combined. This is a great challenge to the public and governments!

Table 1. World population (million).

Region	1970	1975	1980	1990	2000[1]
Developing countries					
Population	2,623	2,945	3,252	4,027	4,874
Index	100	112	124	154	186
Developed countries					
Population	1,073	1,124	1,163	1,248	1,325
Index	100	105	108	116	123

Source: FAO–GIFAD Bulletin, Vol. 12, No. 2, March/April, 1986.
[1] Estimated

The population distribution between the developing and developed countries leads to uneven distribution of arable land (Table 2). An agricultural worker in the Far East owns only 0.94 hectares of land, but in North America, a worker has 92.3 hectares, approximately 100 times more land for farming. Less land per capita for farming means less food production per family resulting in lower income, lower living standards, and lower social benefits.

Table 2. Arable land per agriculture worker, 1984.

Region	Far East	Africa	Latin America	Western Europe	E. Europe & USSR	North America	Oceania
Hectare	0.94	1.5	4.5	6.1	7.7	92.3	104.0

Source: FAO – World Food Report, 1984.

CROP YIELD AND LOSSES

People should appreciate the improved agricultural technology, practices, and policies in the use of modern agriculture. The world's farmers produced twice as much food in 1980 as they did in 1950. However, per capita food production in the developing countries increased little in the past decades (3).

Not only do the agricultural workers in the developing countries produce less food per family on a limited land base, but also a high percentage of their crops is lost or damaged in the field or during transportation and storage. Adam (1) estimated that the average losses of rice, small grains, and cotton were approximately 20 to 30% of crop yield, and vegetables and fruits are subject to a 40 to 60% loss. The Food and Agricultural Organization (FAO) of the UN has estimated that about 40% of the annual harvest in the developing countries is lost to weeds, diseases, and insects (Table 3). When post harvest losses of 10 to 20% are added, more than one-half of crops produced may be lost.

Table 3. Worldwide harvest losses in 5 major crops.

Crop	Potential harvest (1000 T)	Harvest 1978 (1000 T)	Losses through Weeds (%)	Diseases (%)	Insects (%)	Total (%)
Rice	716,000	379,000	10.6	9.0	27.5	47.1
Corn	563,000	363,000	13.0	9.6	13.0	35.6
Wheat	578,000	437,000	9.8	9.5	5.1	24.4
Sugarcane	1,603,000	738,000	15.1	19.4	19.5	54.0
Cotton	63,000	42,000	5.8	12.1	16.0	33.9
Total	–	–	10.9	11.9	16.2	39.0

Source: FAO – GIFAO Bulletin, Vol. 12, No. 2, March/April, 1986.

THE ENVIRONMENTAL INPUT ON CROP LOSS

In the Asia-Pacific region, most countries have abundant rainfall, high temperature, and a long growing season. Such environmental conditions encourage the development of lush weed growth, insect pests, and diseases which threaten crop production. Intensive agriculture practices such as multiple cropping and dense crop stands aggravate the problem. Therefore, farmers have to use all possible means to reduce or minimize crop losses. However, labor for handweeding in some developing countries is no longer available as the rural population moves to industrial centres in search of higher paying jobs. These factors combine to create serious problems in effective pest control in developing countries. Thus, farmers have to use other means to combat pests. One of the effective means is the use of chemical methods. The chemical sciences, including agro-chemistry, has had a strong role in increasing the amount of food production (3).

PESTICIDE USAGE AND CROP PROTECTION

The volume of chemicals used in crop protection varies considerably from one country to another. The leading country, Japan uses 1233 g/ha, while the Philippines uses only 27 g/ha (Table 4). Pecticide use in Taiwan is approximately equal to that of Korea.

Table 4. Crop protection chemicals used in the Far East countries.

Countries	Japan	Korea	Sri Lanka	India	Phillippine
g/ha[1]	1,233	214	145	50	27

Source: Adam, A.V., 1976 (1).
1 Total quantities used/total area treated.

Table 5. World pesticide market.

		Product		
Herbicides	42%		Insecticides	34%
Fungicides	19		Others	5
		Region		
USA & Canada	30%		Europe	23%
Japan & Far East	19		Rest	28

Source: FAO – Plant, Production and Protection, 1982.

When the dollar value of crop protection chemicals used commercially is compared, herbicides control 42% of the market, insecticides 34%, and fungicides 19%. By region, North America shared 30%, Europe 23%, and Japan plus Far East 19% of the market, respectively.

The 10 leading countries spent about $5.26 billion annually on herbicides to control weeds in crops, forestry, and industrial or road areas (Table 6).

Table 6. Herbicide market shared by 10 leading countries.

Country	Dollar, billion (US)	Country	Dollar, billion (US)
USA	2.41	UK	0.22
France	0.41	W. Germany	0.21
Brazil	0.32	Italy	0.10
Japan	0.30	Australia	0.10
Canada	0.24	S. Africa	0.70
	Total $5.26 billion		

Source: Eue, L., 1985 (6).

LIMITATION OF PESTICIDE USAGE

Adam (1) pointed out that the volume of crop protection chemicals used by countries varied considerably (Table 4). The following factors may be associated with the limited use of chemicals:

1. Crop protection chemicals are expensive. High costs arise from the great expense of synthesizing, discovering, testing, and evaluating new chemicals to determine their efficacy, as well as safety to humans, animals, and the environment. These developmental costs have been estimated to average over $40 million per pesticide. Chemical manufacturers certainly take this into account when developing and marketing the pesticides. Only those pesticides suitable for large market justify the investment.
2. Some pesticides are very costly because they are only required for a small, spceific market. Therefore, the unit cost of production and marketing is high.
3. Farmers do not receive adequate training and education in the effective use of pesticides.
4. Continuous cropping sytems in the sub- or tropical regions require large usage of pesticides which can induce pest tolerance or resistance to the pesticides, reducing their effectiveness.
5. Psychological barriers, fears of unwanted side effects, and under-employment of the population (2) may also be involved.

IMPACT ON THE ENVIRONMENT

Excessive, indiscriminate, or frequent uses of pesticides throughout the year can have an undesirable impact on the environment, and increase pesticides residues in agricultural products. Rules for the safe use of pesticides are often ignored. This is a common and serious problem in some developing countries.

ADJUVANT CONTRIBUTION

Use of adjuvants as a method of reducing the number and rate of pesticide application, while still attaining satisfactory control of pesticides, is worth investigating. Surfactants, one type of adjuvants, were not used much with herbicides before the early 1960's. Before then, about their only use was as nonselective sprays around industrial sites and along right-of-ways (7). The widespread use of diuron and triazine with corn oil containing Atplus in the USA, and the successful application of diclofop-methyl (Hoe-Grass, Hoelon), BAS 9021 and sethoxydim (BAS 9052, Poast) for grass weed control in Canada (Table 7), promoted a rapid increase in the use of adjuvants (4, 10). Worldwide research has also demonstrated that the addition of appropriate adjuvants, either in developing products or in the spray solutions prior to application, has allowed a reduction in the rate of pesticides required for effective control.

Some adjuvants improved the effectiveness of herbicides due to their greater retention and quicker penetration which counteracted reduced herbicide performance by rainfall (9). This is of particular importance in tropical regions where rain frequently occurs during and after application.

Table 7. Effect of adjuvants on the herbicides for wild oat control and crop tolerance.

Treatment	Shoots (g/pot)[1,2]	
	Wild oat	Crop[3]
Experiment I		
Untreated check	4.9 a	5.1 a
Corn oil containing Atplus (I), 0.5%	5.1 a	5.0 a
Diclofop-methyl, 1.12 kg/ha	3.0 b	5.3 a
Diclofop-methyl, 1.12 kg/ha + (I), 0.5%	0.9 c	5.2 a
Experiment II		
Untreated check	17.4 a	36.6 a
BAS 9021, 0.7 kg/ha	11.5 b	38.5 a
BAS 9021, 0.7 kg/ha + Citowett, 0.5%	10.9 b	40.1 a
BAS 9021, 0.7 kg/ha + Renex-36, 0.5%	6.4 c	37.2 a
BAS 9021, 0.7 kg/ha + Atplus, 0.5%	1.2 d	39.9 a

[1] Dry wt. in Experiment I and fresh wt. in II, respectively.
[2] Values significantly different within the column in each experiment followed by the different letters.
[3] Wheat in Experiment I and rapeseed in II, respectively.

ECONOMIC BENEFIT/COST OF ADJUVANTS

In general, farmers in developing countries are reluctant to use effective, costly pesticides which are generally not manufactured locally. As discussed, appropriate adjuvants can be used to reduce the application rates of pesticides. This is an appropriate approach to reducing the cost of pesticide application, since a small amount (0.5% of the spray volume) of relatively inexpensive adjuvant added to the formulated herbicides or the spray solution can reduced the amount of costly pesticide required, and consequently the cost of pest control can be substantially lowered (Table 8).

Table 9 indicated that when weeds were controlled with herbicides, the benefit/cost ratios were great, ranging from 8 (sugar beets) to 2.8 (small grains), and between 4 to 5 for corn, soybeans, and wheat reduction (1).

Table 8. Approximate price and cost of adjuvants and herbicides.

Chemical	Unit price (1984) ($ Can.)	Cost per ha[1,2] ($ Can.)	Herbicide used in major crop or weed
Adjuvant			
Agral–90	7.50/L	4.17	–
Ag–Surf	4.50/L	2.50	–
Atplus 411 F	2.30/L	1.28	–
Citowett plus	4.80/L	2.67	–
Ammonium sulfate	0.44/kg	0.24	–
Herbicide			
Glyphosate (Roundup)	24.4/L	145.2	quackgrass
Sethoxydim (Poast)	23.0/L	42.8	rapeseed
Diclofop-methyl (Hoe-Grass, Hoelon)	8.3/L	34.3	wheat
Trifluralin (Treflan)	9.0/L	14.7–25.3	rapeseed
2,4–D amine	2.75/L	2.6– 5.3	wheat
MCPA amine	3.60/L	3.3– 6.6	wheat

1 Adjuvants added to the herbicide solution were based on 0.5% of the spray volume (111 L/ha or 45 L/A).

2 The 1987 cost/ha of each herbicide was calculated based on use of major crops or weed (8).

Table 9. Economic benefit/cost ratio using herbicides for weed control.

	Benefit/cost ratio
Small grains	2.8:1
Sugar beets	8:1
Corn, soybeans, wheat	4-5:1

A UNIVERSAL ADJUVANT?

There are about 200 non-ionic surfactants for agro-chemical uses on the market. Our research with adjuvants on herbicides revealed that some adjuvants not only increased weed control of newly developed herbicides, but also improved the performance of existing commercial products. On a percent basis, 86% of new herbicides and 79% of commercial herbicides have shown better weed control when one or two surfactants were added. However, not all surfactants added to the herbicides elicited the same response (5). Any surfactants may increase, decrease, or not affect the performance of a herbicide, depending on which surfactants and herbicides were mixed. Therefore, farmers must be aware that there is no universal adjuvant which can improve all pesticides. This implies that the herbicide/adjuvant interaction is a complex chemical relationship. Addition of an inappropriate surfactant to pesticides could translate into economic losses.

LITERATURE CITED

1. Adam, A.V. 1976. The importance of pesticides in developing countries. Pesticides and Human Welfare, 115–130. Oxford University Press. Oxford, U.K.
2. Aebi, H. 1976. Opportunities and limitations in the use of herbicides in developing countries. Proc. 1976. Br. Crop Prot. Conf. –Weeds, 817–830.
3. Brady, N.C. 1982. Chemistry and world food supplies. Science 218:847–853.
4. Chow, P.N.P. 1977. Significance of adjuvants to activities of some herbicides. Proc. 4th Ann. Meet. Plant Growth Regulator Working Group, 310–313. Hot Springs, AR.
5. Chow, P.N.P. 1984. Adjuvants and how they work with herbicides. Weeds Today, 15:2–3.
6. Eue, L. 1985. World challenges in weed science. Weed Sci. 34:155–160.
7. Jordon, T.N. 1979. Influencing the action of herbicides:adjuvants. Crop Soil Mag. 32:9–12.
8. Manitoba Agriculture. 1987. Herbicide price list, field crops. Weed Reference Bull., General. 1–10.
9. Nishimoto, R.K. 1983. Some mechanisms to enhance foliar absorption of herbicides. Proc. 9th Conf. Asian-Pacific Weed Sci. Soc., 1–14. Manila, Philippines.
10. O'Sullivan, P.A., H.A. Friesen, and W.H. Vanden Born. 1977. Influence of herbicides for broad-leaved weeds and adjuvants with diclofop-methyl on wild oat control. Can. J. Plant Sci. 57:117–125.

WEED HOSTS OF THE CYST AND THE ROOT-LESION NEMATODES

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ABSTRACT

The cyst, *Heterodera,* and the root-lesion, *Pratylenchus,* nematodes are the second and third most destructive plant parasitic nematode genera, respectively, to crop production on a worldwide basis, causing damage to the minor as well as the major crops sustaining mankind. The objectives of the weed hosts as pest reservoirs activities are to emphasize the overall impact of weeds on crop production, to offer another criterion in defining the importance of weeds, and to promote effective control of weeds. The greatest numbers of weed host entries for 23 species of the cyst nematode were in the families Cruciferae, Gramineae, and Leguminosae. *Vicia, Solanum, Lathyrus,* and *Chenopodium* were the genera represented by the greatest numbers of host species. The greatest numbers of weed host entries for 20 species of the root-lesion nematode were in the families Compositae, Gramineae, and Leguminosae. *Crotalaria, Cassia, Vicia, Amaranthus,* and *Trifolium* were the genera with the greatest numbers of entries.

INTRODUCTION

Among the plant-parasitic nematodes, those which live on plant roots pose the greatest threat to agriculture because they inflict the greatest damage to plants, are predominant, and are difficult to control. The cyst *(Heterodera)*, root-lesion *(Pratylenchus)*, and root-knot *(Meloidogyne)* nematodes live on plant roots and cause more damage to crops worldwide than any other genera of nematodes. They are among the world's most destructive plant pathogens, causing damage to the minor as well as the major crops sustaining mankind.

INTEGRATED NEMATODE MANAGEMENT

Integrated nematode management principles must be employed for nematode control if sustainable agroecostystems are to be developed and maintained. Prevention, crop tolerance, and nematode population are three principles which should be considered. As in weed control, the first-order defense is exclusion or prevention. The well-known proverb that 'an ounce of prevention is worth a pound of cure' is all too seldom practiced. If one adds 'and cheaper' after 'cure', the import of this proverb for nematode control becomes apparent (3).

The second principle is to increase crop tolerance to nematodes. This might be done by breeding and use of resistant crop cultivars, by use of appropriate agricultural chemicals, and by careful cultural manipulations.

The third principle, since total elimination of established nematode populations generally is not feasible, involves reducation of established populations. It is an attainable and a desirable goal in production agriculture. Those means used for weed population reduction – biological, chemical, physical, and cultural – are means used for nematode population reduction. Examples of means for nematode reduction include use of cover crops and trap crops, roguing of infested plants, fallowing, and weed management. Additionally, a major means of nematode population reduction in agriculture is rotation to non-host crops. However, the good effects of crop rotations are lost if nematode populations are maintained by weeds. Weeds which serve as hosts must be exterminated in order to free the soil of the nematodes All too often, those who determine the measures of control of plant-parasitic nematodes underestimate the value of weed control.

WEED HOSTS AS PEST RESERVOIRS

Since weeds as well as crops are primary producers, they provide energy, nutrients, and shelter for the various classes of pests, such as insects, nematodes, pathogens, and vertebrates, which are primary or secondary consumers. Under these circumstances as producers, plants serve as hosts for consumers. As hosts, they serve as pest reservoirs by maintaining populations of those organisms. Nematodes not only feed on plants, but use them as temporary or permanent dwelling places. A nematode population may increase several-fold or decline rapidly within a short period of time under the influence of the plant cover. Therefore, the use of weeds for supposedly desirable purposes may be counter-productive if those weeds maintain populations of crop-destroying pests.

Plants are arbitrarily designated "weeds" depending upon the specific circumstances. These are subjective decisions, generally relating to competition by unwanted plants with crops for limited supplies of water, mineral nutrients, or light. Consequently, a plant designated as a weed under one set of circumstances may not necessarily always be a weed. Plants reducing the aesthetic value of an area or polluting aquatic environs used by man are termed weeds, as are plants causing such human health problems as mechanical injury, dermatitis, or allergies. Plants poisonous to man or animals are weeds. Some plants also host vectors or alternate hosts of some of the world's most devastating and widespread human diseases, such as encephalitis, trypanosomiasis, schistosomiasis, scrub typhus, and clonorchiasis, and, thus, might properly be termed weeds. Plants which host pests of crops might also be termed weeds whether or not they interfere directly with crops as strong competitors.

HOST–NEMATODE INTERACTION

In considering host-nematode interactions, it may be difficult to distinguish the impact of nematode infestations on crop yield reductions. Each host-parasite combination has its own characteristics. Some nematode species appear to be weak pathogens, with individual nematodes having only a slight effect on their hosts. Other species are such strong pathogens that one individual nematode can stunt a seedling. Hosts also differ in their responses to nematodes. When phyto-parasitic nematodes increase rapidly to high populations, disease results. Disease development also depends on the growth stage of the host when nematodes enter. A high population of nematodes present in soil when crop seeds germinate is much more damaging than the same numbers later in the season. Crop yields are generally reduced in proportion to the intensity of nematode infestation. Furthermore, environmental conditions such as temperature, moisture, nutrition, and soil type also influence the development of disease.

Two additional factors, important in determining whether disease will occur, are environmental or physiological stress on the host (e.g. drouth or fruit load) and the interaction of other pathogenic organisms. The following are relevant examples of the wide array of plant diseases caused by associations between nematodes and other pathogens.

Nematode	Pathogen	Disease	Host
Heterodera	*Fusarium oxysporum*	Fusarium wilt	Tomato
	Rhizoctonia solani	"White foot"	Potato
		Rhizoctonosis	Tomato
	Verticillium dahliae	Verticilium wilt	Potato
Pratylenchus	*Cylindrocarpon radicicola*	Root rot	Carrot, Red clover, Potato, Spinach, Tomato
	Rhizoctonia oxysporum	Fusarium wilt	Wheat
	Trichoderma viride	Collar rot	Celery
	Verticillium albo-atrum	Verticilium wilt	Eggplant
	Verticillium dahliae	Verticilium wilt	Potato
		Verticilium wilt	Tomato

In general, nematodes parasitizing the roots of plants facilitate the penetration and transmission of pathogens by acting as vectors and by puncturing openings for pathogen penetration. Nematode infestation may cause physiological changes within the host resulting in susceptibility to a disease to which the host is normally resistant. In some cases, simultaneous attack by a nematode and a pathogen may produce a disease unlike that resulting from attack by either orgainsm alone.

In addition to weeds serving as reservoirs for nematodes by hosting them, a further significant consideration is that weed hosts provide a very favorable environment for race development in nematode species. Race development in nematodes reduces the effectiveness of resistance bred into crops to withstand specific infection. Consequently, the cost of breeding for crop resistance and costs of the yield losses sustained are increased.

HORIZONTALLY INTEGRATED PEST MANAGEMENT

The weed hosts as pest reservoirs concept implies a multidisciplinary approach in pest management. It is one approach to horizontal integration in pest management. It is assumed that vertical integration for management of each pest species, using appropriate combination of preventive, biological, physical-mechanical, and chemical methods or tools, will be used in crop cultural practices. The premise is that, if the weed hosts of specific pests – insect, nematode, pathogen, or vertebrate – are controlled, the populations of those pests will be reduced, thus reducing production costs and being more economical than managing each pest independently. Attention is also drawn to the desirability of using alternative crops in production programs. The prupose of research on the weed hosts as pest reservoirs concept, therefore, is to emphasize the impact of specific weeds and the importance of their control in crop production.

CYST NEMATODES

The cyst nematodes are considered to be the second most serious genera of plant-parasitic nematodes affecting worldwide crop production, exceeded only by the root-knot nematodes. This genus includes more than 40 species, many of which are parasites of agricultural crops. They were first recognized as plant pathogens causing a disease of sugarbeets called "beet tiredness." In 1871, *Heterodera schachtii* was identified as the cause of the disease. Potato production had a similar history, with *Heterodera rostochiensis* being identified as the causal organism.

The cyst nematodes differ from all other known nematodes in the transformation of females into cysts which form protective sacs for their eggs (5). Each female may produce several hundred eggs. The life cycle is completed in 3 to 4 weeks. When the adult female dies, its cuticle tans into a brown leathery sac, the "cyst", which drops fróm the root into the soil. Here it may remain for years, a package of quiescent, unhatched juveniles. When a stimulus leaching out of growing host roots reaches the cyst, the enclosed nematodes become active. Soil that has not had host plants for 10 years or more may still have enough nematodes to build dangerous populations when suitable hosts are planted again.

The information on nematode biology was obtained from several sources, but chiefly from Decker (4) and Dropkin (5).

Over 500 entries were listed as weed species hosting one or more of the 23 *Heterodera* species included in a compiled literature search (2). These weed hosts were distributed non-uniformly among 30 plant families, 145 genera, and 314 species. More than half of the weed hosts of *Heterodera* species were members of three families: Leguminosae, with 85 species in 25 genera, Gramineae, with 47 species, in 24 genera, and Cruciferae, with 44 species in 29 genera. The four plant genera which had the most host species were *Vicia* with 15, *Solanum* with 14, and *Chenopodium* and *Lathyrus* each with 13 host species. All other genera had less than 10 host species each.

Among the cyst nematodes, *schachtii, glycines,* and *trifolii* were hosted by the most weed species. *H. schachtii,* which infects beets, cabbage, and rape, was hosted by more weed species distributed throughout more families than any other species of cyst nematodes. Of the 111 weed host entries, 43 were Cruciferae, 24 were Chenopodiaceae, 11 were Polygonaceae, and 8 were Amaranthaceae. *Chenopodium, Amaranthus, Rumex, Atriplex,* and *Brassica* were the most frequent genera hosting *H. schachtii.*

The cyst nematode *H. glycines,* which infects soybeans and *Phaseolus* species, had 73 weed host entries, of which 64 were Leguminosae. *Vicia, Crotalaria, Indigofera,* and *Phaseolus* were the most frequent hosts of *H. glycines.*

H. trifolii, which infects clovers, ranked third among the species of cyst nematode, with 53 weed host entries. Of these, 22 were Leguminosae and 12 were Caryophyllaceae. *Trifolium, Rumex,* and *Vicia* were the most frequent hosts of *H. trifolii.*

ROOT–LESION NEMATODES

The root-lesion nematodes are considered to be the third most serious genera of plant-parasitic nematodes affecting worldwide crop production, exceeded only by the root-knot and cyst nematodes.

Severe attack usually results in poor top growth, sensitivity to moisture stress, and reduced yield in many crop species. These nematodes feed on a cell, kill it, and move to an adjacent cell, usually in a longitudinal direction. All stages, especially juveniles and adults, migrate freely between roots and soil, as well as moving within the roots. The feeding of emerging larvae is such that extensive regions of the roots may be destroyed. Roots of many plants infected with *Pratylenchus* spp. have elongated narrow brown streaks at the surface. These enlarge to form extensive necrotic areas which often coalesce into discolored lesions harboring bacteria, fungi, and free-living nematodes. Probably the most important means by which the root-lesion nematodes cause damage is the interaction of other pathogens with them. Many species of this genus of migratory endoparasistes are implicated in vascular wilts and root rots.

Over 650 entries were listed as weed species hosting one or more of the 20 *Pratylenchus* species included in a compiled literature search (2). These weed hosts were distributed non-uniformly among 69 plant families, 239 genera, and 326 species. Almost half of the weed hosts of *Pratylenchus* species were members of three families: Gramineae, with 61 species in 36 genera, Leguminosae, with 56 species in 33 genera, and Compositae, with 45 species in 37 genera. The five plant genera which had the most host species were *Crotalaria* with 7, *Cassia* and *Vicia* each with 6, and *Amaranthus* and *Trifolium* each with 5 host species. All other genera had less than 4 host species each.

Among the root-lesion nematodes, *penetrans, brachyurus,* and *coffeae* were hosted by the most species. *P. penetrans* was hosted by more weed species distributed throughout more families than any other species. Of the 189 weed host entries, 32 were in the family Compositae, 28 were Gramineae, 22 were Leguminosae, and 17 were Cruciferae. *Trifolium, Brassica, Polygonum, Solanum,* and *Vicia* were the most frequent host genera of *P. penetrans.*

The root-lesion nematode *P. brachyurus* ranked second, with 83 weed host entries. Of these, 27 were Leguminosae and 18 were Gramineae. *Cassia, Crotalaria, Paspalum,* and *Trifolium* were the most frequent hosts.

P. coffeae ranked third among the species of root-lesion nematodes, with 61 weed host entries, of which 20 were Leguminosae. *Cassia* and *Crotalaria* were the most frequent host genera of *P. coffeae.*

The root-knot nematodes cause the most damage to crops on a worldwide basis. Review of published data on the root-knot nematodes shows that there were over 2200 weed entries distributed non-uniformly among 113 plant families hosting one or more of the 19 species of *Meloidogyne* (1).

A comparative summary of the weed hosts of the cyst, the root-lesion, and the root-knot nematodes shows that the families Leguminosae and Gramineae are among the most frequent hosts of all three genera of nematodes. However, at the genus level, there is more diversity. *Vicia, Amaranthus,* and *Trifolium* are the only genera represented among the most frequent weed hosts of more than one of the three nematode genera.

The weed hosts as pest reservoirs concept emphasizes: 1) the need for multidisciplinarity in development of pest management programs; 2) horizontal integration in pest management; 3) economy in sustainable agrosystems by the use of weed control to reduce populations of insect, nematode, pathogen, and vertebrate pests; and 4) use of alternative crops in sustainable agroecosystems.

The purpose of research on weed hosts of the cyst and the root-lesion nematodes, therefore, was to emphasize the impact of specific weeds and the importance of their control in crop production. The weed hosts as pest reservoirs concept offers another criterion, in addition to interference by competition and allelopathy, in defining the significance of weeds in crop production.

LITERATURE CITED

1. Bendixen, L. E. 1986. Weed hosts of *Meloidogyne*, the root-knot nematodes. 101–167. *In* K. Noda and B. L. Mercado, Eds. Weeds and the environment in the tropics. Asian-Pacific Weed Science Society and Japan International Cooperation Agency, Bangkok.
2. Bendixen, L. E. 1988. Weed hosts of *Heterodera*, the cyst, and *Pratylenchus*, the root-lesion, nematodes. Special Circular. Ohio Agr. Res. Dev. Cent., The Ohio State University, Columbus. (in press).
3. Bird, G. W. 1981. Integrated nematode management for plant protection. 355–375. *In* Zuckerman, B. M. and R. A. Rohde, Eds. Plant parasitic nematodes, Vol. III. Academic Press, New York.
4. Decker, H. 1981. Plant nematodes and their control (Phytonematology). Amerind Pub. Co., New Delhi.
5. Dropkin, V. H. 1980. Introduction to plant nematology. John Wiley and Sons, New York.

DORMANCY AND GERMINATION OF LIGHT SENSITIVE WEED SEEDS BURIED IN THE SOIL

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ABSTRACT

Many weed species have light sensitive seeds. They could germinate easily on the soil surface and may be induced to germinate in high or low temperatures after leaving in the soils. Effects of burying in the soil on dormancy breaking and germination of seeds of five cyperaceous weeds, *Scirpus juncoides, Cyperus iria, Cyperus microiria, Cyperus difformis* and *Fimbristylis miliacea* were studied. Seeds of *C. iria* and *C. microiria* buried in the upland field germinated well every month for one year. The germination percentage of *C. iria* seeds buried in the flooded soil were lowered in the late winter and spring. And that of *C. microiria* buried in the flooded soil did not increase till autumn. The germination tests of these cyperaceous weed seeds were carried out under alternate temperature condition in light. Seeds of *Digitaria adscendens* buried in the upland field increased its germination percentages in course of time. Increasing patterns were different among conditions of germination tests, and germination percentages in 30/20° C alternate temperature and light were larger than in constant temperature or in darkness. But seeds buried in the soil at depths of five and ten centimeters in bare field and at a depth of one centimeter under vegetation cover germinated better than seeds buried at the other depths.

INTRODUCTION

Many weed species have light sensitive seeds. These seeds germinate well on soil surface under sunlight. Their dormancy may be broken by alternate temperature in the soil. Study was made of difference in light sensitivity of seeds among weed species and of influences of light and alternate temperature on dormancy breaking and germination.

MATERIALS AND METHODS

Preparation of germination Seeds of five cyperaceous weeds were put in the soil of an upland field just after their harvest. They were digged out 0, 4, 8, 12 weeks after putting in the soil and transferred to petri-dishes for germination tests. The germination tests were carried out in the green house of phytotron under the natural sunlight. Though the room temperature of green house was regulated to be constant, the temperature in petri-dishes alternated by solar radiation. Therefore the germination test in this case was carried out under alternate temperature by light. Weed species used in this experiment are

Scirpus juncoides, Cyperus iria, Cyperurs microiria, Cyperus difformis and *Fimbristylis miliacea.*

Germination beds Temperatures of germination beds were measured with thermoelectric couples and recorded with a hybrid-recorder. A sealed bottle sunk in the water of a 30cm x 70cm thermoregulator bath was used as a germination bed in order to regulate the temperature in the germination bed under solar radiation. Seeds of *Cyperus serotinus* were put on a filter paper on small gravels in the sealed bottle. The temperature of the bath-water was kept at 25°C for constant temperature, and 20°C and 30°C for alternating temperature. A vinylon cheesecloth was used as a shading material for the regulation of solar radiation.

Effects of storage condition Seeds of *C. iria* and *C. microiria* harvested in the experimental field were sown in pots placed in the open air, and some seeds were germinated. The rest were dried in the green house, and they were stored in various conditions as follows:

1) At a 20cm depth in an upland field
2) At a 20cm depth in a submerged field
3) At a dry condition in the laboratory
4) In a desicator in the laboratory
5) In a 5°C storeroom

Seeds were transferred from each storage place to petridishes for the germination test once a month for one year. The germination test were conducted at 20/30° C alternated temperature in a light provided by cool white fluorescent tubes.

Burial depth on germination of *Digitaria adscendens* Fresh seeds of *Digitaria adscendens* harvested in a field were put in the soil of an upland field at 0, 1, 2, 5, 10cm depths on November 26. Seeds were digged out for germination test six times until April 1 in the next year. Germination test was conducted under 4 combined condition; alternate and constant temperature with light and dark.

RESULTS AND DISCUSSION

Relation between putting period in the soil and seed germination of cyperaceous weeds The result of germination test is shown in Table 1. Just after ripening four species except *C. difformis* hardly germinated. After putting for four weeks seeds of *C. microiria* did not germinate yet, but seeds of *Scirpus juncoides* germinated well, and dormancy breaking of seeds of *C. iria* and *F. miliacea* facilitated. After eight weeks seeds of *C. microiria* began to germinate. After twelve weeks seeds of all species were advancing in awakening from dormancy, but stages of awakening were different among species.

Temperature in germination bed Temperature in petri-dishes was different among dishes according to space between body and cover of petri-dishes. Temperature measured with the very fine thermocouple keeping the space very little varied between 20° C and 40° C by solar radiation in the daytime. Forty to fifty percentage of radiation was intercepted by one sheet of vinylon chessecloth and maximum temperature was 30° C. In the case of covering with two or four sheets the transmission efficiency was less than several percent and the temperature in petri-dish was almost same as room temperature. Transmitted light seems too little to affect the temperature in petri-dishes.

Table 1. Germination percentages of seeds of five cyperaceous weeds put in the soil for different periods[1].

Weed species	Period of putting in the soil (weeks)			
	0[2]	4[2]	8[3]	12[3]
Scirpus juncoides	1	81	87	92
Cyperus iria	0	15	12	30
Cyperus microiria	0	0	10	32
Cyperus difformis	31	30	35	63
Fimbristylis miliacea	1	38	11	65

[1] Seeds were put in the soil on October 5.

[2] Germination percentages are values after 15 days after transferring seeds to petri-dishes.

[3] Ditto, but 9 days.

Effects of storage conditions on seed germination Courses of seed germination of *C. iria* are shown in Fig. 1. Forty percent of freshly harvested seeds of *C. iria* germinated, but those of *C. microiria* did not germinate at all. Seeds of both species put in the soil more than one month germinated well in every month.

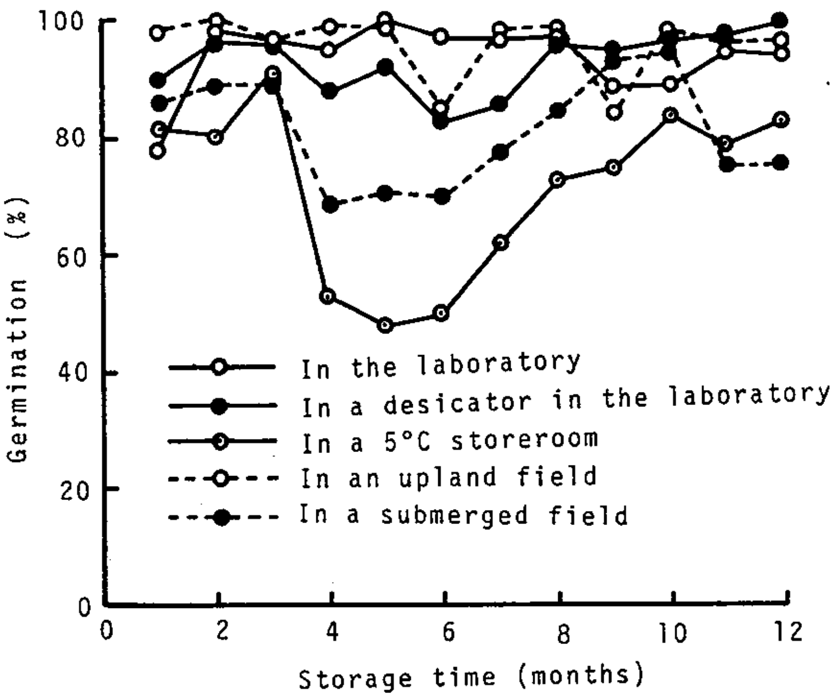

Fig. 1. Effects of storage conditions on seed germination of *Cyperus iria*.

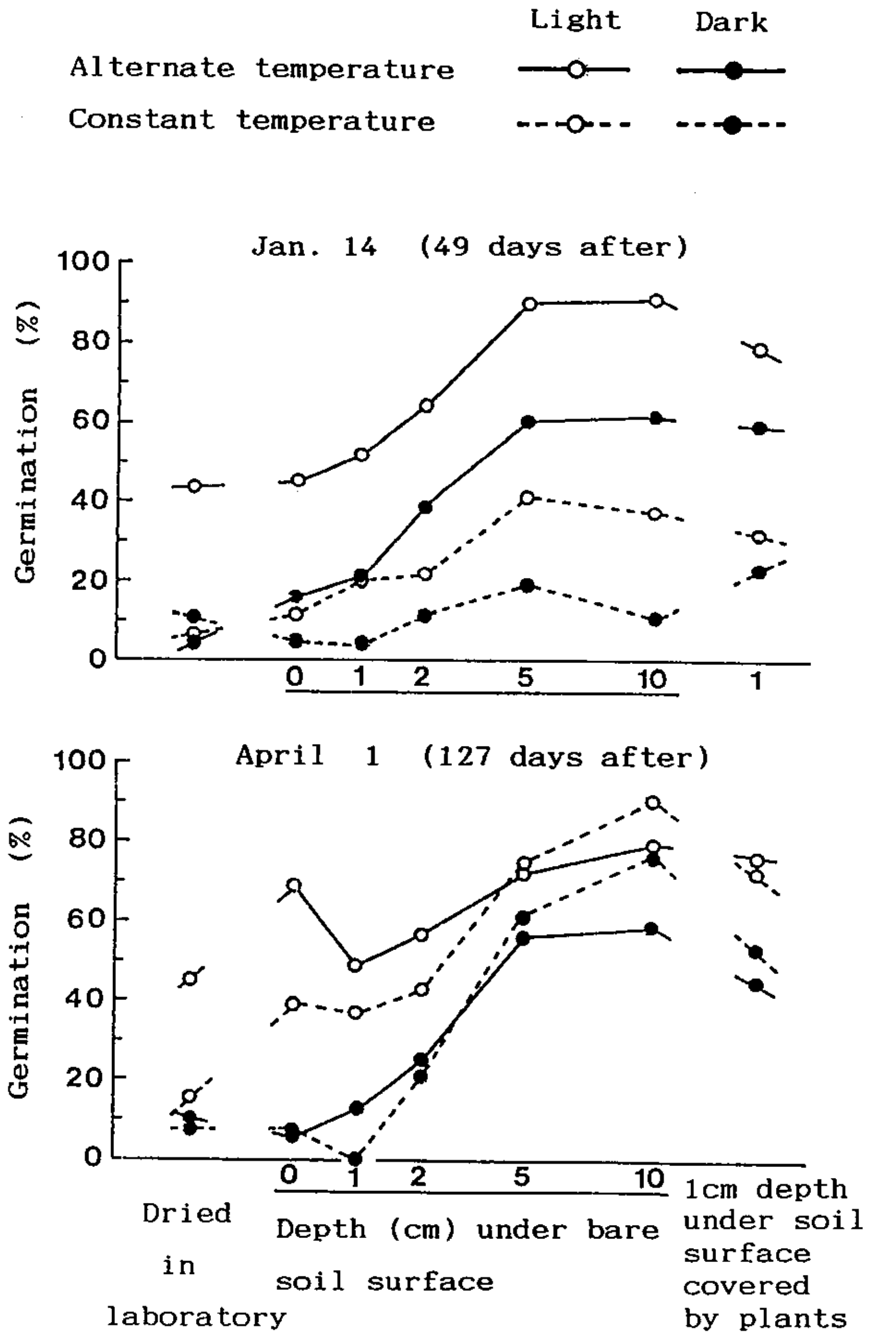

Fig. 2. Germination of *Digitaria adscendens* seeds put in the soil at different depths.

Soil moisture conditions seems to have different effects on seed germination. Germination percentages of seeds in the submerged field were lower than those of seeds in the upland field, and this effect was more clearly shown in seeds of *C. iria* kept in the submerged condition for four to seven months. Seeds of *C. iria* stored at 5°C in darkness showed a low germination percentage, and those of *C. microiria* under the same condition showed about 20% at every times.

Influence of location in the soil on seed germination of *D. adscendens* The results of germination test are shown in Fig. 2. A large germination percentage was obtained in *D. adscendens* seeds put at 5cm and 10cm under bare soil surface and at 1cm under the soil surface covered by plants for 48 days, and those seeds required a light and an alternate temperature for their germination. After 126 days of putting period their germination percentages were large under any germination condition, and requirement for light and alternate temperature seems to be decreased.

The germination percentage of *D. adscendens* seeds in the upland field increased with a prolongation of putting period. This trend of increase was different according to conditions of germination test, and germination percentage under conditions with light and alternate temperature was larger than that under conditions either with constant temperature or without light.

More seeds died at 5 cm and 10 cm under bare soil surface and at 1 cm under the soil surface covered with plants than at any other depth under bare soil, but the germination percentage of the survival was better in the former than in the latter.

MEFENACET, A NEW PADDY HERBICIDE (2)
– As a component of one-shot application herbicides –

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ABSTRACT

Mefenacet is a novel amide type herbicide, having a specific effectiveness against major noxious paddy weeds, especially *Echinochloa crus-galli,* during a wide range of the growth stage from preemergence to 3.0 leaves. Several combinations of Mefenacet with some other herbicides for controlling certain sedges and broadleaf weeds, which cannot be covered well by Mefenacet along, have been examined for the simultaneous control of a wide spectrum of the weeds. In many field trials, Mefenacet combinations such as Mefenacet and Pyrazolate and Bromobutide 3.5 & 4.0 & 4.0% GR (Leedzon®), Mefenacet and Napranilide and Bromobutide 3.5 & 7.0 & 4.0% GR (Shinzan®), Mefenacet and Pyrazolate and Bentazone 3.5 & 4.0 & 5.5& GR (Clealand®), Mefenacet and Bensulfuron methyl 4.0 & 25% GR (Zark 25®), 3.5 & 0.17% GR (Zark 17®), provided excellent effectiveness against most of the economically damaging weeds along with good plant compatibility in transplanted rice from preemergence to 3.0 leaf stages of *Echinochloa crus-galli,* i.e. up to around 15 DAT at the rate of 30 kg/ha in their formulation bases. In recent years, early stage (Type I group) one-shot application herbicides have become more and more popular in Japan. Generally, they have high efficacy against major weeds from preemergence to 1.5 leaf stage of *Echinochloa crus-galli,* i.e. up to 7 (partly 10) DAT. On the other hand, the Mefenacet combinations are highly effective up to around 15 DAT, as mentioned above. This longer period of optimum application is the most emphatic advantage over currently used early stage one-shot application herbicides. These Mefenacet combinations have officially been positioned into another category, known as Type II group, that is "Early-middle stage one-shot application herbicide". The five Mefenacet combinations have been registered in 1986-1987 in Japan. These products may offer a potential for the control of dominant weeds in practical rice fields in other areas of the world, too.

INTRODUCTION

In recent years in Japan, rice herbicides have been applied in paddy field twice per one rice growing season on an average, as shown in Table 1.

The typical application methods of the herbicides are systematic ones of PPI application herbicide or/and early stage herbicides followed up by middle stage herbicides or/and late stage herbicides.

Table 1. Transition of the area of paddy herbicide usage in recent years in Japan[1].

(unit: 1,000ha)

Type of Herbicide	1975	1981	1982	1983	1984	1985	1986
PPI application	317	478	494	452	458	439	446
Early stage application	2,823	2,320	2,119	1,950	1,888	1,772	1,537
Middle stage application	1,846	1,847	1,679	1,566	1,566	1,455	1,375
Late stage application	960	476	479	480	454	529	432
One-shot application	–	–	25	269	454	678	876
Total area of herbicide appli. (A)	5,946	5,121	4,796	4,7171	4,820	4,873	4,666
Area of rice cultivation (B)	2,350	2,251	2,230	2,246	2,290	2,318	2,279
Average times of herbicide appli. (B/A)	2.2	2.3	2.2	2.1	2.1	2.1	2.0

[1] JAPR fact-finding reports on paddy weed control and other statistics

At each application time, different herbicides are applied for the control of major annual and perennial weeds which must be controlled by herbicides and other weeding methods.

The recent situation of major weed flora in paddy fields in Japan is shown in Table 2. The figures in the table indicate that some species of perennial weeds such as *Scirpus juncoides, Sagittaria pygmaea, S. trifolia* increased in the past several years.

On the other hand, single applications of some herbicides which are commonly known as one-shot application herbicides have become more and more popular in these years, as shown in Tables 1 and 3.

Table 2. Change of the weed flora in paddy field in recent years in Japan[1].

Group	Weeds	1987		1982		1986	
Annual	ECHOR	82[2]	(74)[3]	87[2]	(79)[3]	86[2]	(79)[3]
	MOOVP	33	(24)	33	(25)	32	(24)
	ROTIN	12	(12)	16	(10)	15	(10)
	Others	42	(31)	35	(25)	35	(15)
Perennial	ELOAL	33	(20)	34	(24)	30	(22)
	SCPJU	28	(23)	41	(34)	44	(38)
	CYPSE	22	(16)	24	(18)	24	(19)
	ELOKU	8	(6)	10	(7)	12	(10)
	SAGPY	28	(22)	37	(30)	36	(30)
	SAGTR	15	(11)	20	(15)	21	(17)
	ALSCA	15	(12)	16	(11)	18	(15)
	PTMDI	6	(4)	6	(4)	7	(5)
	OENJA	7	(4)	12	(5)	13	(7)

[1] JAPR fact-finding reports on paddy weed control and other statistics

[2] % of the area infested with indicated weeds out of the total cultivated paddy area

[3] % of the area must be controlled by herbicides and other weeding methods

Weed code:

ECHOR = *Echinochloa crus-galli*
MOOVP = *Monochoria vaginalis*
ROTIN = *Rotala indica*
ELOAL = *Eleocharis acicularis*
SCPJU = *Scirpus juncoides*
CYPSE = *Cyperus serotinus*
ELOKU = *Eleocharis kuroguwai*
SAGPY = *Sagittaria pygmaea*
SAGTR = *Sagittaria trifolia*
ALSCA = *Alisma canaliculatum*
PTMDI = *Potamogeton distinctus*
OENJA = *Oenanthe javanica*

Table 3. Transition of paddy field area treated with one-shot herbicides out of the total cultivated paddy field[1]

Year	1982	1983	1984	1985	1986	1987
% of area treated by one shot herbicides	1	12	20	29	37	45[2]

[1] JAPR fact-finding reports on paddy weed control

[2] As of the end of June

One shot application herbicides such as the mixture of Butachlor and Pyrazolate, which is the most popular one, provide a sufficient effectiveness against broad spectrum of annual and perennial weeds from preemergence to 1.5 leaf stage of *Echinochloa crus-galli,* i.e. up to 7 DAT (partly 10 DAT) with good plant compatibility in transplanted rice.

Mefenacet, 2-(2-benzothiazolyloxy)-N-Methyl-N-Phenylacetamide, provides outstanding effectiveness against some troublesome paddy weeds, especially *Echinochloa crus-galli* during a long application period, i.e. from preemergence to 3-leaf stage with good plant compatibility in transplanted rice.

The compound, however, is unstable against some perennial Cyperaceae weeds under certain conditions, and is weak against *Sagittaria* spp. and some other perennial broadleaf weeds.

The objective of this study was to develop new products of Mefenacet combinations which provide a sufficient effectiveness against a wide spectrum of economically damaging paddy weeds along with good plant compatibility in transplanted rice by single application during a wider application time from preemergence to 3 leaf stage of *Echinochloa crus-galli,* i.e. up to around 15 DAT.

MATERIALS AND METHODS

Mefenacet and its combinations used in this study were:
1. Mefenacet 4.0% GR (Hinochloa ®); 2. Mefenacet and Pyrazolate and Bromobutide 3.5 and 4.0 and 4.0% GR (Leedzon ®); 3. Mefenacet and Naproanilide and Bromobutide 3.5 and 7.0 and 4.0% GR (Shinzan ®); 4. Mefenacet and Pyrazolate and Bentazone 3.5 and 4.0 and 5.5% GR (Clealand ®); 5. Mefenacet and Bensulfuron-methyl 4.0 and 0.25% GR (Zark 25®); 6. Mefenacet and Bensulfuron-methyl 3.5 and 0.17% GR (Zark 17®).

Pyrazolate: 4-(2,4-dichlorobenzoyl)-1,3-dimethyl-5-pyrazolyl-p-toluenesulfonate; Bromobutide: (RS)-2-bromo-N-(α.α-dimethylbenzyl)-3.3-dimethyl-butyl-amide; Naproanilide: α-(2-naphthoxy) propionanilide; Bentazone: 3-isopropyl-1H-2.1.3-benzothiadiazin-(4)-3H-one-2.2-dioxide (Na-salt); Bensulfuron-methly: methyl α-(4,6-dimethoxypyrimidin-2-ylcarbamoyl. sulfamoyl)-o-toluate.

Many field trials of the Mefenacet and its combinations were conducted in paddy fields naturally infested with some paddy weed species in Miyagi, a cool region, in Tokyo, Ibaraki and Kanagawa, warm regions and in Kochi, Saga and Kagoshima, hot regions in 1980-1986.

Young rice seedlings (2-3 leaf stage, 15 cm in height on an average) were planted in the fields by transplanting machine at a depth of around 3 cm from the soil surface during the suitable planting season in each location. Plot size was 5-10 m^2 with 2-3 replications of randomized block design.

The herbicides were applied to the testing plots at three different timings i.e. at 0-1, 1-2 and 2-3 leaf stages of ECHOR by water surface treatment. The water in the testing plots was managed in accordance with farmer's watering practices.

Weed control efficacy and crop tolerance of the combinations were evaluated by visual observations 5-6 weeks after the applications. Yield evaluations of rice grains were done at harvesting time.

RESULTS AND DISCUSSION

Weed control effectiveness

Mefenacet GR (Hinochloa ®) Mefenacet 4.0% GR alone at the rates of 30 and 40 kg/ha was highly effective against some economically damaging weeds, especially ECHOR (*Echinochloa crus-galli*) which is one of the most troublesome weeds in Japan, with a wide range of application time from preemergence to 3 leaf stage of the weed, irrespective of the testing regions. The herbicide, however, was unstable against certain species of annual broadleaf weeds and perennial sedges such as ROTIN (*Rotala indica*), SCPJU (*Scirpus juncoides*) and CYPSE (*Cyperus serotinus*) as shown in Table 4. Also, the herbicide was weak against *Sagittaria* spp. such as SAGPY (*Sagittaria pygmaea*) and SAGTA (*S. trifolia)* in the preliminary evaluations which had been conducted prior to this study.

To overcome this narrow weed control spectrum, it was essential to combine Mefenacet with some other herbicides effective against some noxious weeds tolerant to Mefenacet.

Table 4. Weed control effectiveness of Mefenacet 4.0% GR (1980–1986).

Rate	Appli. time		% of weed control effectiveness						
kg/ha	ECHOR[1]	DAT	ECHOR	CYPDI	MOOVP	BBBBB	ELOAL	SCPJU	SYPSE
in cool region									
30	0-1	7	100	100	100	85	100	94	93
	1-2	13	97	100	99	77	98	50	72
	2-3	18	93	98	97	47	92	35	49
40	0-1	7	100	100	100	90	100	96	97
	1-2	13	100	100	100	84	100	73	84
	2-3	18	98	100	98	57	100	46	56
in warm region									
30	0-1	6	100	100	100	88	100	93	94
	1-2	10	99	100	97	81	99	97	84
	2-3	15	94	99	90	53	93	55	57
40	0-1	6	100	100	100	95	100	99	98
	1-2	10	100	100	100	83	97	98	81
	2-3	15	99	98	99	59	92	52	65
in hot region									
30	0-1	5	100	100	100	90	100	75	95
	1-2	8	100	100	95	82	99	69	85
	2-3	11	100	100	73	57	75	45	62
40	0-1	5	100	100	98	96	100	95	97
	1-2	8	100	100	93	82	100	89	84
	2-3	11	100	100	89	60	86	40	66

ECHOR[1] Leaf stage of ECHOR (*Echinochloa crus-galli*) at application

Mefenacet and Pyrazolate and Bromobutide GR (Leedzon®) The combination of Mefenacet and Pyrazolate and Bromobutide 3.5 and 4.0 and 4.0% GR at the rate of 30 kg/ha was highly effective against overall annual weeds and some perennial ones such as ELOAL (*Eleocharis acicularia*), SCPJU, SAGPY and PTMDI (*Potamogeton distinctus*) by the application up to 3 leaf stage of ECHOR irrespective of testing regions.

For the control of CYPSE and SAGTR, early stage application, i.e. up to 1 leaf stage of ECHOR was much better than later stage applications.

Against ELOKU (*Eleocharis kuroguwai*), the combination was not fully effective as shown in Table 5.

Mefenacet and Naproanilide and Bromobutide GR (Shinzan®) The weed control performance of the combination of Mefenacet and Naproanilide and Bromobutide 3.5 and 7.0 and 4.0% GR at the rate of 30 kg/ha was very similar to that of the combination of Mefenacet and Pyrazolate and Bromobutide GR in both weed control efficacy and spectrum except for the control of SAGTR, as shown in Table 6.

Mefenacet and Pyrazolate and Bentazone GR (Clealand®) The weed control performance of the combination of Mefenacet and Pyrazolate and Bentazone 3.5 and 4.0 and 5.5% GR was nearly equal to that of Mefenacet and Pyrazolate and Bromobutide except for the efficacy on CYPSE, against which good results were obtained irrespective of application timing within 3 leaf stage of ECHOR, as shown in Table 7.

Mefenacet and Bensulfuron methyl GR (Zark 25® and Zark 17®) The field trials of Mefenacet and Bensulfuron methly 4.0 and 0.25% GR were conducted in cool and warm regions and those of 3.5 and 0.17% GR were done in warm and hot regions respectively, because of the difference in their performance both in effectiveness and crop tolerance under cool and hot weather conditions.

Mefenacet and Bensulfuron methyl 4.0 & 0.25% GR at 30 kg/ha provided an outstanding effectiveness against overall tested weeds by all application timings in cool regions including OENJA (*Oenanthe javanica*) which is one of the hardest weeds to be controlled in Japan. In warm regions, the overall effectiveness was similar to that in the cool regions, however, when applied at the later growing stage of ECHOR (2-3 leaf stage), SYPSE was not fully controlled as it was too advanced in their growth stage as shown in Table 8.

The combination of Mefenacet & Bensulfuron methyl 3.5 & 0.17% GR at 30 kg/ha was also effective against wider range of weeds in warm and hot regions and was similar to the combination of 4.0 & 0.25% GR in the warm region, as shown in Table 9.

Crop tolerance

In general, the crop tolerance of Mefenacet and its combinations tested in this study was good in most of the trials, irrespective of testing regions. In some exceptions, slight crop damage was observed on transplanted rice with growth stunting as a symptom. Only in a few cases, the color of the herbal part of rice plants turned from normal green to dark green along with the above mentioned stunting. The integrated results on crop tolerance of all trials are indicated in Table 10.

Rice plants, however, recovered well from the damage within 40-50 DAT, i.e. by the initial step of panicle formation stage of rice. Furthermore, no significant reduction of the yield of rice grains was detected in any of the trials.

Whilst Mefenacet and its combinations are rather safe on loam, loamy clay and clay soils, it shows a tendency to induce growth stunting in sandy soil field, as shown in Table 11.

Table 5. Weed control effectiveness of Mefenacet and Pyrazolate and Bromobutide 3.5 and 4.0 and 4.0% GR (1983 – 1986).

Rate	Appli. time		% of weed control effectiveness												
kg/ha	ECHOR[1]	DAT	ECHOR	CYPDI	MOOVP	BBBBB	ELOAL	SCPJU	SYPSE	ELOKU	ALSCA	SAGPY	SAGTR	PTMDI	OENJA
in cool region															
30	0-1	7	100	100	100	91	100	100	94	90	100	91	95	95	
	1-2	13	98	100	100	96	96	100	87	85	95	95	90	97	
	2-3	18	93	100	98	92	98	99	75	66	99	90	85	91	
in warm region															
30	0-1	6	100	100	100	97	100	100	98	89		98	95	99	
	1-2	10	100	100	99	99	100	100	93	86		97	85	99	
	2-3	15	94	100	99	92	100	98	86	82		98	85	99	
in hot region															
30	0-1	5	100	100	100	99	100	100	94	68		94	97	100	
	1-2	8	100	100	100	99	100	100	91	96		93	90	100	
	2-3	11	99	100	99	99	100	97	83	82		96	86	95	

ECHOR[1] Leaf stage of ECHOR (*Echinochloa crus-galli*) at application

Table 6. Weed control effectiveness of Mefenacet and Naproanilide and Bromobutide 3.5 and 7.0 and 4.0% GR (1981 – 1986).

Rate	Appii. time		% of weed control effectiveness												
kg/ha	ECHOR[1]	DAT	ECHOR	CYPDI	MOOVP	BBBBB	ELOAL	SCPJU	CYPSE	ELOKU	ALSCA	SAGPY	SAGTR	PTMDI	OENJA
in cool region															
30	0-1	7	100	100	100	99	98	99	95	58	98	92		92	
	1-2	13	97	100	100	99	98	99	91	75	99	94		87	
	2-3	18	94	100	100	97	100	100	57	57	99	80		77	
in warm region															
30	0-1	6	100	100	99	98	99	100	96	68		94		95	
	1-2	10	99	100	98	96	100	99	88	66		92		83	
	2-3	15	93	100	91	98	99	95	68	65		75		73	
in hot region															
30	0-1	5	98	100	100	98	100	100	99	87		94		90	
	1-2	8	100	98	100	96	100	99	93	77		92		89	
	2-3	11	99	96	100	95	96	96	88	82		77		86	

ECHOR[1] Leaf stage of ECHOR (*Echinochloa crus-galli*) at application

Table 7. Weed control effectiveness of Mefenacet and Pyrazolate and Bentazone 3.5 and 4.0 and 5.5% GR (1981 – 1985).

Rate	Appli. time		% of weed control effectiveness												
kg/ha	ECHOR[1]	DAT	ECHOR	CYPDI	MOOVP	BBBBB	ELOAL	SCPJU	CYPSE	ELOKU	ALSCA	SAGPY	SAGTR	PTMDI	OENJA
in cool region															
30	0-1	7	100	100	100	97	99	93	96	82	99	96	91	92	
	1-2	13	99	100	100	99	99	94	90	73	100	97	85	92	
	2-3	18	93	100	100	100	100	98	100	70	95	97	80	100	
in warm region															
30	0-1	6	100	100	100	100	99	98	100	80		97	90	100	
	1-2	10	99	100	100	99	100	98	98	75		99	85	100	
	2-3	15	95	100	97	97	100	92	96	72		85	78	100	
in hot region															
30	0-1	5	99	98	100	100	100	94	95	93		97	93	95	
	1-2	8	99	100	100	97	99	90	99	84		99	85	91	
	2-3	11	98	100	99	98	100	90	91	79		100	61	99	

ECHOR[1] Leaf stage of ECHOR (*Echinochloa crus-galli*) at application

Table 8. Weed control effectiveness of Mefenacet and Bensulfuron methyl 4.0 & 0.25% GR (1983 – 1986).

Rate	Appli. time		% of weed control effectiveness												
kg/ha	ECHOR[1]	DAT	ECHOR	CYPDI	MOOVP	BBBBB	ELOAL	SCPJU	CYPSE	ELOKU	ALSCA	SAGPY	SAGTR	PTMDI	OENJA
in cool region															
30	0-1	6	100	100	100	100	100	99	99	90	100	96	90	98	100
	1-2	14	97	100	100	100	100	98	98	97	100	97	92	100	100
	2-3	20	94	100	100	100	100	95	93	95	99	96	90	99	96
in warm region															
30	0-1	5	100	100	100	100	100	100	99	87		99	93	100	100
	1-2	10	98	100	100	100	100	98	95	90		97	90	98	100
	2-3	19	97	100	99	96	99	94	85	94		98	77	97	95

ECHOR[1] Leaf stage of ECHOR (*Echinochloa crus-galli*) at application

Table 9. Weed control effectiveness of Mefenacet and Bensulfuron methyl 3.5 and 0.17% GR (1984 – 1986).

Rate	Appli. time		% of weed control effectiveness												
kg/ha	ECHOR[1]	DAT	ECHOR	CYPDI	MOOVP	BBBBB	ELOAL	SCPJU	CYPSE	ELOKU	ALSCA	SAGPY	SAGTR	PTMDI	OENJA
in warm region															
30	0-1	6	100	100	100	100	100	99	95	87		96	90	99	100
	1-2	10	99	100	100	98	100	98	95	90		96	77	98	96
	2-3	15	97	99	100	95	99	95	85	93		98	73	96	92
in hot region															
30	0-1	5	99	100	100	98	100	99	99	80		95	95	100	100
	1-2	8	99	100	100	99	100	94	97	86		93	89	99	100
	2-3	11	99	100	99	99	100	94	87	90		96	85	99	98

ECHOR[1] Leaf stage of ECHOR (*Echinochloa crus-galli*) at application

Table 10. Crop tolerance of Mefenacet and its combinations in different regions (1980 – 1986).

Region	Application		Mefenacet		Leedzon		Shinzan		Clealand		Zark 25		Zark 17	
	Time (DAT)	Rate (kg/ha)	Rate of Growth (%)	Yield (%)	Rate of Growth (%)	Yield (%)	Rate of Growth (%)	Yield (%)	Rate of Growth (%)	Yield (%)	Rate of Growth (%)	Yield (%)	Rate of Growth (%)	Yield (%)
Cool	7	30	100	100	99	102	100	102	99	102	99	104		
		40	100	97	98	101	97	98	100	103	97	101		
	13	30	99	98	99	100	99	96	100	102	99	102		
		40	97	101	98	100	96	102	99	103	99	103		
	18	30	100	102	100	102	100	97	100	97	99	99		
		40	100	105	100	103	100	95	100	97	97	108		
	Hand weeding		100	100	100	100	100	100	100	100	100	100		
Warm	6	30	99	100	98	101	97	101	99	100	95	104	98	102
		40	100	102	100	98	96	97	100	99	94	101	97	100
	10	30	98	101	98	98	98	102	98	101	97	100	98	101
		40	97	100	99	99	97	101	99	99	96	98	95	99
	15	30	99	98	99	101	99	97	99	101	97	100	98	101
		40	99	102	100	99	98	96	98	103	95	98	98	99
	Hand weeding		100	100	100	100	100	100	100	100	100	100	100	100
Hot	5	30	97	100	99	99	99	98	97	97			96	98
		40	98	99	98	100	95	97	98	99			93	97
	8	30	98	99	98	101	99	99	99	99			97	101
		40	97	97	100	100	96	96	99	102			93	100
	11	30	99	105	99	99	98	98	100	98			98	102
		40	99	105	100	101	100	99	100	98			99	101
	Hand weeding		100	100	100	100	100	100	100	100			100	100

Table 11. Crop tolerance of Mefenacet and its combinations in different soil types (1980 – 1986).

Herbicide	Application		Sandy loam soil		Loam-clay soil	
	Time (DAT)	Rate (kg/ha)	Rate of Growth (%)	Yield (%)	Rate of Growth (%)	Yield (%)
Mefenacet	6	30	94	97	99	100
4.0% GR		40	92	95	100	99
	11	30	92	99	98	99
		40	89	98	97	99
	16	30	98	100	100	102
		40	95	100	99	104
Mefenacet and Pyrazolate	6	30	95	100	99	101
and Bromobutide		40	95	99	99	100
3.5 and 4.0 and 4.0% GR	11	30	95	100	99	100
		40	95	98	99	100
	16	30	99	98	99	100
		40	100	104	100	100
Mefenacet and Naproanilide	6	30	100	98	99	100
and Bromobutide		40	93	95	96	97
3.5 and 7.0 and 4.0% GR	11	30	95	100	99	99
		40	92	98	96	100
	16	30	97	100	99	100
		40	96	99	100	100
Mefenacet and Pyrazolate	6	30	99	98	98	100
and Bentazon		40	96	97	99	100
3.5 and 4.0 and 5.5% GR	11	30	99	99	99	101
		40	100	99	99	102
	16	30	98	98	100	99
		40	95	94	99	99
Mefenacet	6	30	100	111	97	104
and Bensulfuron-methyl		40	92	101	96	101
4.0 and 0.25% GR	11	30	100	103	98	101
		40	95	99	98	101
	16	30	100	106	98	100
		40	99	103	96	103
Mefenacet	6	30	96	98	97	101
and Bensulfuron-methyl		40	93	92	95	99
3.5 and 0.17% GR	11	30	98	99	98	101
		40	93	95	94	99
	16	30	97	98	98	10
		40	95	95	98	100

In conclusion, the tested Mefenacet combinations are effective against a wide species of troublesome paddy weeds along with good plant compatibility on rice plants up to 3 leaf stage of *Echinochloa crus-galli* i.e. around 15 DAT. This longer period of optimum application is the most emphatic advantage over currently used early stage one-shot application herbicides. These Mefenacet combinations have been positioned into another category of one-shot application herbicides, that is "early-middle stage one-shot application herbicide".

The tested five Mefenacet combinations have been registered in 1986-1987 in Japan. These products are expected to contribute to practical rice cultivation in other areas of the world, too.

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WL95481–A NOVEL HERBICIDE FOR USE IN FLOODED, TRANSPLANTED RICE

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ABSTRACT

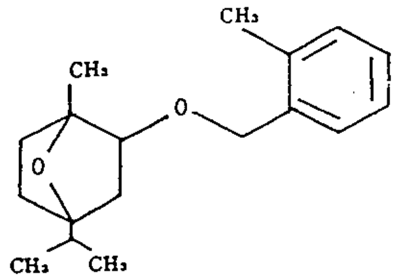
WL95481 (BSI proposed name - cinmethylin) is a novel herbicide. When applied to paddy water at low doses of 15-100 g ai/ha it has given outstanding activity on *Echinochloa* spp. at stages of growth from preemrgence up to three leaves. Other important weeds, including *Monochoria vaginalis, Rotala indica* and annual *Cyperus* spp., were also susceptible. The compound has the facility to be used alone or as a component in a herbicide mixture depending upon the weed spectrum present in rice paddies. WL95481 has shown good selectivity to transplanted rice once the crop has established. WL95481 inhibits meristematic growth in both the roots and shoot of susceptible plants and is readily metabolised. It has a low order of mammalian toxicity and shown no tendency to accumulate in the environment.

INTRODUCTION

WL95481 (trade mark, ARGOLD (R)) is a novel herbicide, representing new chemistry in the cineole family. It is being developed extensively by Shell International Chemical Company in paddy rice at low doses of 15-100 g ai/ha.

Chemical and Physical Properties

Chemical name (IUPAC)	exo-1-methyl-4-(1-methylethyl)-2-(2-methyl phenylmethoxy) -7-oxabicyclo-[2.2.1] heptane
Common name	cinmethylin (BSI proposed)
Code number	WL95481
Molecular formula	C_{18} H_{26} O_2
Structural formula	



Solubility Miscible in all proportions with a large range of organic solvens. Water solubility at 20°C is 63 mg/l.

Formulation WL95481 is available as an emulsifiable concentrate containing 100 g ai/l and as granule formulations of 1.5 to 3 g ai/kg.

Toxicology and environmental toxicity WL95481 is unusual for a pesticide, being composed of only carbon, hydrongen and oxygen. It has a low order of mammalian toxicity and is readily degraded by animals, plants and soil. The toxicological effects of the compound have been investigated in a wide range of species and show that it should have minimal effect on the environment.

Herbicidal effect WL95481 herbicidal effects result primarily from disruption of meristematic development in shoots and roots of susceptible species. Physiological effects on older, more mature, plant parts or tissues have not been observed.

Uptake of WL95481 from the soil solution or in the vapour phase occurs through the shoots and roots of germinating or emerging weeds. The parent material has limited apoplastic mobility in both broadleaved and grass species.

MATERIALS AND METHODS

Since 1985 WL95481 has been evaluated in field trials in transplanted paddy rice in several Asian countries, but primarily in the Peoples Republic of China, Japan and The Philippines.

The methods of evaluation have been varied, but include:

1. Small plot glasshouse tests to evaluate primary efficacy and weed spectrum.
2. Concrete pot outdoor tests primarily designed to evaluate crop selectivity and spectrum under carefully controlled conditions of water depth, rate of water loss etc.
3. Small scale trials in growth rooms to gain understanding of metabolism and activity under conditions of varying temperature.
4. Replicated small plot ($1m^2$ - $50m^2$) field trials in which plots were isolated by earthen bund walls or plastic barriers and irrigation water was fed to each plot independently. Herbicide applications of diluted liquid formulations were generally made using small-plot sprayers. Granule formulations were broadcast by hand. In all cases herbicide applications were made over the crop, and weeds if emerged, in plots containing a nominal water depth of 3-5 cm. Wherever possible a permanent water level was maintained in the plots for some weeks after application.

Herbicide treatments were applied to rice crops at a range of timings from zero up to eighteen days after transplanting. At these timings the growth stage of *Echinochloa* spp. ranged from pre-emergence to early tillering.

Assessments of crop injury and activity on weed species were made at intervals following herbicide application. The efficacy data presented in the tables of results were derived from assessments based on counts, estimates of % cover or fresh weights of weeds.

RESULTS

Performance - Dose rate *Echinochloa crus-galli, E. oryzicola* and *E. glabrescens* were well controlled by WL95481 applied pre- or post-emergence at growth stages up to 2.5 to 3 leaves when used in the range 15-100 g ai/ha. This range in dose rates reflected the geographical distribution and agronomic practices of the trial locations.

In the Philippines good control of *Echinochloa* spp. was given by WL95481 at 100 g ai/ha in the period zero to ten days after transplanting which covered pre-emergence to the two to three leaf stages of the grass weed. Control of later growth stages required a higher dose of WL95481 (Table 1).

Table 1. Percentage control of *Echinochloa* spp. following treatment with WL95481 at different application timings in The Philippines.

Application timing – days after transplanting		0-4	5-7	8-10	11-13
Echinochloa spp. leaf number at treatment		pre-1	1-2	2-3	3-early tillering
WL95481 g ai/ha	50	76(6)[1]	78(5)	55(3)	19(1)
	75	91(1)	84(5)	–	28(2)
	100	95(8)	97(12)	94(2)	42(3)
	200	95(7)	98(7)	97(3)	94(1)

[1] (x) number of trials.

In trials in the Peoples Republic of China, similarly effective control of *Echinochloa* spp. was given by WL95481 at lower doses of 12.5 - 25 g ai/ha (Table 2). This followed applications made to the grass weed at the 1 to 1.5 leaf stage, four to seven days after transplanting. The crops were transplanted by hand at the four to five leaf stage and 20 cm in height. They rapidly formed a crop canopy that was highly competitive to weeds so allowing the use of lower rates of WL95481 for *Echinochloa* spp. control since long persistence of effect was not necessary.

Table 2. The performance of WL95481 on *Echinochloa* spp. in Peoples Republic of China. Summary of 5 trials.

WL95481 g ai/ha	6.25	12.5	25	50	100
Percentage weed control	73	92	94	96	99

In similar work recently completed in Japan a rate of 45 g ai/ha gave effective control up to the 2 leaf stage of *Echinochloa crus-galli,* but 60 g was necessary for effective control at the three leaf stage (Table 3).

Table 3. Performance of WL95481 (in pot trials) in Japan.

% control of *Echinochloa* spp.		Leaf stage at Application		
		1	2	3
WL95481 g ai/ha	90	100	100	95
	60	100	100	95
	45	100	100	80
	30	100	80	40

Results from field trials have shown that the optimum dose does vary between countries. This partly reflects differences in cultural practice, but is also influenced by environmental factors. Using controlled environment growth chambers, it has been demonstrated that the activity of WL95481 on *Echinochloa* spp. in simulated paddy conditions was influenced by temperature. Under cool conditions of 25°C day/10°C night, *E. crus-galli*, treated at the one leaf stage was very sensitive to WL95481 at a low dose of 30 g ai/ha. To achieve similarly effective control under higher temperatures of 35°C day/20°C night, icreases in dose of up to 60-90 g ai/ha were needed (Table 4). Investigation of the ways in which environmental factors affect the performance of WL95481 is continuing.

Table 4. The influence of temperature on the activity of WL95481 on *Echinochloa* spp. in simulated paddy conditions.

Temperature regime (day / night)	Percentage Weed Control Dose g a.i./ha of WL95481		
	30	60	90
Cool (25°C/10°C)	87	100	100
Warm (35°C/20°C)	59	82	98

Performance – Weed spectrum Some other important rice weeds including *Monochoria vaginalis* and annual *Cyperus* spp. proved susceptible to WL95481. Data from The Philippines presented in Fig. 1 show that susceptibility of these weeds varied with application timing. While *Monochoria vaginalis* was susceptible to 100 g ai/ha of WL95481 applied up to 7 days after transplanting; *Echinochloa* was susceptible up to 10 days and *Cyperus difformis* up to 13 days.

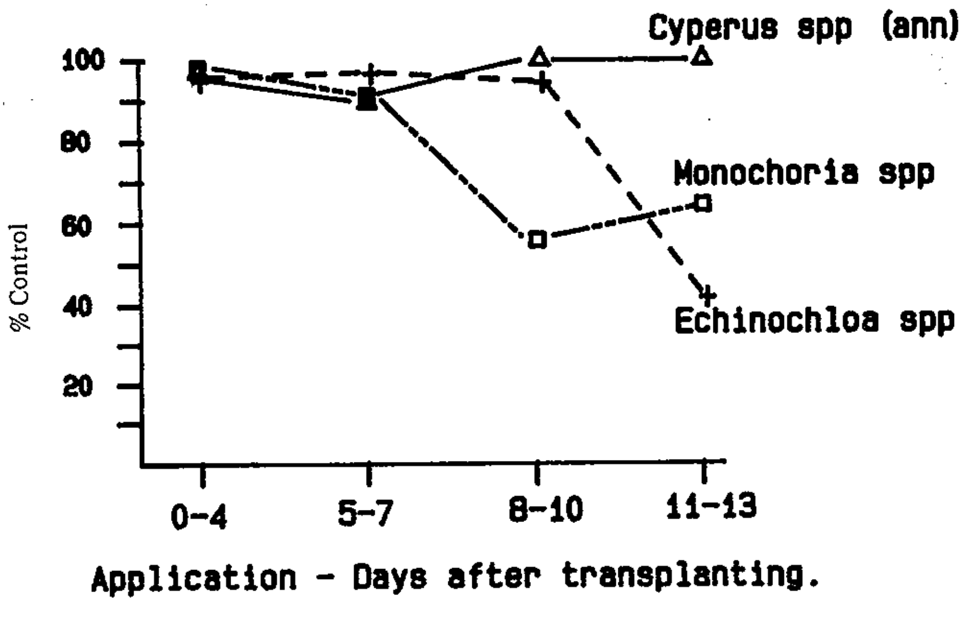


Fig. 1. Effect of application timing on activity. Philippines – 100 g ai/ha.

Based on the trials undertaken over the past two years the following list of weed susceptibilities can be proposed at a dose rate of 50 - 100 g ai/ha.

Efficacy	Annual	Perennial
Excellent	– *Echinochloa crus-galli* – *Echinochloa oryzicola* – *Echinochloa glabrescens* – *Monochoria vaginalis* – *Cyperus difformis*	
Good	– *Dopatrium junceum* – *Elatine triandra* – *Rotala indica* – *Cyperus iria*	– *Eleocharis acicularis* – *Scirpus juncoides*
Poor	– *Lindernia pyxidaria*	– *Sagittaria pygmaea* – *Cyperus serotinus* – *Sagittaria trifolia* – *Potamogeton distinctus* – *Eleocharis kuroguwai* – *Oenanthe javanica*

Performance-mixtures The excellent performance of WL95481 against *Echinochloa* species and a limited range of other important weeds indicated its suitability as a mixture partner in herbicide combinations. Trials to evaluate such mixtures are in progress in several countries. Partners being evaluated include well established products such as 2,4-D or butachlor as well as more recently developed candidates including sulphonyl ureas, pyrazols, phenoxys such as clomeprop, and acetamides such as pretilachlor.

For example, by adding 2,4-D ester to WL95481 in trials in The Philippines the consistency of performance on *M. vaginalis* was enhanced, and the overall performance of this treatment in terms of weed control and grain yield matched the commercial treatment with butachlor/2,4-D (Table 5).

Table 5. Summary of the performance of WL95481 + 2,4 - D applied four to ten days after transplanting of rice in The Philippines.

		Percentage weed control (7)[1]			Grain yield (5)[1]
	g ai/ha	*Echinochloa* spp.	*Monochoria vaginalis*	*Cyperus* spp.	% of untreated
WL95481	100	96	88	94	146
WL95481 + 2,4 - D	100+500	98	96	100	161
butachlor/ 2,4 - D	750/500	97	99	100	153

[1] number of trials.

Similarly, mixtures with pyrazols have extended the spectrum of annual broadleaf weeds whilst with sulphonyl ureas the spectrum has been extended to control perennial sedges.

Crop tolerance Crop tolerance has been influenced by cultural practices in different rice growing areas.

In The Philippines, rice seedlings hand transplanted at the three to four leaf stage were initially sensitive to treatment with WL95481. However, as seedlings became established they rapidly became tolerant such that applications more than four days following transplanting were safe at 200 g ai/ha (Table 6). Seedlings were sensitive while roots were close to the soil surface, but as the root-system penetrated more deeply into the soil the sensitivity declined.

Table 6. Crop effects on EWRC 1-9 scale in transplanted rice in The Philippines following applications made at intervals after transplanting.

Application - DAT		0	1	2	4	6-8	9-11	12-18
WL95481 g ai/ha	50	2.7	1.9	1.0	1.0	1.0	1.0	1.0
	100	3.2	1.5	1.0	1.0	1.0	1.0	1.0
	200	5.0	2.2	1.3	1.5	1.0	1.1	1.0
Number of trials		1	2	1	4	12	4	2

Under Japanese conditions younger rice seedlings, normally at the 2 to 3 leaf stage, are transplanted by machine. Here WL95481 exhibited good crop selectivity at 60 g ai/ha in applications made from seven days after transplanting. This delay in application in Japan allowed an adequate period for root establishment of the younger rice transplant growing more slowly in cooler conditions. If transplanted to 3 cm depth, seedling tolerance was good but shallower transplants required the longer period to become tolerant. The effect of leaching has been investigated in pot and concrete tank tests which showed acceptable crop tolerance with water loss rates of up to 1 cm per day. Selectivity has been affected by temperature, being reduced under conditions of high and variable temperature.

No visible symptoms of crop phytotoxicity were observed in trials in the Peoples Republic of China following applications of WL95481 at doses up to 50 g ai/ha made four to seven days after transplanting of rice.

Crop yield Grain yields from trials in The Philippines treated with WL95481 showed large increases over untreated controls. This reflected the effective control of heavy infestations of weeds and safety to the crop (Table 7). In trials in the Peoples Republic of China, against light weed infestations, WL95481 gave small but consistent yield increases at doses up to 50 g ai/ha (Table 8).

Table 7. Grain yields expressed as a percentage of the untreated control in The Philippines (heavy weed infestation).

Dose - g ai/ha of WL95481	0	50	75	100	200
Yield - % of untreated	100	183(7)[1]	143(8)	160(18)	206(10)

[1] (x) number of trials.

Table 8. Grain yields expressed as a percentage of the untreated control in the Peoples Republic of China (light weed infestations). Summary of 5 trials.

Dose g ai/ha of WL95481	0	6.25	12.5	25	50	100
Yield - % of untreated	100[1]	102	106	107	105	100

1 Mean grain yield in untreated control equivalent to 6 tonnes/ha.

DISCUSSION

The physical, chemical and toxicological features of WL95481 make the product attractive for use in paddy conditions. The compound has a low order of mammalian toxicity. In addition it has moderate persistence and shows no tendency to accumulate in the environment.

WL95481 at low doses of 15-100 g ai/ha in paddy water provided outstanding control of *Echinochloa* spp. with a wide window of application. The compound was also effective against several other important rice weeds including *M. vaginalis,* and annual *Cyperus* spp. WL95481 was safe to large hand transplanted rice plants at doses up to 200 g ai/ha when applied 4 days after transplanting. Smaller, machine transplanted rice required a longer period of establishment to aquire tolerance i.e. 7 days.

In many countries the spectrum of weeds controlled by WL95481 covers the principal weeds of paddy rice and the compound could therefore be used alone. Where other weeds are encountered WL95481 provides a sound base of performance on which mixture combinations can be built to suit local needs.

Having demonstrated potential in transplanted rice, the performance of WL95481 in the direct-seeded crop is currently being investigated.

ACKNOWLEDGEMENTS

The authors thank their colleagues in Shell companies and co-operators in Asia for the production of technical information used in this report.

A NEW TRIAZINE HERBICIDE FOR UPLAND CROPS: 6-DIFLUOROMETHYLTHIO-N,N-BIS (1-METHYLETHYL)-1,3,5-TRIAZINE-2,4-DIAMINE

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ABSTRACT

SSH-108, 6-difluoromethylthio-N,N-bis (1-methylethyl)-1,3,5-Triazine-2,4-diamine, is a new triazine herbicide discovered by Shionogi & Co., Ltd. for weed control in a wide variety of crops and fruit trees. SSH-108 controls a wide spectrum of annual broadleaf weeds and grasses when applied either pre-or post-emergence. It is selective as a pre-emergence application on corn, sorghum, wheat, soybean, potato and certain other crops. The inhibition of photosynthesis was found to be the primary factor for the herbicidal activity. The activity is little affected by environmental factors such as temperature, soil type and organic matter content. SSH-108 does not readily move through soil, and adequate soil moisture following application has effect on satisfactory pre-emergence weed control.

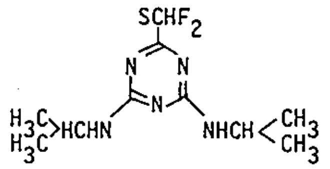
INTRODUCTION

SSH-108 is one of the s-triazine derivatives synthesized by Shionogi & Co., Ltd. The compound has a systemic herbicidal activity against broadleaf weed and grasses at pre-or early post-emergence application. In soil, the compound showed a minimal movement and longer residual activity.

SSH-108 has been tested on many upland crops and has shown a potential use as a pre-emergence application herbicide on soybean, corn, wheat and barley.

Physico-chemical and toxicological properties

The chemical formula of SSH-108 is:



Empirical formula : $C_{10}H_{17}N_5SF_2$
Molecular weight : 277.34
Melting point : 57-58.0°C
Vapour pressure : 2.5 10^{-5} mmHg

The technical material is a white crystalline solid, essentially odorless and with a solubility of 38 ppm (20°C). It is readily soluble in ethanol, aceton and xylene.

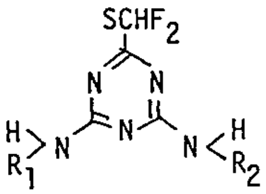
Its acute oral LD_{50} is 618 mg/kg for male rats and 889 mg/kg for female rats. The material is not mutagenetic in Ames Test. The LC_{50} value for Japanese carp is 1.54 ppm, and 17.8 ppm for water free.

RESULTS

Biological properties

Herbicidal activities SSH-108 was selected in a number of newly synthesized s-triazine derivatives with the broad spectrum of weed control (Table 1).

Table 1. Herbicidal activity of the triazine derivatives[1].



R1	R2	Pre-appl.						Post-appl.					
		E. crus-galli	*D. ciliaris*	*P. lapathifolium*	*A. viridis*	*E. oryzicola*	*M. vaginalis*	*E. crus-galli*	*D. ciliaris*	*P. lapathifolium*	*A. viridis*	*E. oryzicola*	*M. vaginalis*
$CH(CH_3)_2$	$CH(CH_3)_2$ (SSH-108)	5[2]	5	5	5	5	5	5	5	5	5	5	5
CH_2CH_3	CH_2CH_3	5	5	5	5	5	5	5	5	5	5	5	5
CH_2CH_3	$CH(CH_3)_2$	5	5	5	5	5	5	5	5	5	5	5	5
CH_3	CH_3	4	5	5	5	5	5	4	5	5	5	5	5
H	H	0	0	0	0	0	0	4	1	4	4	4	4
CH_2CH_3	$(CH_2)_7CH_3$	1	1	3	5	3	5	5	5	5	5	5	5
Prometryne		5	5	5	5	5	5	5	5	5	5	5	5
Untreated		0	0	0	0	0	0	0	0	0	0	0	0

[1] Dosage: 4 kg ai/ha

[2] Activity ratings: 0: no injury – 5: complete kill

The compound demonstrated a systemic herbicidal activity on broadleaf weeds (*Amaranthus* spp., *Chenopodium* spp. and grass (*Digitaria* spp., *Alopecurus* spp.) at pre-or early post-emergence application, with inhibition of photosynthesis. The herbicidal spectrum is characterized at lower rates of 0.25-0.5 kg/ha by its high activity (Table 2).

Table 2. Herbicidal spectrum of SSH-108 at pre- or post-emergence in upland conditions.

Weed Species	Pre-emergence				Early post-emergence			
Kg/ha	0.25	0.5	1.0	2.0	0.25	0.5	1.0	2.0
Digitaria ciliaris	S[1]	S	S	S	S	S	S	S
Echinochloa crus-galli	S	S	S	S	MS	S	S	S
Alopecurus aequalis	S	S	S	S	S	S	S	S
Poa annua	S	S	S	S	S	S	S	S
Cyperus microiria	S	S	S	S	–	–	–	–
Polygonum lapathifolium	S	S	S	S	S	S	S	S
Chenopodium album	S	S	S	S	–	–	–	–
Amaranthus viridis	S	S	S	S	S	S	S	S
Portulaca oleracea	S	S	S	S	–	–	–	–
Mollugo verticillate	S	S	S	S	–	–	–	–
Stellaria media	S	S	S	S	–	–	–	–
Capsella bursa-pastris	S	S	S	S	–	–	–	–
Rorippa indica	S	S	S	S	–	–	–	–
Veronica persica	S	S	S	S	–	–	–	–
Lamium amplexicaule	S	S	S	S	–	–	–	–
Gallium aparine	S	S	S	S	MR	MS	S	S

[1] Susceptibility: S: susceptible MS: moderately susceptible MR: Moderately resistant
R: resistant – : not tested

SSH-108 has been evaluated on many upland crops and showed a potential use as a pre-emergence herbicide on corn, sorghum, wheat, barley, soybean, cotton, peanut, potato and carrot etc., and a little susceptible to vegetables (Table 3). Herbicidal effects of SSH-108 was evaluated at different leaf stage of weed. The most susceptible stage of weeds to the compound was pre-emergence to early post-emergance of 1-2 leaf stage, and grass of post-stages were moderately resistant in compared with broadleaf (Fig. 1).

Behavior in soil The activity of SSH-108 was slightly affected by the kind of soil, and demonstrated of crop tolerance in planting crops at pre-application system. The activity was maximum at rate of 0.25 kg in loam and sandy loam, 0.12 kg in loamy sand soil on *Polygonum* spp. (Table 4).

Table 3. Crop tolerance of SSH-108 at pre- or post-emergence applications.

Crop	Pre-emergence				Early post-emergence			
	0.25	0.5	1.0	2.0	0.25	0.5	1.0	2.0
Corn	R[1]	R	R	R	R	R	MR	MR
Sorghum	R	R	R	R	–	–	–	–
Upland rice	R	R	R	R	–	–	–	–
Wheat	R	R	R	R	MS	S	S	S
Barley	R	R	R	MR	–	–	–	–
Oat	R	R	MS	S	–	–	–	–
Soybean	R	R	R	R	S	S	S	S
Azuki bean	R	R	R	R	–	–	–	–
Kidney bean	R	R	R	MR	–	–	–	–
Common bean	R	R	R	R	–	–	–	–
Cowpea	R	R	R	MS	–	–	–	–
Peanut	R	R	R	R	–	–	–	–
Potato	R	R	R	R	–	–	–	–
Cotton	R	R	R	R	MS	S	S	S
Sugarbeet	S	S	S	S	S	S	S	S
Oil seed rape	MR	MR	S	S	S	S	S	S
Tomato	S	S	S	S	S	S	S	S
Sunflower	R	R	R	R	–	–	–	–
Carrot	R	R	R	R	–	–	–	–

[1] Susceptibility: R: resistant MR: moderately resistant
MS: moderately susceptible S: susceptible
– : not tested

The distribution of SSH-108 in soil column was determined by bioassay with *Digitaria* spp. in sandy loam soil, compared with other herbicides. Simulated rainfall of 30 mm per hrs was given after treatment of the compound 1.0 kg. Leaching bioassay demonstrated that SSH-108 was slightly leached in the soil than prometryne or atrazine, for the reason of the solubility of 38 ppm in water. In column soil SSH-108 was leached to a depth of 2 cm, prometryne and atrazine to 3-4 cm, respectively (Fig. 2).

SSH-108 was applied at 1.0 kg of soil surface application under field conditions. The test soils were sampled and determined of the residue amount of the compound in soil in gas chromatography. The half-life of SSH-108 was about 90 days in sandy loam, 60 days in sandy clay loam soil, and 20 days of atrazine. From the results the compound demonstrated to have a longer residual activity in soil (Table 5).

Field evaluation Pre-emergence application of SSH-108 provided excellent (85-100 %) control of

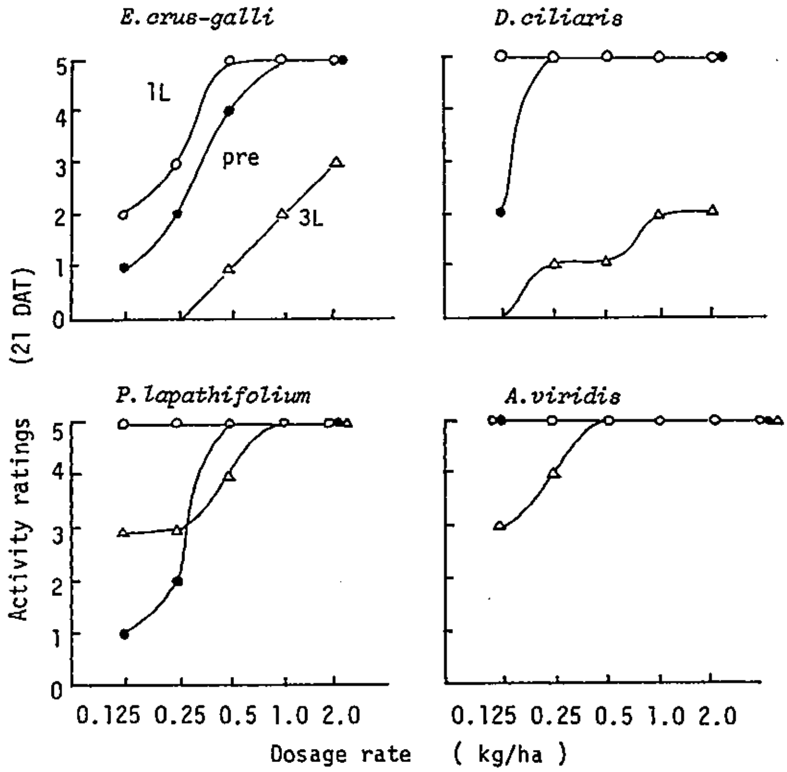


Fig. 1. Herbicidal effect of SSH-108 treated at different leaf stages of weed. Activity ratings: 0: no injury – 5: complete kill

Table 4. Influence of soil texture on the herbicidal activity of SSH-108[1].

Rate of SSH-108 kg/ha	Herbicidal activity (rating[2]: 0-5)					
	D. ciliaris			*P. lapathifolium*		
	Loam	Sandy loam	Loamy sand	Loam	Sandy loam	Loamy sand
0.125	0	2	5	4	4	5
0.25	3	3	5	5	5	5
0.5	5	5	5	5	5	5
1.0	5	5	5	5	5	5
2.0	5	5	5	5	5	5
Untreated	0	0	0	0	0	0

1 Application : Pre-emergence (soil surface); Evaluation : 21 DAT

2 Activity ratings : 0: no injury – 5: complete kill

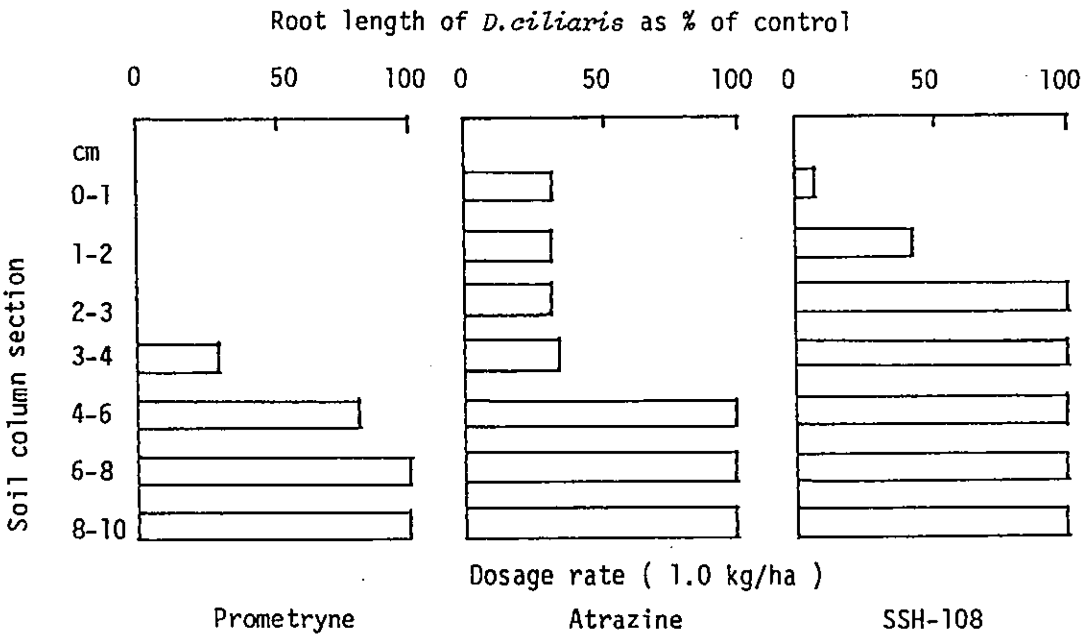


Fig. 2. Leaching of SSH-108 as indicated by relative root length of *Digitaria ciliaris* grown in sandy loam soil from the column.

Table 5. Half-life of SSH-108 in soil under field coditions[1].

Soil	Half-life in soil (day)[2]	
	SSH-108	Atrazine
Sandy loam	90	20
Sandy clay loam	60	20

[1] Application : Soil surface application; Analytical method : Gas chromatography
[2] Dosage rate : 1.0 kg/ha

important species of broadleaf (*Stellaria media, Capsella bursa-pastoris*) and grass (*Alopecurus aequalis*) weeds at 0.25-0.5 kg/ha in winter field, 1985. In general, wheat and barley showed good tolerance to the pre-emergence application of SSH-108 at rates up to 1.0 kg/ha (Table 6).

Table 6. Performance of SSH-108 at pre-emergence application in wheat and barley[1].

Compound	Rates (kg/ha)	Crop injury		% Weed[2] control		
		Wheat	Barley	AA	SM	CB
SSH-108	0.25	None	None	87	99	97
	0.5	None	None	100	100	100
	1.0	None	None	100	100	100
Linuron	0.75	None	None	100	100	100
Untreated	0	None	None	0	0	0

[1] Field trial, September-October 1985.

[2] AA : *Alopecurus aequalis* SM : *Stellaria media* CB : *Capsella bursa-pastoris*

In corn field and soybean, pre-emergence application of SSH-108 provided excellent (90-100 %) control of a variety of broadleaf and grass weeds at 0.75 kg, *Veronica, Portulaca* and *Amaranthus* spp. found very susceptible, in summer field. Corn and soybean showed good tolerance to pre-application of SSH-108 at rate of 1.0 kg/ha.

SSH-108 is under extended field evaluation for corn, wheat, soybean and other crops with respect to a wide herbicidal spectrum and crop selectivity.

Table 7. Performance of SSH-108 at pre-emergence application in corn and soybean.

Compound	Rates (kg/ha)	Crop injury		% Weed[1] control						
		Corn	Soybean	EC	CM	VP	SM	PO	AV	CA
SSH-108	0.5	None	None	90	86	100	81	98	97	94
	0.75	None	None	98	90	100	94	100	99	100
	1.0	None	None	100	98	100	98	100	100	100
Prometryne	1.0	None	None	100	94	100	88	99	100	100
Atrazine	0.75	None	–	48	94	95	98	100	100	100
Linuron	0.75	–	None	45	44	95	79	85	99	94
Untreated	0	None	None	0	0	0	0	0	0	0

[1] EC : *Echinochloa crus-galli* CM : *Cyperus microiria* VP : *Veronica persica*
SM : *Stellaria media* PO : *Portulaca oleracea* AV : *Amaranthus viridis*
CA : *Chenopodium album*
Field trial, May-June 1985

LITERATURE CITED

1. Gysin, H. 1962. Chem. Ind (London), 4: 1393.
2. Morita, K., K. Ide and Y. Hayase. 1987. Agric. Biol. Chem., 51: 1339.
3. Morita, K., T. Nagare and Y. Hayashi. 1987. Agric. Biol. Chem., 51: 1955.

ACTIVITY, ABSORPTION, AND TRANSLOCATION OF FLUAZIFOP-BUTYL IN UPLAND RICE (*ORYZA SATIVA*) AND IN THREE GRASS WEEDS

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ABSTRACT

The activity, absorption, and translocation of fluazifop-butyl [(±)-2-[4-[[5-trifluoromethyl)-2-pyridinyl] oxylphenoxy) propanoic acid] in upland rice (*Oryza sativa L.*) and in three grass weeds were determined in field, greenhouse, and laboratory studies at the International Rice Research Institute. Fluazifop-butyl injured rice more when applied at pretillering or early tillering than when applied at tillering or late tillering. Rice recovered from initial injuries immediately after herbicide treatment, with the faster and more complete recovery at lower herbicide rates and/or later applications. Control of grasses was excellent at 0.05 kg ai/ha fluazifopbutyl or higher, applied not later than 2ǀdays after rice emergence. Goosegrass [*Eleusine indica* (L.) Gaertn. # [3] ELEIN] (# [3] Letters following this symbol are a WSSA-approved computer code from composite List of Weeds, Weed Sci. 32, Suppl. 2). was more susceptible than itchgrass [*Rottboellia cochinchinensis* (Lour.) Clayton # ROOEX] or junglerice [*Echinochloa colona* (L.) Link # ECHCO]. *E. indica* also translocated more ^{14}C-fluazifop-butyl than did rice or the other two weed species. At 24 h after foliar application of C^{14}-fluazifop-butyl, radioactivity in parts outside the treated leaf of goosegrass was 40 times higher than in rice, itchgrass, or junglerice.

INTRODUCTION

Upland rice is planted on 4.6 M ha of the rice area in Southeast Asia; 0.4 M ha of it in the Philippines (7). After drought stress, weeds are the second most important factor in reducing upland rice yields, with yield losses reported to range from 42 to 100% (2, 12).

An ideal weed control program in upland rice should provide adequate control from 4 to 9 weeks after sowing (18). Weed competition with upland rice is more critical at this stage than in lowland rice because of the absence of standing water and because of the close similarity between direct-seeded rice and weed seedlings. The time of land preparation for upland rice, which coincides with the start of the rainy season when the soil is soft enough for tillage, is also an ideal time for grass weeds to germinate and grow profusely.

Available weed control options include cultural methods (one to four hand or hoe weedings) and chemical control (10). Most of the available herbicides are preemergence compounds; the control provided usually does not last through the critical competition period. Most preemergence herbicides also are dependent on soil moisture for optimum activity (15).

Postemergence herbicides can provide adequate control of weeds in rice at later growth stages than can be achieved with currently available preemergence herbicides. But propanil (3', 4'-dichloropropionanilide), commonly used against grasses, has compatibility problems with certain insecticides. 2,4-D

[2,4-Dichlorophenoxy) acetic acid] and MCPA [(4-chloro-o-tolyl) oxylacetic acid] mainly control broadleaf weeds.

The recent discovery of postemergence grass herbicides offers a potential for more flexibility and expands the control options for rice growers. Although these compounds are highly selective to dicotyledonous plants, there are indications that they have possibilities for postemergence grass control in rice. Reports from rice-growing areas in the U. S. A. and in Costa Rica have shown that rice can tolerate these herbicides at low rates and with timely applications (5, 16, 17). Although fluazifop-butyl applied at panicle initiation injured rice, when applied at the vegetative stage it did not cause injury (5). Most studies have confirmed rice tolerance with respect to yield to fenoxaprop [(±)-2-[(6-chloro-2-benzoxazolyl) oxylphopanoic acid] (16). The rates they reported also were shown to provide adequate control of major grass weeds infesting upland rice.

The principal objective of these studies was to identify rates and times of fluazifop-butyl applications which are selective to rice, yet provide adequate control of three grass weeds -- itchgrass, goosegrass, and junglerice -- under field and greenhouse conditions. Because activity and selectivity of postemergence herbicides are generally influenced by their behavior in the plant, we also studied in the laboratory the absorption and translocation of ^{14}C-fluazifop-butyl in rice and in the three grasses.

MATERIALS AND METHODS

Field The field study was conducted at the IRRI experimental farm from June to October 1986. Soil was Lipa clay loam (Eutropepts, pH 5.5, organic matter 2.7%, CEC 38 meq/100g soil). Average rainfall during the experimental period was 461mm; daily radiation, 15.4 MJ/m^2; day and night temperatures, 31/21°C; and relative humidity, 78%. Treatments were arranged in a split plot design with times of application in the main plots and weed control treatments in the subplots. Each treatment had three replications. Treatment means were compared using LSD at 5% level.

Prior to land preparation, the predominant weeds were itchgrass, goosegrass, spiny amaranth (*Amaranthus spinosus* L. # AMASP), morningglory (*Ipomoea triloba* L. # IPOTR), and crabgrass [*Digitaria ciliaris* (Retz.) Koel. # DIGSP]. The field was plowed once and harrowed twice. Rice cultivar UPL-Ri-7 was seeded June 10, 1986, into 3 x 5 m plots at 100 kg/ha. Urea fertilizer (100 kg/ha) was applied in three splits at 18, 30, and 65 days after rice emergence.

Four rates of fluazifop-butyl were applied at four growth stages of rice. Number of leaves and number of tillers per plant at those growth stages averaged over all replications are summarized in Table 1. Because low yields resulted from extremely wet conditions at harvest, rice yield data are not shown. Fluazifop-butyl was sprayed with a hydraulic knapsack sprayer at a volume of 260-300 L/ha. Agral 90 (0.1% by volume) was added to the spray solution.

Rice plant injury was rated on a scale of 0 (untreated) to 100 (dead plant) once a week for the 4 weeks following each treatment. Morphological symptoms were recorded.

Weeds from two 0.5 by 0.5 m quadrats in each plot were counted by morphological classification (grass, broadleaf, sedge) at 40 days after first treatment and fresh and dry weights recorded.

Greenhouse Studies in January 1985 to August 1987 at the IRRI greenhouse used soil from the field in which the field study was done. Treatments were completely randomized, with three replications. Means were separated by LSD at 5% level.

Dose-response Seedlings of rice cultivar IR58 and the three grass weeds grown in plastic pots and trays were sprayed with fluazifop-butyl at four rates (for rice) and five rates (for weeds) at pretillering and early tillering. Seeds germinated at staggered intervals in order to have all stages of growth at one time to ensure uniform conditions after treatment. Average size of plants at different times of treatment are in Table 1. Crop and weed injury were rated on a scale of 0 (untreated) to 100 (dead plant) weekly for the first 4 weeks following treatment. Rice root and shoot fresh weights and numbers of tillers were recorded 30 days after treatment.

Table 1. Number of leaves and tillers of rice and three weed species at various times of fluazifop-butyl application in the laboratory, greenhouse, and field studies. [1]

Time of treatment[2] (DAE)	Rice		Itchgrass		Junglerice		Goosegrass	
	Leaf (no./plant)	Tiller	Leaf (no./plant)	Teller	Leaf (no./plant)	Tiller	Leaf (no./plant)	Teller
Pretillering (7)	3-4	–	3-5	–	3-4	–	3-4	–
Early tillering (14)	7-8	2-3	7-8	–	7-8	2-3	7-8	2-3
Tillering (21)	12-15	4-6	10-15	1-2	10-15	3-4	20-50	6-10
Late tillering (28)	15-20	6-10	20-30	9-10	15-20	4-5	100-150	15-20

[1] Averaged over all studies.

[2] Numbers in parentheses indicate days after emergence (DAE) at particular growth stages.

Time of application IR58 rice and weed seedlings were sprayed with fluazifop-butyl at two rates (for rice) and five rates (for weeds) at four growth stages. Data gathered were similar to those described in the dose-response study.

Laboratory Laboratory studies were conducted in the IRRI Radioisotope Laboratory from October 1985 to March 1986. Statistical design and analysis were similar to those of the greenhouse studies.

Absorption and translocation in rice IR58 seeds were germinated in plastic pots filled with a mixture of 1:1 sand and upland soil. At the 3-leaf stage, the middle leaf was treated with 20 μL of 0.03 μCi ^{14}C-fluazifop-butyl. At 1, 4, and 8 days after treatment, the plants were sectioned into treated leaf, shoot above the treated leaf, shoot below the treated leaf, and root system. The treated leaf was washed for 30 seconds in 35 ml hexane. One milliliter of the wash was added to 10 ml scintillation fluid and radioassayed to account for radioactivity on the treated leaf surface. Each plant part was cut into 2 mm pieces, placed in 20 ml vials, and combusted in a biological oxidizer. The $^{14}CO_2$ was trapped by a CO_2 absorbed, scintillation fluid was added, and radioactivity counted in a Packard 300 liquid scintillation counter.

Absorption and translocation in rice and weeds Seeds of rice cultivar IR58 and of itchgrass, junglerice, and goosegrass were germinated and grown as in the first laboratory study. At the 3-leaf stage, the middle leaf was treated with 20 μL of 0.2 μCi ^{14}C-fluazifopbutyl. At 6 and 24 h after treatment, plants were cut, combusted, and radioassayed following the procedure of the first study.

RESULTS AND DISCUSSION

Field Herbicide applied at pretillering resulted in 20 to 40% injury to rice at the three highest rates and no injury at the lowest rate 1 week after spraying (Table 2). By 2 weeks after spraying, plants treated at the three lowest rates had recovered. Plants treated with 0.25 kg/ha fluazifop-butyl also showed recovery by 3 weeks after treatment. Herbicide applied at early tillering resulted in 60% injury at the highest rate, 10 to 20% injury at the two middle rates, and no injury at the lowest rate 1 week after application. Full recovery of plants treated with 0.10 kg herbicide/ha or less and partial recovery of plants treated with 0.25 kg/ha was evident 3 weeks after treatment. The same trend, although with much lower injury, was observed with later applications. No injury was observed at 0.01 kg/ha applied 21 days after rice emergence and at 0.05 and 0.01 kg/ha applied 28 days after rice emergence. Plants treated at later stages and at lower rates recovered fully, and at a faster rate.

Weed dry weights at 40 days after the first spraying showed excellent control of annual grasses at 0.05 kg/ha fluazifop-butyl or higher applied 7 to 21 days after rice emergence (Table 3). Grass control was inadequate when fluazifop-butyl was applied at rates of 0.05 kg/ha or lower 28 days after emergence. Weed weights at 0.01 kg/ha applied 28 days after emergence were comparable to those of untreated plots. Control of grasses resulted in a shift to broadleaf weeds (Table 3). When weight of grasses and broadleaf weeds were combined, the best treatments were those at 0.05 kg/ha or higher applied 7 to 21 days after rice emergence or 0.10 kg/ha or higher applied 28 days after emergence.

Greenhouse

Dose response, rice Seven days following fluazifop-butyl application, plants treated at pretillering with the three highest rates had 60% or more injury; those treated at the two highest rates did not recover (Table 4). When fluazifop-butyl was applied at early tillering, rice and 46% or more injury at the three highest rates; injury increased to more than 60% at 2 weeks following treatment. Shoot fresh weights show that plants treated with 0.01 kg/ha at pretillering and those treated with 0.01 an 0.05 kg/ha at early tillering eventually recovered fully (Table 4). Except in plants treated at pretillering, root fresh weights were not reduced with later applications. Inhibited growth of apical shoots may have released apical dominance and resulted in increased tillering weight 0.05 and 0.10 kg/ha at both application times.

Time of application, rice Injury ratings and shoot and root fresh weights showed similar trends to those of the dose-response study (Table 4). Application at 21 to 28 days after emergence caused negligible differences in shoot and root fresh weights. As in the dose-response study, increased tillering was observed at 0.05 kg/ha applied at or more than 14 days after emergence, probably due to damaged apical meristems.

Table 2. Injury rating of rice cv. UPL-Ri-7 treated with four rates of fluazifop-butyl at four growth stages at the IRRI experimental farm during the 1986 wet season.

Growth stage[1] (DAE)	Rate (kg ai/ha)	Injury rating[2]			
		7 DAT	14 DAT	21 DAT	28 DAT
Pretillering	Unweeded	0	0	0	0
(7)	Hand weeded 2x	0	0	0	0
	0.01	0	0	0	0
	0.05	17	0	0	0
	0.10	23	0	0	0
	0.25	40	20	10	10
Early tillering	Unweeded		0	0	0
(14)	Hand weeded 2x	0	0	0	0
	0.01	0	0	0	0
	0.05		10	0	0
	0.10		23	10	0
	0.25		63	30	10
Tillering	Unweeded			0	0
(21)	Hand weeded 2x			0	0
	0.01			0	0
	0.05			3	0
	0.10			13	0
	0.25			33	10
Late tillering	Unweeded				0
(28)	Hand weeded 2x				0
	0.01				0
	0.05				0
	0.10				10
	0.25				20

[1] Numbers in parentheses indicate days after rice emergence.

[2] Average of 3 replications: Rating scale: 0 = as untreated; 100 = dead plant.
DAT = days after treatment.

Table 3. Dry weight of weeds in rice cv. UPL-Ri-7 treated with four rates of fluazifop-butyl at four growth stages at the IRRI experimental farm during the 1986 wet season.

Rate (kg/ha)	Growth[2] stage (DAE)	Weed weight (g/m²)[1]							
		Grasses				Broadleaf weeds			
		7[2]	14	21	28	7[2]	14	21	28
Unweeded		730	740	644	562	15	21	5	24
Hand weeded 2x		4	5	6	3	2	18	11	2
0.01		353	147	291	475	78	87	14	22
0.05		15	1	0	178	116	155	105	51
0.10		5	2	4	49	313	110	99	103
0.25		8	0	19	0	111	155	94	118
LSD (0.05)		186	186	186	186	86	86	86	86

[1] Average of three replication; taken 40 days after the first herbicide spraying.

[2] Growth stage at days after emergence (DAE): 7 = pretillering, 14 = early tillering, 21 = tillering, 28 = late tillering.

Rate and time of application, weeds Itchgrass was completely controlled at the two highest rates (0.25 and 0.5 kg/ha) with all times of application (Table 5). The lower rates did not provide adequate control, even when applied at earlier growth stages. Junglerice was completely controlled at all except the lowest rate applied at pretillering. Only the higher rates applied 14 to 21 days after emergence provided adequate control. Junglerice was tolerant to all rates of fluazifop-butyl applied 28 days after emergence. Goosegrass was more susceptible to fluazifop-butyl than were either itchgrass or junglerice. At rates 0.10 kg/ha or higher, all plants were completely controlled at all growth stages. Even the lowest rate (0.01 kg/ha) applied at pretillering and early tillering provided excellent control (90-100%). When applied later than 14 days after emergence, higher rates (0.05 to 0.10 kg/ha) were needed.

From the greenhouse and field studies, the following observations can be made on the morphological reactions of rice and weeds at different rates and times of fluazifop-butyl application. Morphological injury symptoms were fully apparent about 7 days after foliar application in all studies. Young leaves and growing points were chlorotic, leaves emerging at the time of treatment were crinkled or rolled and twisted. Dark green or bright red pigmentation resembling senescence pigment changes were observed in older leaves. Symptoms were similar in goosegrass, large crabgrass [*Digitaria sanguinalis* (L.) Scop #DIGSA], and itchgrass (1, 4).

In the greenhouse, although rice suffered initial injury immediately after herbicide application, particularly at rates higher than 0.05 kg/ha applied at pretillering or early tillering, the plant did recover

Table 4. Injury, weight, and tiller production of IR58 rice seedlings treated with fluazifop-butyl at the IRRI greenhouse.[1]

Growth stage[2] (DAE)	Rate (kg ai/ha)	Injury rating[3]		Fresh weight[4] (g/plant)		Tillers[4] (No./20 plants)
		7 DAT	14 DAT	Shoot	Root	
DOSE RESPONSE						
Pretillering	0	0	0	6.5	3.5	23
(7)	0.01	39	10	8.1	4.6	23
	0.05	60	35	2.3	1.5	41
	0.10	62	60	2.0	1.6	37
	0.25	84	90	0.4	0.5	25
Early tillering	0	0	0	7.6	3.5	21
(14)	0.01	25	13	5.2	2.3	27
	0.05	46	33	5.4	3.6	41
	0.01	21	65	2.0	2.7	27
	0.25	77	73	1.1	1.1	23
LSD (0.05)				2.6	2.6	5
TIME OF APPLICATION						
Pretillering	0	0	0	26	30	36
(7)	0.01	45	3	23	20	39
	0.05	95	55	16	11	36
Early tillering	0	0	0	35	21	24
(14)	0.01	38	5	32	20	25
	0.05	76	23	24	16	37
Tillering	0	0	0	41	21	32
(21)	0.01	19	0	45	21	34
	0.05	39	15	38	19	50
Late tillering	0	0	0	40	20	28
(28)	0.01	10	0	38	19	22
	0.05	23	3	35	19	37
LSD (0.05)				6	4	8

[1] Average of 3 replications.

[2] Numbers in parentheses indicate days after emergence (DAE).

[3] Rating scale: 0 = as untreated; 100 = dead plant; DAT = days after treatment.

[4] Taken 30 days after treatment.

Table 5. Injury and shoot fresh weights of three grass weeds 30 days after treatment with five rates of fluazifop-butyl at four growth stages at the IRRI greenhouse. [1]

Time (DAE)[2]	Rate (kg ai/ha)	Itchgrass[3]		Junglerice[3]		Goosegrass[3]	
		Injury rating	Shoot fresh weight (g/plant)	Injury rating	Shoot fresh weight (g/plant)	Injury rating	Shoot fresh weight (g/plant)
Pretillering (7)	0	0	5.23	0	4.25	0	5.92
	0.01	0	5.37	0	5.35	93	2.94
	0.05	55	0.45	100	–	100	–
	0.10	63	0.13	100	–	100	–
	0.25	93	0.06	100	–	100	–
	0.50	100	–	100	–	100	–
Early tillering (14)	0	0	3.80	0	5.80	0	2.73
	0.01	7	2.95	0	0.99	93	0.73
	0.05	17	1.27	77	0.54	92	0.02
	0.10	47	0.17	100	–	100	–
	0.25	88	0.14	93	0.83	100	–
	0.50	97	0.14	100	–	100	–
Tillering (21)	0	0	10.08	0	5.68	0	8.82
	0.01	13	4.39	0	7.95	0	4.77
	0.05	45	1.75	0	4.69	100	–
	0.10	62	0.74	63	2.06	100	–
	0.25	87	0.79	100	–	100	–
	0.50	100	–	100	–	100	–
Late tillering (28)	0	0	9.42	0	13.68	0	6.57
	0.01	28	4.07	0	10.02	0	6.83
	0.05	43	2.23	0	10.00	28	5.03
	0.10	88	1.32	10	12.20	100	–
	0.25	90	0.66	15	7.96	100	–
	0.50	98	0.94	68	5.44	100	–
LSD (0.05)			2.29		2.43		1.55

[1] Average of three replications.

[2] Numbers in parentheses indicate days after emergence (DAE).

[3] Rating scale: 0 = as untreated; 100 = dead plant. Taken 30 days after treatment.

fully within 1 or 2 weeks following treatment at lower rates and with later applications. In the field, rice exhibited a greater degree of tolerance with faster and more complete recovery at lower rates and later applications. Rice can tolerate up to 0.25 kg herbicide/ha applied at late tillering.

Other studies have reported greater sensitivity of rice to fluazifop-butyl at panicle initiation than at vegetative stage (5). Although yields were not reduced, Snipes and Street (16) observed greater susceptibility of rice to fenoxaprop applied at booting or heading than at early vegetative stages.

In the field, excellent control of grasses was obtained with 0.05 kg herbicide/ha or higher applied not later than 21 days after rice emergence. Later applications needed higher rates for control. In the greenhouse, goosegrass was consistently more susceptible to fluazifop-butyl at all times of application than junglerice and itchgrass. Junglerice was more susceptible than itchgrass with early applications but was more tolerant than itchgrass with later applications.

The rates used in our studies were in the range of effective dosages reported in other studies. Deer et al.(4) observed good to excellent control (90-100%) of goosegrass with 0.03 to 0.14 kg/ha fluazifop-butyl at tillering. When applied at late tillering, goosegrass was controlled at higher rates (0.28 and 0.56 kg/ha). Those workers also observed consistently greater susceptibility of goosegrass than foxtail and crabgrass. Itchgrass was controlled at 0.08 to 0.20 kg fluazifop-butyl/ha (1, 11, 14).

Laboratory Recovery of radioactivity in treated leaf wash and plant tissues averaged 92% over the 24 h period following ^{14}C-fluazifop-butyl application. The amount of ^{14}C recovered decreased with time and was less than 50% of the total ^{14}C applied 7 days after treatment. These figures agree with those obtained by Kells et al. (9), whose recoveries from quackgrass [*Agropyron repens* (L.) Beauv. # AGRRE] ranged from 69 to 76% 6 days after application. Derr et al. (3) reported recovery figure from goosegrass, crabgrass, and giant foxtail (*Setaria faberii* Herrm. # SETFA) ranging from 79 to 88% 24 h after application.

Absorption and translocation in rice The amount of ^{14}C-fluazifop-butyl absorbed by rice seedlings increased across 1 to 8 days after foliar application (Table 6). The largest rate of absorption occurred during the first 4 days, as shown by ^{14}C accumulated in the treated leaf. Although the amount of ^{14}C moving out of the treated leaf also increased with time, this did not exceed 9% of the total ^{14}C recovered 8 days after application. Most (90 to 95%) of the radioactivity remained in the treated leaf. Slightly greater ^{14}C was transported to plant parts below the treated leaf. At 8 days after application, the amount of ^{14}C-fluazifop-butyl per dry weight of plant tissue decreased in the treated leaf and increased slightly in parts outside the treated leaf.

Absorption and translocation in rice and weeds Six hours after ^{14}C-fluazifop-butyl application, the amount of radioactivity absorbed by rice and itchrass was lower (22 and 28%) than that absorbed by junglerice and goosegrass (49 and 52%) (Table 7). Twenty-four hours after application, junglerice had the highest rate of absorption, followed (in decreasing order) by goosegrass, rice, and itchgrass.

Of the ^{14}C-fluazifop-butyl absorbed in the plant, 96 to 98% remained in the treated leaves of rice, itchgrass, and junglerice; about 58% remained in the treated leaf of goosegrass. Goosegrass translocated the greatest amount of ^{14}C-fluazifop-butyl (40%) into parts outside the treated leaf. The amount translocated by the other three species was about 40 times less. In all four species, radioactivity translocated to parts below the treated leaf, including the root system, ranged from 0.2 to 2.8%. The amount of ^{14}C-fluazifop-butyl per dry weight tissue showed a similar trend.

Fluazifop-butyl is absorbed mainly through the foliage. Following foliar absorption, it is hydrolyz-

Table 6. Distribution of radioactivity over time in various plant parts following foliar application of ^{14}C-fluazifop-butyl to IR58 rice seedlings at the three-leaf stage.

Days after treatment (d)	Plant part[1]			
	Treated leaf	Shoot above treated leaf	Shoot below treated leaf	Root System
	disintegration/min (dpm)			
1	15431 (95.0)	47 (0.4)	331 (2.4)	370 (2.1)
4	37297 (94.0)	561 (1.4)	1203 (3.4)	532 (1.3)
8	39884 (91.2)	1229 (2.9)	1804 (4.1)	805 (1.8)
LSD (0.05)	13470	ns	ns	ns
	dpm/mg dry weight tissue			
1	2239 (97.0)	6 (0.3)	39 (1.7)	24 (1.0)
4	6202 (97.5)	43 (0.7)	91 (1.4)	25 (0.4)
8	4851 (96.1)	56 (1.1)	106 (2.1)	33 (0.7)
LSD (0.05)	2236	ns	ns	ns

[1] Numbers in parentheses indicate percent of total radioactivity in plant; ns = not significant at 5% level.

ed by esterases (19). The free acid is translocated through the xylem and phloem and accumulates in meristems (8), where it is believed to interfere with ATP production in susceptible species (6). Although it is readily translocated to active sites within 24 h and arrests growth within 48 h, maximum injury is not fully apparent until 7 to 14 days after application.

The absorption and translocation patterns we found were similar to those observed by Derr et al. (3) in goosegrass, crabgrass, and foxtail and to those observed by Kells et al. (9) in quackgrass. Derr et al. (3) observed higher ^{14}C-fluazifop-butyl concentrations at tillering in parts above the treated leaf in goosegrass than in crabgrass or foxtail. Although they observed that goosegrass was more susceptible to the herbicide at this stage, they did not attribute this to differential absorption or retention.

Our results show greater susceptibility of goosegrass to fluazifop-butyl than either junglerice or itchgrass. Goosegrass translocated greater amounts of the herbicide than did the other two species. This may indicate that differential translocation possibly is a factor in the enhanced susceptibility of goosegrass to fluazifop-butyl, in addition to such mechanisms as differential metabolism. Plowman et al. (13) reported that the selectivity of fluazifop-butyl is believed to be mainly due to rapid degradation followed by conjugate formation in tolerant plants.

Table 7. Distribution of radioactivity in leaf wash, plant and plant parts 6 and 24 hours following foliar application of ^{14}C-fluazifop-butyl to IR58 rice and three weed seedlings at the three-leaf stage.

Species	Time (h)	Leaf wash	Whole plant	Treated leaf	Shoot above treated leaf	Shoot below treated leaf	Root system
		disintegrations/min (dpm)					
Rice	6	359790	101174	99078	1324	468	423
	24	184122	284124	277676	1162	4763	524
Itchgrass	6	314048	125940	123710	748	872	601
	24	220670	266607	256927	1811	7367	502
Junglerice	6	166880	164626	163343	205	364	714
	24	110367	289999	285240	2422	1742	595
Goosegrass	6	217847	239527	122461	109992	5648	1426
	24	157722	261234	169927	88158	2612	538
LSD (0.05)		11063	137278	119038	ns	ns	ns
		%					
Rice	6	78	22	97.8	1.3	0.5	0.4
	24	39	61	97.7	0.4	1.7	0.2
Itchgrass	6	72	28	98.2	0.6	0.7	0.5
	24	45	55	96.4	0.7	2.8	0.2
Junglerice	6	51	49	99.2	0.1	0.2	0.4
	24	26	74	98.3	0.8	0.6	0.2
Goosegrass	6	48	52	51.1	45.9	2.4	0.6
	24	38	62	65.0	33.7	1.0	0.2
		dpm/mg dry weight tissue					
Rice	6		3157	17003	595	83	27
	24		10080	54255	668	718	30
Itchgrass	6		1693	20130	45	89	19
	24		4966	48022	96	906	24
Junglerice	6		6212	33922	57	52	66
	24		12371	53368	648	453	61
Goosegrass	6		16068	38953	42496	983	404
	24		12397	43715	12414	542	96
LSD (0.05)			6977	24616	27053	ns	177

ns = not significant at 5% level.

CONCLUSION

Our results indicate that, at certain rates and times of application, rice can tolerate fluazifop-bytyl. These rates and times of application also provide adequate-to-excellent control of the grass weeds commonly associated with upland rice. The susceptibility of goosegrass, which was greater than that of itchgrass of junglerice, could have been due in part to the greater translocation of the herbicide in this species.

LITERATURE CITED

1. Baltazar, A. M. and F. V. Bariuan. 1986. Effect of fluazifop-butyl on *Rottboellia cochinchinensis.* Philipp. J. Weed Sci. 13: 50-55.
2. De Datta, S. K. and H. M. Beachell. 1972. Varietal response to some factors affecting production of upland rice. Pages 685-700 in Rice breeding. Int. Rice Res. Inst., Los Banos, Philippines.
3. Derr, J. F., T. J. Monaco and T. J. Sheets. 1985. Uptake and translocation of fluazifop-butyl by three annual grasses. Weed Sci. 33: 612-617.
4. Derr, J. F., T. J. Monaco and T. J. Sheets. 1985. Response of three annual grasses to fluazifop-butyl. Weed Sci. 33: 693-697.
5. Eastin, E. F. 1986. Rice response to over-the-top herbicides. Weed Abstr. 26: 4.
6. Gilreath, J. P. 1984. Postemergence grass herbicides. Weeds Today 14: 3-5.
7. Gupta, P. C. and J. C. O'Toole. 1986. Upland rice: A global perspective. Int. Rice Res. Inst., Los Banos, Philippines. 359 pp.
8. Hendley, P., J. W. Dicks, T. J. Monace, S. M. Slyfield, O. J. Tummon and C. J. Barret. 1985. Translocation and metabolism of pyridinyloxyphenoxypropionate herbicides in rhizomatous quackgrass. Weed Sci. 33: 11-24.
9. Kells, J. J., W. F. Meggitt and D. Penner. 1984. Absorption, translocation, and activity of fluazifop-butyl as influenced by plant growth stage and environment. Weed Sci. 32: 143-149.
10. Lopez, L. M., S. K. De Datta and B. B. Mabbayad. 1980. Integrated weed control methods in upland rice. Philipp. J. Weed Sci. 7: 45-56.
11. Migo, T. R. and S. K. De Datta. 1984. Chemical control of *Rottboellia exaltata* in upland rice. Philipp. J. Weed Sci. 11: 83-98.
12. Okafor, L. I. and S. K. De Datta. 1974. Competition between weeds in upland rice in monsoon Asia. Philipp. Weed Sci. Bull. 1: 39-45.
13. Plowman, R. E., W. C. Stonebridge and J. N. Hawtree. 1980. Fluazifop-butyl: A new selective herbicide for control of annual and perennial grass weeds. Proc. Brit. Crop Prot. Conf. - Weeds. Pages 29-37.
14. Robles, R. P. and G. L. Magsino. 1985. Postemergence control of *Rottboellia exaltata* in soybean by fluazifop-butyl. Philipp. J. Weed Sci. 12: 69-74.
15. Schiller, J. M. and P. Indhaphun. 1979. Weed control studies in direct-seeded upland rice. Proc. Asian-Pac. Weed Sci. Soc. Conf. 7: 271-276.
16. Snipes, C. E. and J. E. Street. 1987. Rice tolerance to fenoxaprop. Weed Sci. 25: 401-406.

17. Soto, A., N. Zuniga and R. Aguero. 1986. Tolerance of rice to fenoxapropethyl and fluazifop-butyl: Some doses and application dates. Weed Abstr. 26: 4.

18. Vega, M. R., J. D. Ona and E. C. Paller. 1967. Weed control in upland rice at the U. P. College of Agriculture. Philipp. Agric. 51: 397-411.

19. Velovitch, J. J. and F. W. Slife. 1983. Uptake, translocation, and metabolism of fluazifop-butyl in foxtail millet and common cocklebur. Weed Abstr. 23: 74.

LONDAX®+ BAS 514..H: A BROADSPECTRUM WEED CONTROL TREATMENT IN RICE

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ABSTRACT

"LONDAX", Methyl 2-[[[[[(4,6-dimethoxypyrimidin-2-yl) amino] carbonyl] amino] sulfonyl] methyl] benzoate and BAS 514..H, 3,7-dichloro-8-quinolinecarboxylic acid, have been tested along and in combination for broadspectrum weed control in rice. "LONDAX" (20-40 gm ai/ha) effectively controls most annual and perennial broadleaves and sedges prevalent in rice paddies, while BAS 514..H (150-300 gm ai/ha) provides excellent control of barnyardgrass. In Thailand, combination of "LODNAX" 20 gm ai/ha plus BAS 514..H 250 gm ai/ha consistently controls *Echinochloa crus-galli* L., *Sphenoclea zeylanica* Gaertn, *Marsilea crenata* Presl, *Monochoria vaginalis* (Burm.f.) Presl, *Cyperus difformis* L. and *Fimbristylis miliacea* (L.) Vahl, when applied at 4-10 days after seeding. Residual control is at least 45 days and no crop injury (direct seeded rice) has been observed. Crop rotation studies revealed that the combination does not cause injury to crops commonly planted following rice. This new herbicide combination has undergone extensive evaluation in Asia Pacific rice growing regions (1985-1987). Supporting evidence from other countries suggests that "LONDAX" plus BAS 514..H can be effectively used in direct seeded and transplanted rice, exhibits excellent crop tolerance and offers a broad window for application timing.

INTRODUCTION

In direct seeded rice, weed control plays an important role in alleviating the detrimental effects of weeds which otherwise result in loss of rice yields (1). Among the several weed species infested in the paddy, *Echinochloa crus-galli* and *Sphenoclea zeylanica* are becoming increasingly important as grassy and broadleaf weeds respectively. Hand weeding in direct seeded rice fields is not practical due to the difficulty in entering the field without causing extensive damage to the rice plants. A suitable alternative to hand weeding is to use herbicides (2). Several herbicides have limited property for weed control in rice e.g. effective only for either grassy or broadleaf weeds, have narrow application timing, need extra effort for application or cause phytotoxicity to rice.

"LONDAX" has demonstrated an excellent broadleaves and sedges control while BAS 514..H provides consistent good control of *Echinochloa* spp. Both "LONDAX" and BAS 514..H at the recommended rate cause no crop injury. In Thailand, "LONDAX" + BAS 514..H at various rates, application timings, application methods were investigated for weed control efficacy and crop tolerance in 18 replicated trials for 4 consecutive seasons. Crop rotation studies to evaluate soil residual effect were also conducted. "LONDAX" + BAS 514..H at 20 + 250 gm ai/ha is recommended for consistently control of *Echinochloa crus-galli, Sphenoclea zeylanica, Marsilea crenata, Monochoria vaginalis* and *Cyperus* spp. when applied at 4-10 DAS. No residual in soil to cause injury to crops commonly planted following rice.

MATERIALS AND METHODS

"LONDAX" 10%WP, BAS 514..H 50%WP and "LONDAX" + BAS 514..H premixed were used for testing. The experiments were conducted in the central area of Thailand during 1985-1986 for 4 consecutive seasons in direct seeded rice. Experimental details are presented for each of these trials in Table 1. In experiments 1-8 and 12-13, a randomized complete block design with 3 replications was used. In experiments 9-11, a split plot design with 3 replications was used. In all experiments, assessment for weed control was done visually at 2-week intervals after herbicide application for a total of 3 times by using a (%) control scale. The phytotoxicity rating was taken at 2 weeks after application based on a scale 0 = no injury, >3 = unacceptable, 10 = complete kill. Yield was taken from the whole plot and threshing was done with a small thresher. Yield data is presented with standardized moisture content of 14%.

Experiments 1-2 These trials were designed to evaluate weed control efficacy and crop tolerance of BAS 514..H 50%WP in direct seeded rice. BAS 514..H was tested at 150, 300 and 600 gm ai/ha. "LONDAX" 10%WP at 40 gm ai/ha and pretilachlor + safener 300EC at 450 gm ai/ha were served as standard treatments. All herbicide treatments were applied into flooded soil at 7 days after seeding (DAS), except pretilachlor + safener which was applied into saturated soil at 4 DAS.

Experiments 3-6 These trials were designed to evaluate weed control efficacy and crop tolerance of BAS 514..H and its mixture with "LONDAX" 10%WP in direct seeded rice. BAS 514..H at 75, 150, 300 gm ai/ha and their mixtures with "LONDAX" 20 gm ai/ha were tested. Pretilachlor + safener at 300 and 450 gm ai/ha, "LONDAX" at 40 gm ai/ha were used as standard treatments.

Experiments 7-8 These trials were designed to determine the optimum dosage of BAS 514..H for the combination with "LONDAX" at 20 gm ai/ha for the control of weeds in direct seeded rice. "LONDAX" in combination with BAS 514..H at rates of 20 + 200, 20 + 250 and 20 + 300 gm ai/ha were evaluated. "LONDAX" at 20, 40 gm ai/ha and BAS 514..H alone at 200, 250 and 300 gm ai/ha were also included. Application was done at 7 DAS. Pretilachlor + safener 450 gm ai/ha at 4 DAS application and piperophos + dimethametryne 3%G 750 gm ai/ha at 10 DAS application were used as standard treatments.

Experiments 9-10 These trials were designed to evaluate the proper application timings of the combination treatments between "LONDAX" and BAS 514..H for the control of barnyardgrass in direct seeded rice. "LONDAX" + BAS 514..H at 20 + 150, 20 + 200, 20 + 250 and 20 + 300 gm ai/ha were evaluated. Pretilachlor + safener at 450 gm ai/ha, which all the time was applied at 4 DAS, was used as standard treatment. A split plot design with 3 replications was used. Application timings, 4, 7, 10 and 15 DAS, were used as main plots. Herbicide treatments were used as sub-plots.

Experiment 11 This trial was designed to compare the efficacy of "LONDAX" + BAS 514..H at the rates of 20 + 150, 20 + 200, 20 + 250 and 20 + 300 gm ai/ha for the control of barnyardgrass in direct seeded rice between overall application and strip (1/3 of area) application methods. Spray volume was 667 l/ha and 200 l/ha for the respective application method. A split plot design with 3 replications was used. Herbicide treatments were used as main plots while the application methods were used as sub-plots. Application was done at 7 DAS. Pretilachlor + safener at 450 gm ai/ha, as all the time

Table 1. Experimental details of "Londax" + BAS 514..H trials in Thailand.

EXPERIMENT NO.:	1	2	3	4	5	6	7	8	9	10	11	12	13
LOCATION:	LAD LUM KEOW	BANG LANE	DON JEDI	DON JEDI	LAD LUM KEOW	BANG LANE	DON JEDI	SRIPRACHAN	DON JEDI	LAD LUM KEOW	LAD LUM KEOW	DON JEDI	DON JEDI
SEEDING DATE:	MAY 23, 85	JUN 16, 85	MAR 23, 85	MAR 23, 85	MAY 23, 85	JUN 13, 85	MAR 29, 86	APR 22, 86	AUG 4, 85	DEC 20, 85	DEC 20, 85	JUL 18, 86	JUL 18, 85
APPLICATION DATE:	MAY 30, 85	JUN 23, 85	MAR 30, 85	MAR 30, 85	MAY 30, 85	JUN 20, 86	APR 5, 86	APR 29, 86	AUG 8, 85 AUG 11, 85 AUG 14, 85 AUG 19, 85	DEC 24, 85 DEC 27, 85 DEC 30, 85 JAN 4, 86	DEC 27, 85	JUL 25, 86	JUL 25, 86
PLOT SIZE:	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2	15 M^2
RICE VARIETY:	RD 7	RD 21	RD 23	RD 23	RD 7	RD 21	RD 23	RD 23	RD 23	RD 23	RD 23	RD 23	RD 23
SOIL TYPE:	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	SANDY LOAM	CLAY	CLAY	LOAMY CLAY	CLAY
SOIL pH:	5.2	5.0	6.7	6.7	5.4	5.0	5.1	5.3	6.7	5.8	5	5.6	5.4
% O.M.	3.4	2.46	4.37	4.3	3.7	2.8	1.3	2.1	2.4	3.2	3.6	2.4	2.7
% WEED COVER IN UNTREATED	70%	35%	100%	100%	90%	70%	40%	80%	100%	60%	60%	100%	100%
HARVESTING DATE:	SEP 10, 85	OCT 11, 85	–	–	SEP 10, 85	OCT 10, 85	JUL 15, 86	AUG 6, 86	NOV 19, 85	APR 9, 86	APR 9, 86	OCT 27, 86	OCT 27, 86

overall plot application into saturated soil at 4 DAS, was used as standard treatment.

Experiments 12-13 These trials were designed to evaluate weed control and crop tolerance of "LONDAX" + BAS 514..H premixed comparing to "LONDAX" + BAS 514..H tank mixed. Either premixed or tank mixed was tested at 20 + 250 gm ai/ha. BAS 514..H at 250 gm ai/ha was included. Application was done at 7 DAS. Pretilachlor + safener at 450 gm ai/ha, applied at 4 DAS, and piperophos-dimethametryne at 750 gm ai/ha, applied at 10 DAS, were used for comparison.

Experiment 14 This trial was designed to investigate the soil residual effect of "LONDAX" + BAS 514..H to some rotational crops. Soil which had been treated with "LONDAX" + BAS 514..H at 20 + 150, 20 + 200, 20 + 250 and 20 + 300 gm ai/ha since January 4, 1986 were dug for 15 cm depth after harvesting and were put into 45 x 30 cm tray. Ten seedlings or seeds each of egg plant, mustard-green, watermelon and stringbean were transplanted or seeded into the soil on June 30, 1986. Seedling of egg plant and mustardgreen were 3 weeks old. Soil which was treated with pretilachlor + safener at 450 gm ai/ha and "LONDAX" at 40 gm ai/ha were also used for comparison.

RESULTS AND DISCUSSION

Experiments 1-2 The results reported in Table 2 show that BAS 514..H at 150, 300 and 600 gm ai/ha provided excellent control of *Echinochloa crus-galli* which were insignificantly different from "LONDAX" 40 gm ai/ha and pretilachlor + safener at 450 gm ai/ha. All BAS 514..H treatments gave no control of *Sphenoclea zeylanica* while "LONDAX" at 40 gm ai/ha gave excellent control and resulted in the highest yield obtained. No phytotoxicity was noted from any treatments.

Table 2. Effect of BAS 514..H applied as early-post emergence in direct seeded rice. Average from 2 locations.

Treatments	GM AI /Ha	Crop injury[1] at 2 WAA	Weed control at 6 WAA[2]		Yield[3] Tons/Ha
			Echinochloa[1] *crusgalli*	*Sphenoclea zeylanica*	
BAS 514..H 50WP	150	0	94a	0	3.5 b
	300	0	98a	0	3.97ab
	600	0	99a	0	3.82ab
"Londax" 10%WP	40	0	93a	100	4.13a
Pretilachlor/Safener 300EC	450	0	92a	80	3.85ab
Untreated Check	–	0	0b	0	1.63 c
CV (%)			6.39		6.13

[1] 0-10 Crop injury rating system: 0= No injury, ⩽3 = Acceptable crop injury 4-6 = Moderate, 7-9 = Severe, 10 = Complete kill

[2] WAA = Weeks after application

[3] In a column, means followed by the same letter are not significantly different at P = 0.05 by DMRT

Experiments 3-6 Summaries of test results are reported in Table 3. BAS 514..H at 300 gm ai/ha gave very good control of *Echinochloa crus-galli* but it gave poor control on *Sphenoclea zeylanica.* Adding "LONDAX" 20 gm ai/ha to BAS 514..H treatments caused no crop injury and showed significant improvement on *Sphenoclea zeylanica* control which was better than BAS 514..H and pretilachlor + safener. "LONDAX" + BAS 514..H at 20 + 300 gm ai/ha provided the best control of both *Echinochloa crus-galli* and *Sphenoclea zeylanica,* thus, resulted in the highest yield obtained.

Experiments 7-8 A summary of test results is reported in Table 4. BAS 514..H at 200, 250 and 300 gm ai/ha and their mixtures with "LONDAX" 20 gm ai/ha gave excellent control of *Echinochloa crus-galli* which were superior to piperophos-dimethametryne 750 gm ai/ha, "LONDAX" 20 gm ai/ha and the untreated respectively. There were no statistical differences among "LONDAX" + BAS 514..H treatments for both weeds control and yield. All BAS 514..H single treatments gave poor control of *Sphenoclea zeylanica* thus resulted in significantly lower yield than the other herbicide treatments. Phytotoxicity could not be observed in any treatments.

Experiments 9-10 A summary of barnyardgrass control and yield are shown in Table 5. There were no statistical differences among the timing means for the same treatment of "LONDAX" + BAS 514..H, except at 15 DAS timing, for the control of *Echinochloa crus-galli* and yield obtained. "LONDAX" + BAS 514..H at 20 + 300 gm ai/ha when applied at 4, 7, 10 DAS gave a significantly better than "LONDAX" + BAS 514..H at 20 + 150 gm ai/ha and standard treatment. "LONDAX" + BAS 514..H at 20 + 250 gm ai/ha exhibited more consistancy and was insignificantly better both weed control and yield than "LONDAX" + BAS 514..H at 20 + 200 gm ai/ha.

Experiment 11 Test results are reported in Table 6. All "LONDAX" + BAS 514..H treatments when applied as overall cover spray or strip application gave effective control of *Echinochloa crus-galli* equal to pretilachlor + safener at 450 gm ai/ha. There was no difference in weed control between the different application methods. For yield evaluation, there were no significant differences both among herbicide treatments and between application methods. All herbicide treatments were significantly over the untreated.

Experiments 12-13 The results in Table 7 show that there was no difference between "LONDAX" + BAS 514..H premixed and tank mixed at 20 + 250 gm ai/ha for both weeds control and yield obtained. Both "LONDAX" + BAS 514..H gave effective control of *Echinochloa crus-galli, Sphenoclea zeylanica, Monochoria vaginalis* and *Cyperus difformis* which was equal to pretilachlor + safener. Piperophos-dimethametryne also provided very good control for all weeds except *Monochoria vaginalis.* Phytotoxicity could be observed in only piperophos-dimethametryne treatment. All herbicide treatments gave a significantly higher yield than the untreated while "LONDAX" + BAS 514..H tank mixed resulted in highest yield.

Experiment 14 After harvesting of rice crop, "LONDAX" + BAS 514..H treated area had no effect to rotational crops such as egg plant, mustardgreen, watermelon and stringbean as shown in Table 8.

CONCLUSION

The results of these trials show that "LONDAX" + BAS 514..H at 20 + 250 gm ai/ha applied at 4-10 DAS gave an outstanding crop safety and excellent control of *Echinochloa crus-galli, Sphenoclea zeylanica, Monochoria vaginalis, Cyperus difformis.* An effective weeds control when applied

Table 3. Effect of "Londax", BAS 514..H and "Londax" + BAS 514..H applied as early-post emergence in direct seeded rice. Average from 2 locations.

Treatments	Gm AI /Ha	Experiments 3 and 4			Experiments 5 and 6			
		Crop injury at 2 WAA	% Weed control at 6 WAA		Crop injury at 2 WAA	% Weed control at 6 WAA		Yield[1] Tons/Ha
			Echinochloa[1] *crusgalli*	*Sphenoclea*[1] *zeylanica*		*Echinochloa*[1] *crusgalli*	*Sphenoclea*[1] *zeylanica*	
"Londax" 10% WP	20	0	35 e	100a	0	46 cd	99a	2.37 ef
	40	0	60 d	100a	0	61abcd	100a	4.04ab
BAS 514..H 50% WP	75	–[2]	–	–	0	13 ef	0 d	2.03 fg
	150	0	75 bc	7 de	0	63abcd	0 d	2.93 de
	300	0	90a	17 cd	0	78ab	0 d	3.55abcd
	600	0	98a	27 c	–	–	–	–
"Londax" + BAS 514..H	20 + 75	0	73 bcd	100a	0	38 de	100a	3.59abcd
	20 + 150	0	85ab	100a	0	62abcd	100a	3.69abcd
	30 + 300	0	95a	100a	0	81a	100a	4.35a
Pretilachlor/Safener 300EC	300	0	66 cd	65 b	0	49 cd	40 c	3.14 cd
	450	–	–	–	0	53 bcd	70 b	3.81abc
Untreated check	–	0	0 f	0 e	0	0 f	0 d	1.52 g
CV (%)			10.07	12.53		28.17	15.46	12.67

[1] In a column, means followed by the same letter are not significanily different at P = 0.05 by DMRT

[2] No data

Table 4. Effect of "Londax", BAS 514..H and "Londax" + BAS 514..H applied as early-post emergence in direct seeded rice. Average from 2 locations.

Treatments	Gm AI/Ha	Crop injury at 2 WAA	% Weed control at 6 WAA		Yield[1] Tons/Ha
			Echinochloa[1] *crusgalli*	*Sphenoclea*[1] *zeylanica*	
"Londax" 10% WP	20	0	58 b	100a	5.23 c
	40	0	78ab	100a	5.67ab
BAS 515..H 50% WP	200	0	97a	0 c	4.39 d
	250	0	99a	13 c	4.56 d
	300	0	99a	17 c	4.26 d
"Londax" + BAS 514..H	20 + 200	0	99a	100a	5.73a
	20 + 250	0	99a	100a	5.45abc
	20 + 300	0	99a	99a	5.31abc
Pretilachlor/ Safener 300 EC	450	0	96a	96a	5.27 bc
Piperophos + Dimethametryne 3% G	750	0	70 b	70 b	5.06 c
Untreated check	–	0	0 c	0 c	3.86
CV (%)			14.13	17.26	4.41

[1] In a column, means followed by the same letter are not significantly different at P = 0.05 by DMRT

Table 5. Effect of "Londax" + BAS 514..H applied at different timings in direct seeded rice. Average from 2 locations.

Treatments	Gm AI /Ha	% Barnyard grass control at 6 WAA				Means	Yields (Tons/Ha)				Means
		Application timings					Application timings				
		4 DAS[1]	7 DAS	10 DAS	15 DAS		4 DAS	7 DAS	10 DAS	15 DAS	
"Londax"+BAS 514..H	20 + 150	68	58	67	3	49	3.65	3.18	3.53	1.44	2.95
	20 + 200	86	80	95	35	74	4.62	3.85	4.73	2.68	3.97
	20 + 250	93	88	98	50	82	4.84	4.58	5.02	3.25	4.42
	20 + 300	99	95	98	59	88	5.08	4.94	5.12	3.29	4.61
Pretilachlor/Safener	300	60	30	48	49	47	3.44	2.10	2.67	2.96	2.79
Untreated	–	0	0	0	0	0	1.06	1.26	1.0	0.73	1.01
Means		68	59	68	33		3.78	3.32	3.68	2.39	

CV (a) = 20.77%, CV (b) = 24.25% CV (a) = 26.08%, CV (b) = 19.92%

	0.05	0.01	0.05	0.01
LSD 1 = Differences between timing means average overall treatments	9.57	14.5	0.7	1.06
LSD 2 = Differences between treatment means average overall timings	11.31	15.13	0.54	0.72
LSD 3 = Differences between treatment means at the same timing	22.6	30.26	1.08	1.45
LSD 4 = Differences between timing means at the same treatment	22.7	30.98	1.21	1.68

[1] DAS = Days after seeding

Table 6. Effect of "Londax" + BAS 514..H applied at different application methods in direct seeded rice.

Application methods	"Londax" + BAS 514..H (Gm AI/Ha) 20 + 150	20 + 200	20 + 250	20 + 300	Pretilachlor /Safener 450	UTC	Means
% Barnyard grass control at 6 WAA							
Cover spray	96	90	100	95	97	0	79.7
Strip	98	100	99	100	90	0	81.2
Means	97	95	99.5	97.5	93.5	0	

CV (a) = 8.9%, CV (b) = 10.02%

	0.05	0.01
LSD I	9.30	13.2
LSD II	5.90	8.20
LSD III	14.3	20.10
LSD IV	13.8	19.40

Application methods	20 + 150	20 + 200	20 + 250	20 + 300	Pretilachlor /Safener 450	UTC	Means
Yield-Tons/Ha							
Cover spray	6.05	5.80	6.5	6.05	5.90	1.23	5.26
Strip	6.11	6.13	5.92	5.95	6.13	1.25	5.25
Means	6.08	5.97	6.21	6.0	6.02	1.24	

CV (a) = 9.62%, CV (b) = 7.04%

		0.05	0.01
LSD I	= Differences between treatment means average overall application method	0.65	0.93
LSD II	= Difference between application method means average overall treatments	0.27	0.38
LSD III	= Difference between application method means at the same treatment	0.66	0.92
LSD IV	= Differences between treatment means at the same application method	0.80	1.13

Table 7. Effect of "Londax" + BAS 514..H both premixed and tank mixed in direct seeded rice at Donjedi. Average from 2 locations.

Treatments	Gm AI /Ha	Crop injury at 2 WAA	% Weed control at 6 WAA				Yield[1] Tons/Ha
			EC	SZ	MV	CD	
"Londax" + BAS 514..H (Tank mixed)	20 + 250	0	100	100	100	100	4.1a
"Londax" + BAS 514..H (Premixed)	20 + 250	0	100	100	100	100	3.9a
BAS 514..H	250	0	100	0	0	0	3.3 b
Pretilachlor/Safener	450	0	100	100	100	100	3.6ab
Piperophos-dimethametryne	750	3.33	99	100	0	100	3.8a
Untreated check	–	0	0	0	0	0	2.4 c

CV = 5.74%

[1] In a column, means followed by the same leiter are not significantly different at P = 0.05 by DMRT

EC = *Echinochloa crusgalli*

SZ = *Sphenoclea zeylanica*

MV = *Monochoria vaginalis*

CD = *Cyperus difformis*

Table 8. Effect of "Londax" + BAS 514..H residue in soil to rotational crops which were planted after harvesting of rice crop.

Treatments	Gm AI /Ha	No. of survival plants at 4 WAA			
		Egg-plant	Mustard green	Water melon	String bean
"Londax" + BAS 514..H	20 + 150	10	9.67	9.0	9.0
	20 + 200	10	8.67	8.33	9.0
	20 + 250	10	9.67	8.67	8.67
	20 + 300	10	9.67	8.33	8.33
"Londax"	40	10	8.0	8.67	9.67
Pretilachlor/Safener	450	10	8.33	9.0	9.67
Untreated	–	10	9.67 ns	7.33ns	9.33ns
	CV (%)		11.21%	9.86%	8.71%
	LSD	0.05	1.81	1.49	1.41
		0.01	2.54	2.08	1.98

"LONDAX" + BAS 514..H as either overall area or strip application will result in reducing time spent applying the compound to rice growers. The combination also does not cause injury to crops commonly planted following rice.

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LITERATURE CITED

1. De Datta, S. K. 1981. Principles and practices of rice production. John Wiley & John, Inc. New York, 618 p.
2. Lim, E. S. and Azmi Man. 1985. Chemical control of *Echinochloa crus-galli* in direct seeded rice. Paper presented at the tenth Asian Pacific Weed Sci. Soc. Conf., November 24-30, 1985, Chiangmai, Thailand, 233-239.

MON 15100–A NEW HIGH ACTIVE HERBICIDE FOR THE CONTROL OF ANNUAL GRASS WEEDS IN TURF

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ABSTRACT

Mon 15100 has been discovered to be a highly active annual herbicide for annual grassy weeds in turf and has been developed by Monsanto Company. Field and greenhouse studies were carried out from 1986 to 1987 in Japan. Mon 15100 gave excellent control of *Digitaria adscendens* and *Poa annua* at 0.5 kg ai/ha with pre-emergence application. The compound had good longevity and showed excellent weed efficacy on *D. adscendens* at 145 days after application at 0.5 kg ai/ha. No visual turf injury of Zoysia turf was observed up to 4.0 kg ai/ha. This compound showed high turf safety even when the chemical was used consecutively. Good safety was also observed for several greens species such as bentgrass. Results of formulation tests and mixture tests with broadleaf herbicides will be reported.

INTRODUCTION

The most problem grassy weeds in turf are *Digitaria adscendens* in summer and *Poa annua* in winter. Normally turf herbicides are applied two to three times per year at most golf courses in Japan to these weeds. Turf safety and longevity, next to the efficacy on these problem weeds, are important factors to select turf herbicide. Mon 15100 has been discovered by Monsanto Company, and was field tested from 1986 to 1987 at several sites in Japan. This paper describes the field activity of Mon 15100.

MATERIALS AND METHODS

Chemicals used were Mon 15100 (36% EC), simazine (50% WP), propamide (50% WP) and bensulide (50% EC). Chemicals were applied with 2,000 l/ha water. The plots were randomized complete block design with three replications. The size of one plot was 0.25 m^2 to 2 m^2. Turf varieties tested were *Zoysia matrella* (Koraishiba) and *Zoysia japonica* (Noshiba), and green species, *Agrostis palustris* (penncross and Old Orchard) and *Cynodon* spp. (Tifton 328), and *Zoysia matrella* (Himekorai). Height of mowing was set to 20 to 30 mm for *Zoysia* species and set to 5 to 8 mm for green species. Spring application was made from late March to middle April and autumn application was made from middle September to early October. The chemicals were applied both pre- and post-emergent. Water volumes of 1,000 and 2,000 and 4,000 l/ha were examined for spray volume tests. Emulsifiable concentrate (EC) and granule of MON 15100 were applied for the formulation tests. Visual shoot injury and root injury were evaluated.

RESULTS

Herbicidal activity Spring trials showed that MON 15100 gave almost perfect control of crabgrass and violet crabgrass at 0.54 kg ai/ha for pre-emergence application up to 153-206 DAA (days after application) (Table 1). With pre-emergence autumn application, MON 15100 showed excellent control (better than 90%) on annual bluegrass and the broadleaf *Erigeron* spp. at 0.54 kg ai/ha application. Also perfect control of annual bluegrass was obtained at 1.08 kg ai/ha up to 168 DAA (Table 1). The activity of MON 15100 on these summer and winter weeds was higher than that of the commercial products, such as propamide and simazine at 2.0 kg ai/ha. With post-emergence application, MON 15100 had activity on even 2 to 3 tiller-stage crabgrass at 1.08 kg ai/ha (Table 2). The compound also had post-emergence activity on broadleaf weeds, such as *Cerastium glomeratum* and *Veronica arvensis* at 0.72 kg ai/ha. However, MON 15100 showed poor post-emergence control of annual bluegrass at the 2.0 leaf-stage (Table 2). Formulation studies showed that granule and EC of MON 15100 had the same herbicidal activity. Herbicidal activity of MON 15100 was not affected by spray volume and the compound gave equal activity with spray volume form 1,000 l/ha to 4,000 l/ha. One of the most unique points of MON 15100 is its longevity. It was observed that MON 15100 at 1.08 kg ai/ha with autumn application gave excellent control of annual bluegrass in winter and gave excellent control of crabgrass and violet crabgrass the following summer (Table 3). None of the commercial compounds showed such longevity.

Table 1. Pre-emergence activity of MON 15100.

Chemicals	Rate (kg ai/ha)	% Control					
		Spring application			Autumn application		
		Da[1]		Dy[2]	Pa[3]		*Erigeron* spp.
		56-103 DAA	153-206 DAA	177 DAA	69 DAA	168 DAA	153 DAA
MON 15100	1.08	100	97	100	100	100	100
MON 15100	0.54	99	97	100	100	91	98
MON 15100	0.36	98	77	100	–	–	–
MON 15100	0.27	–	–	–	93	67	89
Propamide	4.00	89	47	98	–	–	85
Propamide	2.00	44	48	59	100	100	58
Simazine	4.00	70	65	90	–	–	–
Simazine	2.00	47	33	75	43	0	–

[1] Da: *Digitaria adscendens*

[2] Dv: *Digitaria violascens*

[3] Pa: *Poa annua*

Table 2. Post-emergence activity of MON 15100.

Chemicals	Rate (kg ai/ha)	% Control		
		Spring application[1]	Autumn application[2]	
		Da[1]	Pa[2]	BLW[3]
MON 15100	1.08	79	–	–
MON 15100	0.72	73	0	98
MON 15100	0.54	29	0	89
MON 15100	0.27	–	0	72
Propamide	2.00	27	100	0
Simazine	2.00	49	90	100

[1] *Digitaria adscendens* 2–3 tiller-stage application
[2] *Poa annua* 2.0 leaf-stage application
[3] *Cerastium alomeratum, Veronica arvensis*

Table 3. Year long activity of MON 15100 with autumn application.

Chemicals	Rate (kg ai/ha)	% Control	
		D. adscendens	
		290 DAA	360 DAA
MON 15100	2.16	100	100
MON 15100	1.08	100	99
MON 15100	0.54	99	91
MON 15100	0.27	86	62
Propamide	2.00	44	20
Simazine	2.00	45	20

Safety on turf MON 15100 showed high safety on Koraishiba and Noshiba and no injury was observed up to 4.32 kg ai/ha with both spring and autumn application (Table 4). Moreover, this compound caused neither visual injury nor root injury after four season consecutive use at 2.16 kg ai/ha (Table 5). MON 15100 showed high safety on resodded turf up to 4.32 kg ai/ha even when MON 15100 was applied at one day after turf was resodded.

Safety on green spp. MON 15100 also showed high safety on Himekorai, which is a major variety for greens in Japan, up to 4.32 kg ai/ha. The other varieties such as Penncross, Old Orchard and Tifton 328 were less tolerant to MON 15100 and acceptable turf safety was obtained at 0.54 kg ai/ha.

Mixture test The combination of MON 15100 with simazine was studied to expand weed spectrum

Table 4. Safety of MON 15100 on *Zoysia* spp.

		% Visual injury							
		Spring application				Autumn application			
		35-42 DAA		72-177 DAA		35-45 DAA		165-360 DAA	
Chemicals	(kg ai/ha)	Zm[1]	Zj[2]	Zm[1]	Zj[2]	Zm[1]	Zj[2]	Zm[1]	Zj[2]
MON 15100	4.32	0	–	0	–	0	–	0	–
MON 15100	2.16	0	0	0	0	0	0	0	0
MON 15100	1.08	1	0	1	0	0	0	0	0
Propamide	2.00	0	0	0	0	0	0	0	0
Simazine	2.00	0	0	0	0	0	0	0	0

[1] Zoysia *matrella* (Doraishibs)

[2] *Zoysia japonica* (Noshiba)

Table 5. Safety of MON 15100 on *Zoysia matrella* (Koraishiba) with consecutive use (Four season applications).

Chemicals	Rate (kg ai/ha)	% Visual injury	% Root injury
MON 15100 EC	2.16	0	0
MON 15100 G	2.16	0	0
Propamide	2.00	0	0
Simazine	2.00	0	0

of MON 15100 on broadleaf weeds. Clear synergism was observed for the mixture with autumn post-emergence application and gave perfect control of annual bluegrass, *Alopecurus aequalis, Cerastium glomeratum* and *Veronica arvensis* at 0.125 kg ai/ha MON 7200 and 1.0 kg ai/ha simazine for annual bluegrass at the 2.0 leaf-stage application (Fig. 1). No synergism was observed with this mixture for spring application.

DISCUSSION

MON 15100 has very high unit activity. The recommended rate is 0.54 kg ai/ha for season long control of crabgrass and 1.08 kg ai/ha for season long contol of annual bluegrass. The field test results indicate the autumn application of MON 15100 at 1.08 kg ai/ha provides not only season long control of annual bluegrass but also year long grassy weeds control including crabgrass and violet crabgrass the following summer. This is obviously the outstanding advantage of this compound over other products, especially for labor saving at golf courses where only one herbicide application per year may suffice. Besides grassy weeds, MON 15100 showed activity on some problem broadleaf weeds, such as *Erigeron*

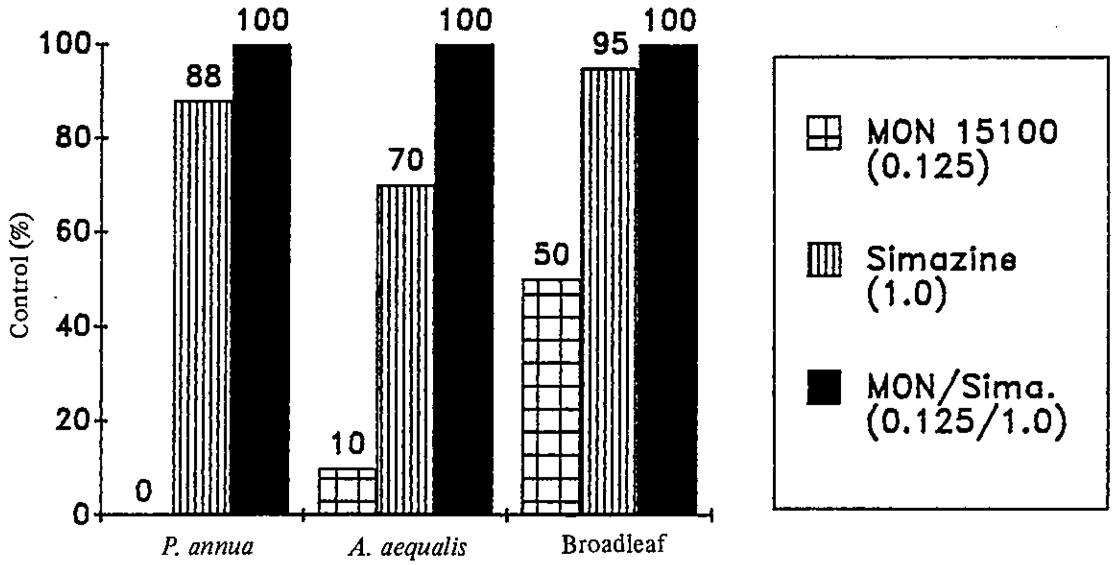

Fig. 1. Post-emergence activity of MON 15100/Simazine mixture.

spp., *Cerastium glomeratum and Veronica arvensis.* Turf safety of this compound is excellent on Koraishiba and Noshiba, and also on Himekorai greens species. The mixture of MON 15100 with broadleaf herbicides is recommended to expand the weed specturm on broadleaf weeds.

HERBICIDAL PROPERTIES OF MON 7200, HIGHLY ACTIVE HERBICIDE FOR TRANSPLANT RICE

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ABSTRACT

MON 7200 has been developed by MONSANTO Company and is a highly active herbicide in transplant rice. Since 1985, MON 7200 has been tested on transplant rice fields in Japan, the Far East, and SEA. MON 7200 showed very high unit activity on most major annual weeds, especially barnyardgrass and *Monochoria vaginalis*. Excellent control of barnyardgrass was obtained at 0.06 kg ai/ha with pre-emergence application and 0.12 kg ai/ha with early post-emergence application (barnyardgrass of 1.5 leaf-stage). The herbicidal activity of MON 7200 was not affected by different soil types, water depth or temperature conditions. MON 7200 has longevity of 70 days. MON 7200 is very safe on transplant rice and acceptable rice safety was obtained even at 0.96 kg ai/ha. Even with shallow transplanting, MON 7200 provided good rice safety if the basal stem of rice was in the soil, even if the roots were exposed to the flooded water. This chemical can be applied both before and after transplanting.

INTRODUCTION

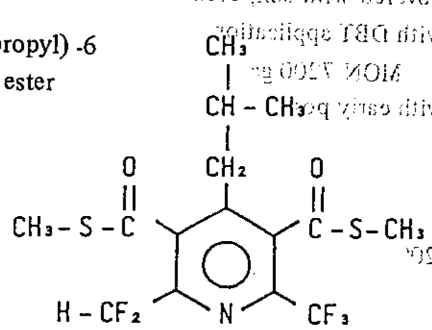
Annual weeds are problem weeds in transplant rice. Several herbicides for annual weeds such as benthiocarb, chlornitrofen, and chlomethoxynil have been developed to date, however, these often need successive herbicide application, especially for barnyardgrass due to insufficient longevity on this weed. To respond to this, Monsanto Co., has developed MON 7200 which is a highly active annual weed herbicide with good longevity, especially on barnyardgrass. This paper describes the field activity of MON 7200 in 1985–1987.

MATERIALS AND METHODS

Chemical and toxicological data

Chemical name 3,5-pyridinedicarbothioic acid, 2-(difluoromethyl) -4- (2-methylpropyl) -6 -(trifluoromethyl) -, S,S-dimethyl ester

Chemical structure



Water solubility 0.7 ppm at 25°C

Toxicology Acute LD_{50}; Oral, Rat & Mouse, >5,000 mg/kg; Dermal, Rat, >5,000 mg/kg; Mutagenicity; negative.

Fish toxicity LC_{50} 96 hrs; Carp, 0.716 mg/l.

Field test method Rice of 2.5leaf-stage was transplanted by machine or hand. Puddling was conducted at 3-4 days before transplanting. Weed seeds and propagules were sown at 1-2 days before transplanting if necessary. Paddy water was maintained at 3 cm depth throughout test period. Chemicals were applied to the soil surface. Plots were randomized complete block design with three replications. Plot size is 4 m^2 (2m x 2m). Visual assessment was made for each observation.

RESULTS

Herbicidal activity MON 7200 showed very high unit activity on most major annual weeds, such as barnyardgrass, *Monochoria vaginalis, Rotala indica, Cyperus difformis* and the small seed perennial broadleaf weed, *Alisma canaliculatum.* MON 7200 provided excellent control of these weeds at 0.06 kg ai/ha with pre-emergence application and 0.12 kg ai/ha with early post-emergence application (barnyardgrass of 1.5 leaf-stage) in Japan and Taiwan (Table 1). The activity of MON 7200 in Thailand was consistent with that in Japan and Taiwan and MON 7200 at 0.12 kg ai/ha gave excellent control of barnyardgrass and *Sphenoclea zeylanica* with early post-emergence spray application (Table 1). The application window of MON 7200 at 0.12 kg ai/ha was 0 to 2.0 leaf-stage of barnyardgrass, however, the activity dropped on barnyardgrass at the 2.5 leaf-stage application (Fig. 1). The longevity of MON 7200 at 0.12 kg ai/ha was 70 days and it was better than that of mefenacet at 1.2 kg ai/ha and butachlor at 1.5 kg ai/ha (Fig. 2). Though MON 7200 showed the longevity of 70 days, MON 7200 did not give any residual effect on succeeding crops after rice harvesting. The activity of MON 7200 on barnyardgrass was not affected by different soil type (Fig. 3), temperature, or water depth conditions. Even if the paddy water was drained after DBT (days befor transplanting) application, MON 7200 gave excellent control of barnyardgrass.

Rice safety MON 7200 gave excellent rice safety on Japonica and Indica rice even at 0.48 kg ai/ha with pre-emergence and early post-emergence applications (Table 2). The rice safety of this chemical was not affected by soil type, temperature, and water depth conditions. Even with the shallow transplanting, MON 7200 provided good rice safety if the basal stem of the rice was in the soil, even if the roots were exposed to the flooded water (Fig. 4). This result suggests that the susceptible part of rice to MON 7200 is the basal stem and MON 7200 gives good rice safety as long as the basal stem of rice seedling is covered with soil, even if rice seedlings are planted very shallowly. MON 7200 gave excellent rice safety with DBT application as well as with DAT application.

Selectivity MON 7200 gave 16 X selectivity on annual weeds with pre-emergence application and 8 X selectivity with early post-emergence application (Fig. 5).

DISCUSSION

Mon 7200 is a high unit active herbicide and the recommended rate of MON 7200 is 0.12 kg ai/ha. MON 7200 at this low rate controls most of the annual weeds and small seed perennial weed with pre-emergence and early post-emergence applications. Longevity is one of most important properties for the

Table 1. Activity of MON 7200

Weeds	The rate (kg ai/ha) of MON 7200 which gave more than 90% control — Application time: Pre-emergence	Early post-emergence[1]
Annual		
Echinochloa crus-galli	0.06	0.12[2]
Monochoria vaginalis	0.06	0.12
Rotala indica	0.06	0.12
Sphenoclea zeylanica	–	0.12[3]
Cyperus difformis	0.06	0.12
Perennial		
Alisma canaliculatum	0.06	0.12
Alisma plantago-aquatica	0.12	0.48
Eleocharis acicularis	0.24	0.24
Scirpus juncoides	1.92	1.92
Cyperus serotinus	1.92	1.92
Sagittaria pygmaea	>1.92	>1.92

[1] Barnyardgrass of 1.5 leaf-stage.
[2] Including Thailand data.
[3] Thailand data.

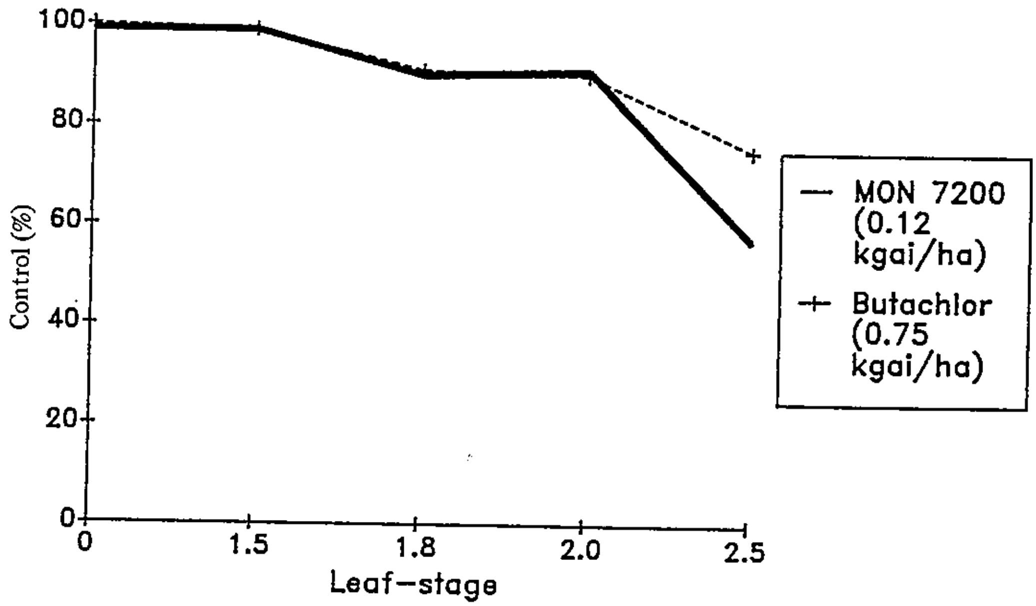


Fig. 1. Application window of MON 7200 on barnyardgrass.

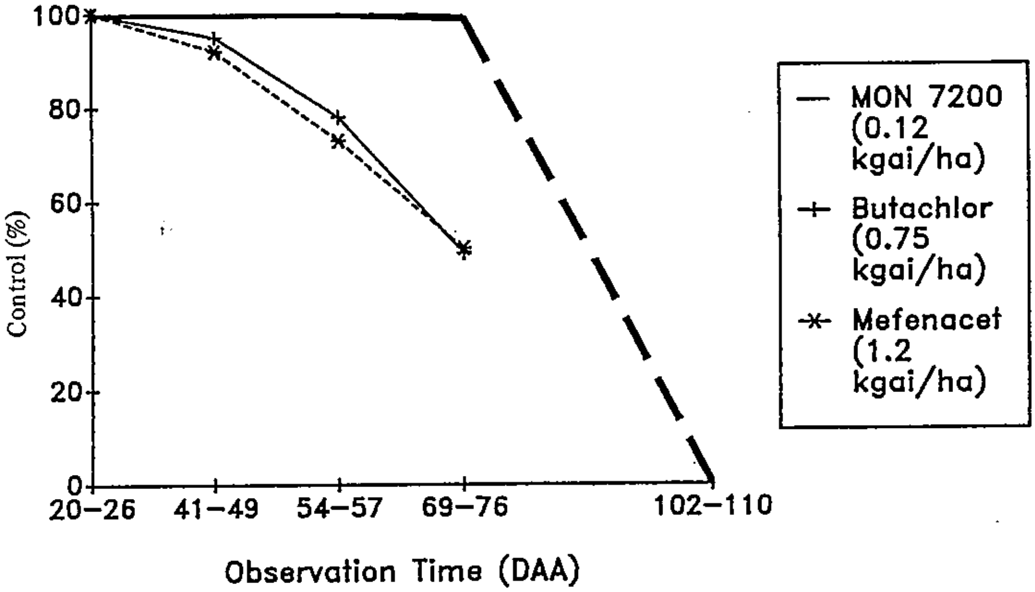


Fig. 2. Longevity of MON 7200 on barnyardgrass.

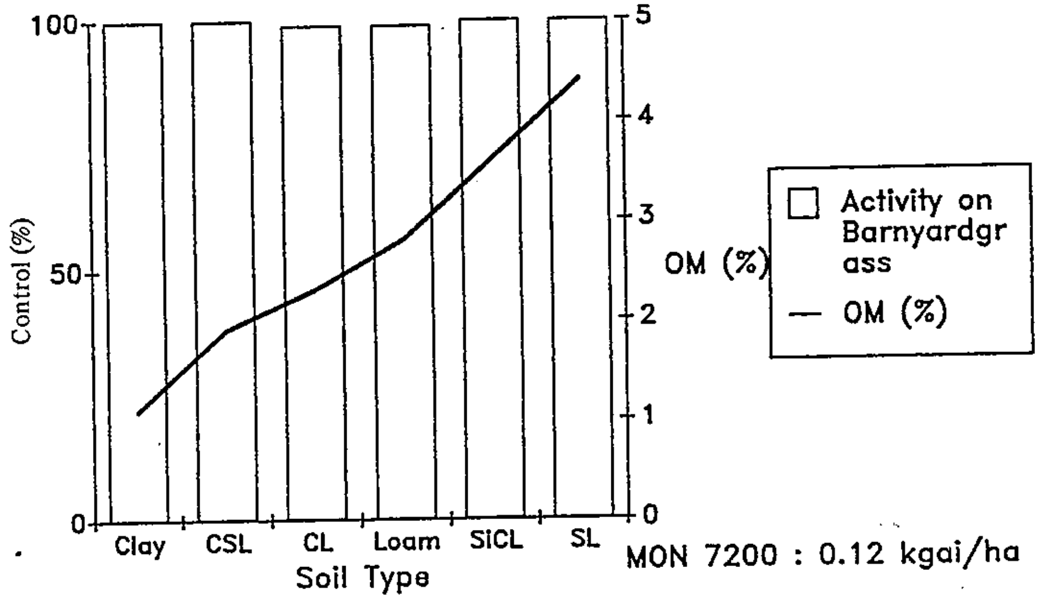


Fig. 3. Activity of MON 7200 on different soil types.

Table 2. Rice safety of MON 7200 on Japonica and Indica rice.

		Rice injury %				
		Japonica rice			Indica rice	
Chemical[3]	(kg ai/ha)	Nihon–bare[1]	Koshi–hikari[1]	Taichung 67[1]	RD 23[1]	RD 23[2]
MON 7200	0.96	13[4]	12	0	–	–
	0.48	8	9	4	2	0
	0.24	5	13	3	0	0
	0.12	4	3	0	0	0

1 Soil treatment

2 Foliar application

3 Chemical application: 1–2 DAT

4 Acceptable rice injury: ⩽15

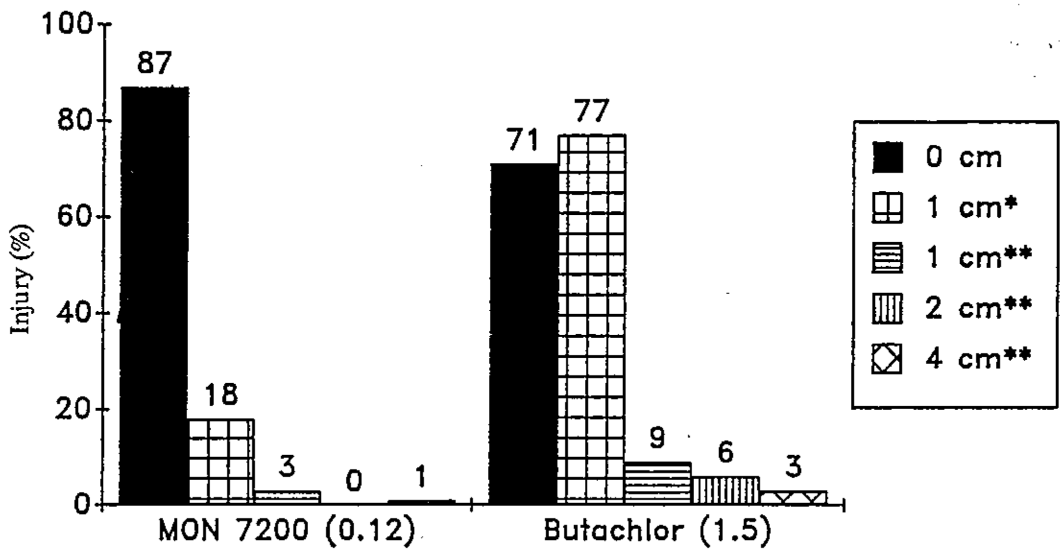


Fig. 4. Rice safety of MON 7200 with different transplanting depth.

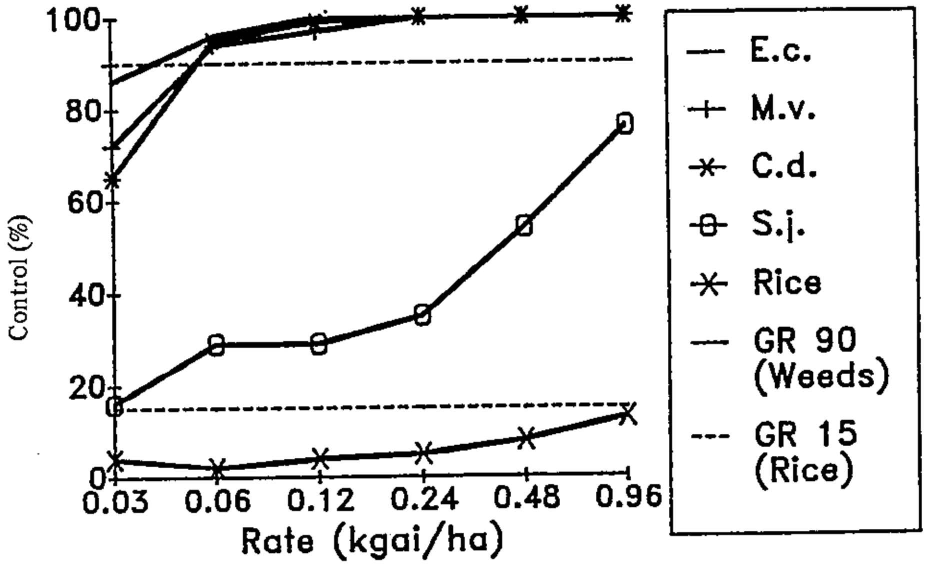


Fig. 5. Selectivity of MON 7200 between rice and paddy weeds.

herbicide especially in low temperature area where weeds germinate slowly and longevity on barnyard-grass is required. The longevity of MON 7200 at 0.12 kg ai/ha (70 days) is long enough to fit into this low temperature area as well as warmer areas. Since MON 7200 gave excellent annual weed control with good longevity, MON 7200 has an excellent potential as a component of one shot herbicide. The mixture of MON 7200 with a perennial weed herbicide is recommended to expand weed spectrum.

NC–311, A NEW SULFONYLUREA HERBICIDE IN RICE

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ABSTRACT

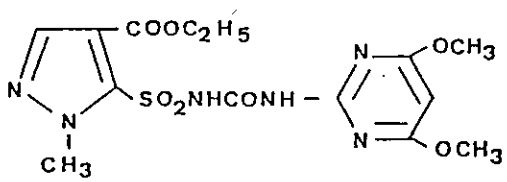
NC–311, pyrazosulfuron-ethyl, is a new selective herbicide for the control of most annual and perennial broadleaf weeds and sedges in paddy rice. This herbicide was discovered and is being developed by NISSAN CHEMICAL INDUSTRIES LTD., In pot tests, NC–311 showed high activity against annual and perennial broadleaf weeds and sedges with pre and postemergence applications. The dosage for 75% control was less than 18 g ai/ha including *Echinochloa crus-galli*. NC–311 was very safe to transplanted rice at 21 g ai/ha under water leaching and shallow planting conditions. However, under similar conditions, NC–311 at 42 g ai/ha was slightly phytotoxic. Indica type rice at 42 g ai/ha was less sensitive to NC–311 than Japonica type. In field trials in Taiwan and Malaysia, granular broadcasting applications of NC–311 at the rate of 21 g ai/ha resulted in excellent control of most weed species with no phytotoxicity to transplanted rice.

INTRODUCTION

NC–311, discovered in 1982, is a new broadspectrum herbicide being developed by NISSAN CHEMICAL INDUSTRIES LTD. for use in transplanted and direct seeded rice. Since 1984 0.07% granular NC–311 at the rate of 21 g ai/ha alone and in combination with other herbicides have been tested in Japan by national and prefectural agricultural stations in cooperation with the Japan Association for Advancement of Phytoregulators (JAPR). In these tests, NC–311 demonstrated excellent effectiveness against broadleaf weeds and sedges including perennials, while showing no phytotoxicity to rice. NC–311 has been tested in various rice producing countries not only as 0.07% granular formulation alone and in combination with other herbicides, but also as a 10% WP and 25% flowable.

This paper describes the herbicidal, as well as, physicochemical and toxicological properties of NC–311.

Chemečal and physical properties

code number	NC–311
common name	pyrazosulfuron-ethyl
chemical name	Ethyl 5- [3- (4,6-dimethoxy pyrimidin-2-yl) ureidosulfonyl] -1- methylpyrazole-4-carboxylate
chemical formula	

molecular weight	414.4
appearance	white crystalline solid
melting point	180–181°C
solubility	water (at 25°C, adjusted with 0.05 M sodium-potassium phosphate buffer)

PH	4.6	6.0	7.0
ppm	8.5	221	1494

formulations	10 % wettable powder
	25% flowable
	0.07% granule

Toxicology

Acute oral	rat	(M,F)	$LD_{50} > 5000$ mg/kg
	mouse	(M,F)	$LD_{50} > 5000$ mg/kg
Acute dermal	rat	(M,F)	$LD_{50} > 2000$ mg/kg
Skin irritation	rabbit		not irritant
Eye irritation	rabbit		not irritant
Ames test			negative
Rec-assay			negative
Fish toxicity	carp		TLm 48hrs > 10 ppm

MATERIALS AND METHODS

Pot tests

Herbicidal spectrum The spectrum of NC–311 was determined by pot tests under paddy conditions. Ten weed species for preemergence and 9 weed species for postemergence tests were used. Weed seeds, tubers and runners were planted in 1.3L, 11.3cm diameter plastic pot containing clay loam soil (clay 18.0%, total carbon 0.15%, pH 6.18). NC–311 and bensulfuron-methyl in diluted suspensions of wettable powder were applied to flood water. Standing water was maintained 4 cm in depth during tests. Between 25 to 35 days after treatment, fresh weight was measured and dosage for 75% control (I–75 value) was calculated for each weed.

Crop safety These tests were conducted on some possible factors affecting safety of NC–311 to transplanted rice. 0.07% granular NC–311 was applied 2 to 4 days after transplanting. Rice (*Oryza sativa* L. var. Nihonbare) seedling at 2.5–3 leaf stage was transplanted two plants per pot with pots and soil as above.

Influence of planting depth Rice seedling was transplanted 1,2 or 3 cm in depth. Standing water was maintained 4 cm in depth during tests, and shoot fresh weight was measured 31 days after treatment.

Influence of water leaching Water leaching began the day after treatment at the rate of 1 cm/day for 3 days. After leaching, standing water was readjusted to a 4 cm. Shoot fresh weight was measured 33 days after treatment.

Phytotoxicity of NC–311 among rice varieties Rice seedling of 5 varieties at 2 leaf stage was transplanted two plants per pot. Shoot fresh weight was measured 36 days after treatment.

Selectivity of NC–311 A water culture study was conducted to determine the range of selectivity between rice seedling and seedling of *Cyperus serotinus* (4–6 cm height). Plants were grown in half-strength Kasugai's solution, in which the concentration of NC–311 varied from 0.1 to 100 ppb. Both rice and *C. serotinus* were cultured for 35 days under greenhouse conditions and after that fresh weight was measured.

All pot tests had with 3 replications.

Field trials

In Malaysia This trial was designed to evaluate weed control and crop safety for transplanted rice in tropical regions. Rice seedling, var. MR–77, was transplanted on Apr. 30, 1985,and 0.07% granular NC–311 was broadcasted at 14 and 21 g ai/ha 2 days after transplanting. 7% granular X–52 at 2100 g ai/ha was broadcasted as standard treatment. Plot size was 50 m^2. Assessment for weed control was done visually from 3 random points of 1 m^2 31 days after transplanting. Yields were measured from the weight of rough rice collected from 3 randomised points at the end of the trial.

In Taiwan This trial was designed to evaluate weed control and crop safety for transplanted rice in subtropical regions. Rice seedling (var. Kaohsiung 141) was transplanted on Mar. 10, 1986, and 0.07% granular NC–311 at 21 g ai/ha was broadcasted 7 and 14 days after transplanting. 5% granular butachlor at 1500 g ai/ha was broadcasted 7 days after transplanting as standard treatment. A split plot design with 3 replications was used. Plot size was 10 m^2. Assessment for weed control was done by measuring % of control fresh weight 45 days after transplanting. The phytotoxicity rating of transplanted rice was taken visually on a scale 0= no injury to 9= completely killed 30 days after transplanting.

RESULTS AND DISCUSSION

Pot tests

Herbicidal spectrum Pre and postemergence application of NC–311 was highly effective against major paddy weeds including noxious perennials of Japan (Tables 1 and 2). The dosages for 75% weed control of pre and postemergence applications were less than 13 g ai/ha and 18 g ai/ha respectively. NC–311 was 1.5 to 15 times more active against these weeds than bensulfuron-methyl except in the case of *Sagittaria trifolia* postemergence application.

Crop safety At the rate of 21 g ai/ha NC–311 did not reduce the fresh weight of rice under water leaching and shallow planting conditions (Tables 3 and 4). However under these conditions, NC–311 was slightly phytotoxic to transplanted rice at double the recommended rate 42 g ai/ha. From these results it is estimated that NC–311 is mainly absorbed through the root system of transplanted rice.

NC–311 caused little effect on the 5 rice varieties tested at 21 g ai/ha (Table 5). However 63 g ai/ha shoot fresh weight of "Nihonbare" and "Carlose" Japonica type rice, were reduced 15 and 24% respectively. At the same rate, shoot fresh weight of "Tae-back" Indica type rice, was reduced 11%. "IR-36" and "IR-8" (Indica type rice) were unaffected. This result indicates that Indica type rice is less sensitive to NC–311 than Japonica type.

Selectivity of NC–311 As shown in Fig. 1, in a water culture study, NC–311 at 1 to 3 ppb stopped the growth of *C. cerotinus* completely. Reducation rate of rice seedling was approximately 20% at 30

Table 1. Herbicidal activity of NC–311 with preemergence treatment.

Weed species	I–75 value (g ai/ha)	
	NC–311	Bensulfuron-methyl
Echinochloa crus-galli	13.0	217
Scirpus juncoides	8.3	25.6
Monochoria vaginalis	2.7	5.8
Alisma canaliculatum	2.1	3.0
Rotala indica	1.5	2.3
Cyperus difformis	2.3	6.1
Sagittaria pygmaea (tuber)	1.9	9.0
Sagittaria trifolia (tuber)	2.3	4.8
Cyperus serotinus (tuber)	0.9	9.1
Eleocharis kuroguwai (tuber)	1.9	27.1

Table 2. Herbicidal activity of NC–311 with postemergence treatment.

Weed species (leaf stage)	I–75 value (g ai/ha)	
	NC–311	Bensulfuron-methyl
Echinochloa crus-galli (1.5L)	18.0	172
Scirpus juncoides (1.5-2L)	12.0	35.0
Monochoria vaginalis (2L)	2.1	6.7
Alisma canaliculatum (3-4L)	1.4	3.6
Sagittaria pygmaea (tuber) (2L)	2.7	9.4
Sagittaria trifolia (tuber) (4-5L)	2.7	2.4
Cyperus serotinus (tuber) (3-4L)	1.9	26.6
Eleocharis kuroguwai (tuber) (10-20cm)	7.4	56.0
Oenanthe javanica (runner with 2 leaves)	1.9	6.8

Table 3. Influence of planting depth on phytotoxicity of NC–311 to transplanted rice (pot test).

		Shoot fresh weight (% Control)		
		Planting depth (cm)		
	g ai/ha	1	2	3
NC–311	21	84	90	92
	42	57	75	80

Table 4. Influence of water leaching on phytotoxicity of NC–311 to transplanted rice (pot test).

		Shoot fresh weight (% Control)	
		Water leaching	
	g ai/ha	None	1 cm/day x 3 days
NC–311	21	94	90
	42	89	70

Table 5. Phytotoxicity of NC–311 against five transplanted rice varieties (pot test).

		Shoot fresh weight (% Control)				
	g ai/ha	Nihonbare (J)[1]	Calrose (J)	Tae-back (I)[2]	IR–36 (I)	IR–8 (I)
NC–311	21	97	102	106	97	94
	63	85	76	89	106	98

[1] J=Japonica type, [2] I=Indica type

Table 6. Weed control and rice yield treated with NC–311 at 2 DAT[1].
From Malaysia field trials in 1985.

Treatment	g ai/ha	% weed control[2] at 31 DAT						Yield
		Sagittaria guyanensis	*Monochoria vaginalis*	*Ludwigia adscendens*	*Limnocharis flava*	*Fimbristylis miliacea*	*Cyperus digitatus*	(t/ha)
NC–311	14	86	100	39	100	94	100	5.33
(0.07% G)	21	92	100	76	100	100	100	5.47
X–52	2100	0	94	65	56	100	77	4.47
(7%G)								
Untreated	–	0	0	0	0	0	0	4.75

1 DAT = days after transplanting.

2 Assessment for weed control was done visually.

Location : Pinang Tunggal, Plot size : 50 m^2, Date of transplanting : Apr. 30 in 1985.

Table 7. Weed control and rice injury treated with NC–311 at 7 or 14 DAT[1].
From Taiwan field trials in 1986.

Treatment	Application timing (DAT)	Crop[2] injury at 30 DAT	% weed control[3] *Echinochloa crus-galli*	*Monochoria vaginalis*	*Sagittaria trifolia*	*Sagittaria pygmaea*	*Lindernia pyxidaria*	*Cyperus digitatus*
NC–311 0.07%C	7	0	93	100	100	100	100	98
(21 g ai/ha)	14	0	99	96	89	93	100	98
Butachlor 5%G (1500g ai/ha)	7	0	96	78	0	0	100	100
Untreated check	–	2	0	0	0	0	0	0

1 DAT = days after transplanting.

2 0 = no injury . . . 9 = completely killed

3 Assessment for weed control was done by measuring (%) control fresh weight.

Location: Yaipu, Taichung pref., Plot size: $10m^2$ with 3 replications. Date of transplanting: Mar. 10 in 1987.

ppb. Comparing I-50 values, *C. cerotinus* was about 300 times as sensitive to NC–311 as was rice. Therefore it is clear that NC–311 has sufficient range of selectivity.

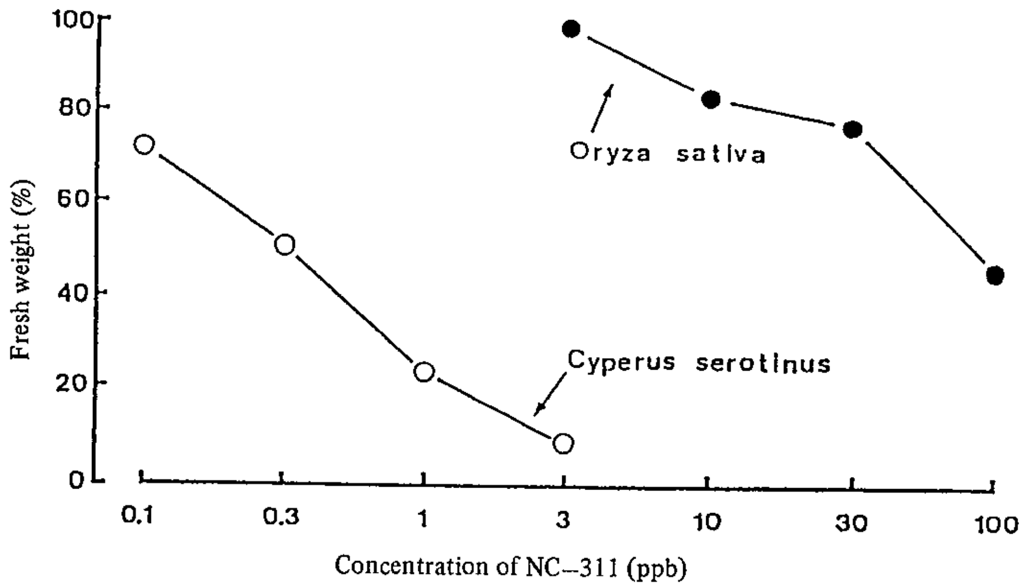


Fig. 1. Selectivity of NC–311 between *Cyperus serotinus* and rice under water culture condition.

Field trials

In Malaysia As shown in Table 6, broadcasted 0.07% granular NC–311 at 14 and 21 g ai/ha gave excellent control of *Sagittaria guyanensis, Monochoria vaginalis, Limnocharis flava, Fimbristylis miliacea* and *Cyperus digitatus.* Control was equal or superior to standard treatments. Although control of *Ludwigia adscendens* at 14 g ai/ha was not satisfactory, more than 75% control was obtained at 21 g ai/ha. The yield of rough rice from the plots with NC–311 at 14 and 21 g ai/ha increased 12.1% and 15.1% respectively as compared to the untreated control plot.

In Taiwan As shown in Table 7, broadcasted 0.07% granular NC–311 at 21 g ai/ha 7 and 14 days after transplanting gave almost complete control of all weeds. These applications caused no phytotoxicity to transplanted rice.

As mentioned above, 0.07% granular NC–311 at 21 g ai/ha gave excellent control of most weeds with no phytotoxicity.

ACKNOWLEDGEMENTS

We acknowledge with gratitude the national and prefectural agricultural stations of Japan and the cooperation of the JAPR.

VIABILITY AND EMERGENCE OF BURIED SEEDS OF *ECHINOCHLOA GLABRESCENS, MONOCHORIA VAGINALIS* AND *CYPERUS DIFFORMIS*[1]

Jong Seong Kim[2] and Beatriz L. Mercado[3]

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ABSTRACT

Seeds of *Echinochloa glabrescens* Munro ex. Hook, *Monochoria vaginalis* Burm. f. Presl. and *Cyperus difformis* L. were buried at different depths of the soil under simulated field at different depths of the soil under simulated field conditions and observed for emergence and viability after 1,2,3, and 4 months. *E. glabrescens* and *C. difformis* seeds required light for germination. For *E. glabrescens,* burial beyond 5 cm from 1 to 3 months induced secondary dormancy. At 4 months, dead seeds increased. For *C. difformis,* surface-sown seeds germinated readily and buried seeds, did so only upon exposure to light. *M. vaginalis* gave poor germination at the surface and none when buried. The seeds appeared to develop the requirement for light at depths below 1 cm after one month burial.

INTRODUCTION

Cultivated soils contain an abundant number of weed seeds distributed throughout the working depth. The emergence and survival of buried seeds depend on the physiological status of the weed and on environmental factors such as light, water, and oxygen. The flush of germination which occurs after cultivation can be attributed to light exposure (11). In such species as *Stellaria media* L. (Wesson & Wareing, 1969), *Chenopodium album* L. (11), *Capsella bursa-pastoris* L. and *Senecio vulgaris* L. (8), their seeds seem to develop a light requirement after burial in soil. Moody (7) observed that weed seed germination decreases with depth of water. *Monochoria vaginalis,* however, requires flooded soil to germinate (13, 14).

Variations in temperature, moisture and oxygen occur with soil depth. There are species that can tolerate deep burial and can germinate freely. Some species develop secondary dormancy in deep burial. Red rice (*Oryza sativa* L.) germinated freely up to 5.1 cm deep at either field capacity or saturation but showed reduced emergence at 10.2 cm (9).

In weed control, seeds buried deep in the soil pose greater problems than those in the upper layers. Seeds in the upper layer lose their viability faster than those in the deeper layer due to exposure to varying environmental conditions (10).

In this study, the viability and emergence of three weed species associated with lowland rice at different soil depths were determined under simulated field conditions.

MATERIALS AND METHODS

General procedure Upland and lowland soils were collected from the University Central Experiment Station. Chemical and physical properties of the soils are given in Table 1.

Table 1. Chemical and physical properties of the soils used.

Property	Amount	
	Upland soil	Lowland soil
Particle size (%)		
Clay	41.0	53.5
Silt	38.0	28.5
Sand	20.5	18.0
pH (1:1 soil:water)	7.3	6.8
Organic C (%)	0.939	2.01
Total N (%)	0.089	0.205
Exchangeable cations		
Phosphorus	13.0	14.0
Potassium	1.36	1.22
Cation exchange capacity (meq/100 g)	33.0	38.3

Mature seeds of *Echinochloa glabrescens* Munro ex. Hook, *Monochoria vaginalis* Burm. f. Presl. and *Cyperus difformis* L. were collected from the lowland ricefields of the University during the first week of November 1985. Seeds were air-dried, cleaned, rid of immature seeds placed in paper envelopes and kept in a laboratory locker.

Four 2m x 4m x 0.6m microplots were prepared in the field where upland, sterilized upland, lowland, and sterilized lowland soil samples were randomly assigned. Prior to placement of soil on the microplots, the plots were lined with two layers of plastic sheets to separate the soil used in this experiment with that of field soil. Seeds were sown at 0, 1, 2, 3, 5, 10, 20, 25, and 30 cm in each microplot.

The treatments were laid out in a split-plot randomized complete block design with three replications. Soil conditions were assigned to the main plots and depths of seed burial to subplots. Fifty mature seeds of each species were separately enclosed in 4 cm x 8 cm fine mesh nylon sachets. Forty mesh nylon sachets were used for *E. glabrescens* and 60 mesh nylon sachets for *M. vaginalis* and *C. difformis.* Twenty-four sachets of each species were placed at different soil depths and then covered with the same soil and flooded 2 cm deep. The set-up was prepared on November 20, 1985.

Germination test before burial Four batches of 100 seeds of the three species were placed in 9 cm petri dishes lined with two layers of filter paper with 5 ml tap water for *E. glabrescens* and *C. difformis* and 1 cm standing water for *M. vaginalis.* One set was covered with aluminum foil to maintain dark condition. The dishes were incubated in alternating day-night temperature of 35/25°C and exposed to light for two weeks.

Germination test after burial One 200 cm x 500 cm x 15 cm seedbed box was prepared and placed in the open field. Three sachets of each species at all soil depths were exhumed at monthly intervals for 4 months. Three sachets each were germinated in the seedbed box for 2 weeks. The remaining seeds in the seedbed box were examined using the same procedure used before burial.

Seeds were categorized as emerged, enforced dormant, innate dormant, and dead. Emerged were those that did not emerge in the microplots but did so in the seedbed box and in the incubator. Innate dormant seeds were the viable seeds that did not germinate even under incubation. Dead seeds were those that did not germinate under any condition and gave a negative response to tetrazolium chloride.

The mean percentages of emerged, enforced dormant, innate dormant, and dead seeds after packets were exhumed at monthyl intervals from 0 to 30 cm soil depth. Viability and germination differences among *E. glabrescens, C. difformis* and *M. vaginalis* seeds sown in lowland, upland, sterilized lowland and upland soil conditions did not differ, therefore, the data from the four soil conditions were combined and averaged.

RESULTS AND DISCUSSION

Viability and germination of buried E. *glabrescens* seeds after 1, 2, 3, and 4 months in the soil Seventy-nine per cent of the seeds placed on the soil surface or 0 cm germinated in one month (Table 2). Those that were buried in the soil did not emerged. This could be due to the absence of light or to the onset of secondary dormancy due to unfavorable conditions since most seeds germinated when placed in the incubator. At 1 to 5 cm, relatively more seeds germinated after incubation than when buried at 10-30 cm depth. At these depths, less seeds no longer responded to light and some must have developed secondary dormancy. The percentage of dead seeds did not differ in all soil depths.

After 2 months burial the general trend was the same as that after one month. The enforced and innate dormant seeds were higher at 10 to 30 cm soil depth than at 1 to 5 cm soil depth. The percentage of dead seeds was about 8% irrespective of soil depth.

After 3 months, soil depth showed an effect not only on the percentage of enforced and innate dormant seeds but also on the dead seeds. The percentage of enforced dormant seeds was highest at 2 to 5 cm soil depth followed by those at 1, 10, and 15 cm soil depth and those below 20 cm. The percentage of innate dormant seeds was highest at 25 and 30 cm soil depth and gradually increased slightly with depth of burial. Some seeds (9%) at 1 cm emerged.

After 4 months burial, percentage of enforced dormant seeds were the same at 2-15 cm. There was a slight decrease at 1 cm and 20-30 cm depths. There were no more enforced dormant seeds at the surface. The percentage of innately dormant seeds increased slightly with burial depth. As in the 3-month burial, emergence was observed with seeds buried at 1 cm. Perhaps, deeper buried seeds may emerge, if the observation time was extended. Seeds of other Echinochloa species such as *E. crusgalli* were observed to emerged from soil depths as low 12 cm (3). Brod (2) found high per centage of emergence from seeds at 2 to 6 cm depths and even up to 10 cm. This behavior can be explained by the ability of *E. crusgalli* to germinate and grow for extended under anaerobic conditions (4). The general trend at any depth is that non-dormant seeds increased with time. Innate dormant and dead seeds

Table 2. Percentage of emerged, enforced dormant, innate dormant, and dead *E. glabrescens* seeds buried at different soil depths after 1, 2, 3, and 4 months recovery.

Burial depth (cm)	Duration of burial (month)															
	1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								%								
0	7 d[2]	12 c	3 b	79	5 d	7 c	5 b	82	3 e	4 c	6 d	87 a	0 d	3 a	7 f	90 a
1	91 a	3 e	4 a		88 a	4 cd	8 a		78 bc	1 d	12 bc	9 b	73 c	1 b	14 de	12 b
2	88 a	7 d	5 a		88 a	4 cd	8 a		86 a	2 d	12 bc		85 a	1 b	14 de	
3	88 a	7 d	5 a		88 a	4 cd	8 a		89 a	1 d	10 c		86 a	1 b	13 e	
5	91 a	4 de	4 a		86 a	5 cd	9 a		88 a	2 d	10 c		85 a	1 b	14 e	
10	81 b	15 bc	4 a		80 b	12 b	8 a		82 b	5 c	13 bc		83 ab	2 b	15 de	
15	80 b	16 b	4 a		81 b	11 b	8 a		81 b	5 c	14 ab		81 ab	2 b	17 cd	
20	78 b	17 b	5 a		77 bc	15 b	8 a		76 a	10 b	14 ab		78 b	2 b	20 bc	
25	77 bc	18 b	5 a		77 bc	14 b	9 a		73 d	11 ab	16 a		78 b	2 b	20 bc	
30	74 c	22 a	4 a		73 c	18 a	9 a		70 d	13 a	17 a		71 c	3 a	26 a	

[1] 1 = enforced dormant, 2 = innate dormant, 3 = dead, and 4 = emergence.

[2] Means having the same letter are not statisticially different at the 5% level.

increased with soil depth. Some seeds at 1 cm lost the light requirement after long burial and eventually emerged.

Viability and germination of buried *M. vaginalis* seeds after 1, 2, 3, and 4 months in the soil After one month burial, no seedlings of *M. vaginalis* emerged from any soil depth (Table 3). The percentage of enforced dormant seeds at 2 to 30 cm soil depth ranged from 5 to 10. Innate dormant seeds were high at 0 and 1 cm soil depth where no enforced dormant seeds were observed.

After two months about 8% of the seeds at 0 cm emerged (Table 2). Enforced dormant seeds increased slightly with the concomitant decrease of innate dormant seeds. There were more dead seeds at the surface than at the lower depths.

After 3 months more seeds (14%) emerged at 0 cm. More seeds lost their innate dormancy. Enforced dormant seeds were highest at 1-25 cm. Slightly less were observed at 30 cm and least at the surface. More dead seeds occurred at the surface than at the deeper layers.

After 4 months about 16% of the seeds emerged at 0 cm. More seeds lost their innate dormancy. More dead seeds occurred at the surface than at the deeper layers.

Up to this time seeds buried in the soil did not emerge. The percentage of enforced dormant seeds was lowest at 0 cm (about 63%) whereas those buried in the soil ranged from 89 to 95%. Innate dormant seeds were highest at 0 cm. The percentage of other soil depths did not differ and ranged from 0 to 4%.

Lamid (5) observed that *M. vaginalis* required at least 2 months storage under laboratory conditions to break dormancy. He obtained 94% germination in 2 weeks for 2-month stored seeds. In this study, only 8% of surface-sown seeds emerged after 2 months and most of the seeds maintained their dormancy in the soil after 4 months. A longer longevity when buried in the soil than when kept under laboratory conditions was also demonstrated with *Striga asiatica* by Bebawi et al, (1). *S. asiatica* seeds remained viable for 14 years in the soil but only 6 years in the laboratory.

These observations indicate that *M. vaginalis* seeds need an after ripening period of more than one month before any seed can emerge. Burial hastened the change from innate dormancy to enforced dormancy. Light is a critical factor for germination as natural emergence was observed only on surface-sown seeds.

Viability and germination of buried *C. difformis* seeds after 1, 2, 3, and 4 months in the soil After 1, 2, 3, and 4 months burial *C. difformis* exhibited almost the same germination behavior (Table 4). Emergence was observed only with seeds sown at the surface. Innate dormant seeds were consistently highest at the surface up to 3 months burial. After 4 months there were none or very few innate dormant seeds at all levels.

In all cases, no seeds emerged when buried in the soil but majority of the seeds germinated when exposed to light in the incubator after recovery. These results indicate light and/or oxygen may be the controlling factor in the germination of *C. difformis* seeds. Lubigan et al. (6) likewise observed that *C. difformis* seeds germinated readily when surface sown but not when buried in the soil although they found very low germination at 1 cm depth.

LETERATURE CITED

1. Bebawi, F. E., R. E. Eplee, C. E. Harris, and R. S. Morris. 1984. Longevity of witch (*Striga asiatica*) seed. Weed Sci. 32:494-497.

Table 3. Percentage of emerged, enforced dormant, innate dormant, and dead *M. vaginalis* seeds buried at different soil depths after 1, 2, 3, and 4 months recovery.

Burial depth (cm)	Time of exhuming (month) 1				2				3				4			
	1[1]	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0	0	96 a[2]	4	0	10 b	73	9 a	8	33 e	44 a	9 a	14	63 d	11 a	10	16
1	0	96 a	4		24 a	69	7 ab		64 bcd	29 cd	7 ab		91 ae	0 e	9 ab	
2	6 b	90 b	4		25 a	70	5 bcd		68 abc	26 cd	26 bc		92 abc	2 c	6 bc	
3	10 a	86 b	4		26 a	70	4 d		72 a	24 d	4 bc		94 a	1 cde	5 c	
5	7 d	88 b	5		27 a	67	6 bc		68 abc	28 cd	4 bc		94 a	0 e	6 bc	
10	8 ab	89 b	3		26 a	70	4 bc		65 bcd	29 cd	6 bc		90 bc	1 de	9 ab	
15	6 b	90 b	4		24 a	73	3 d		69 ab	26 cd	5 bc		91 abc	1 cde	8 ab	
20	7 b	89 b	4		25 a	70	5 bcd		64 bcd	32 bc	4 bc		94 a	0 e	6 bc	
25	6 b	90 b	4		22 a	75	3 d		67 abc	28 cd	5 bc		89 c	4 b	7 bc	
30	5 b	91 b	4		25 a	71	4 cd		59 d	37 b	4 bc		93 a	2 cd	5 c	

1 1 = enforced dormant, 2 = innate dormant, 3 = dead, 4 = emergence.

2 Means having the same letter are not statistically different at the 5% level.

Table 4. Percentage of emerged, enforced dormant, innate dormant, and dead *C. difformis* seeds buried at different soil depths after 1, 2, 3, and 4 months recovery.

Burial depth (cm)	Time of exhuming (month): 1				2				3				4			
	1[1]	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0	7 b[2]	17 a	7	69	0 b	15 a	10 a	75	0 e	14 a	8 abc	78	0 b	2 bc	10	88
1	90 a	6 cde	4		87 a	6 cd	7 ab		92 a	3 d	5 c		92 a	1 cd	7	
2	90 a	3 e	7		86 a	5 cde	9 a		78 d	10 b	12 a		88 a	1 cd	11	
3	86 a	8 bc	6		85 a	4 de	11 a		87 abc	6 cd	7 bc		87 a	4 a	9	
5	84 a	9 b	7		84 a	9 b	7 ab		80 cd	10 b	10 ab		96 a	2 bc	12	
10	85 a	7 bcd	8		85 a	6 cd	9 a		88 abc	6 cd	6 cd		88 a	1 cd	11	
15	89 a	5 cde	6		86 a	3 e	11 a		79 d	11 b	10 ab		89 a	2 abc	9	
20	90 a	4 de	6		91 a	5 cde	4 b		88 ab	4 d	8 abc		90 a	0	10	
25	87 a	4 de	9		89 a	4 de	7 ab		82 bcd	6 cd	12 a		87 a	0	13	
30	84 a	9 b	7		83 a	7 bc	10 a		84 bcd	9 bc	7 abc		88 a	3 ab	9	

[1] 1 = enforced dormant, 2 = innate dormant, 3 = dead, 4 = emergence.

[2] Means having the same letter are not statistically different at the 5% level.

2. Brod, G. 1968. Studies on the biology and ecology of banryardgrass, *Echinochloa crusgalli.* Weed Res. 8:115-127. (In German, English summary).
3. Dawson, J. H. and V. F. Bruns. 1962. Emergence of barnyardgrass, green foxtail and yellow foxtail seedlings from various soil depths. Weed Sci. 10: 136-139.
4. Kennedy, R. A., M. E. Rumpho and D. VanduZee. 1983. Germination of *Echinochloa crusgalli* (Barnyard grass) seeds under anaerobic conditions. Plant Physiol. 72: 787-794.
5. Lamid, Z. 1981. Biology and response of *Monochoria vaginalis* Burm. f. Presl. to selected herbicides at different growth stages. M. S. Thesis. 74pp.
6. Lubigan, R. T., B. L. Mercado and K. Moody. 1985. Effects of soil moisture and burial on germination of *Cyperus difformis* seeds. International Rice Research Newsletter 10(2): 19-20.
7. Moody, K. 1976. Weed management in cropping systems. Paper presented at the Second Workshop on Cropping Systems. 23-24 August 1976, Bogor, Indonesia.
8. Popay, A. I. and E. H. Roberts. 1970. Factors involved in the dormancy and germination of *Capsella bursa-pastoris* (L.) Medik. and *Senecio vulgaris* L. J. Ecol. 58: 103-122.
9. Smith, R. J., Jr. and W. T. Fox. 1973. Soil water and growth of rice and weeds. Weed Sci. 21: 61-63.
10. Stoller, E. W. and L. M. Wax. 1973. Temperature variations in the suface layers of an agricultural soil. Weed Res. 13: 273-282.
11. Taylorson, R. B. 1970. Changes in dormancy and viability of weed seeds in soils. Weed Sci. 18: 265-269.
12. Wesson, G. and P. F. Wareing. 1969. The role of light on the germination of naturally-occurrring population of buried seeds. J. Exp. Bot. 20: 402-413.
13. Yabuno, T. 1983. Biology of *Echinochloa* species. p. 307-318. *In* International Rice Research Institute. Weed Control in Rice. Los Banos, Laguna, Philippines.
14. Yamasue, Y. and K. Ueki. 1983. Biology of paddy weeds and their control in wetland rice. p. 227-242. *In* International Rice Research Institute. Weed Control in Rice. Los Banos, Laguna, Philippines.

EFFECTS OF UREA AND AMMONIUM SULFATE ON 2,4–D ACTIVITY FOR CONTROL OF *CYPERUS ROTUNDUS*

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ABSTRACT

The effects of urea and ammonium sulfate as additives on 2,4-D activity in controlling purple nutsedge (*Cyperus rotundus* L.) were investigated both in pot and field experiments. The results from two pot experiments show that there was significant difference in number of live tubers counted per pot between 2,4-D alone at 1 kg ai/ha and 2,4-D plus either additive at 10 kg/ha. At higher rates of 2,4-D, 1.5 and 2 kg ai/ha, when applied alone and with additives, significant difference was observed only in some comparisons. Field experiment with the same rates of 2,4-D and additives revealed no significant difference in number of live tubers between the with and without additive treatments, but there was a likely trend. Comparing with conventional treatments of 2,4-D at 4 and glyphosate at 2.25 kg ae/ha, 2,4-D at low rates plus either additive resulted in comparable activity. The effects of 2,4-D formulations on nutsedge control were studied in pot and field experiments. The results show that the sodium and amine salts, regardless of additives, seemed slightly more effective than that of the ester form of 2,4-D, even with insignificant difference. Repeat application experiment integrated with soil cultivation to compare efficacy of the combination of 2,4-D at 2 kg ae/ha + urea 10 kg/ha and other selected treatments,i.e., 2,4-D 4 kg ae/ha, glyphosate 2.25 kg ae/ha,and the combination of 2,4-D 1.35 + tricopyr 0.45 kg ae/ha was also conducted. According to the evaluation assessed by live tuber counts, no significant difference was observed among the herbicide treatments. All herbicides provided 33 to 44 % reduction of nutsedge tubers of initial counts after the first application and 46 to 68 % reduction after second application.

INTRODUCTION

Purple nutsedge is regarded as one of the top ten worst weeds of the world (2) and presently threatening at least 52 crops grown in more than 90 tropical and subtropical countries (1). Extensive distribution is attributed to the vegetative propagation by tubers and rhizomes. Tubers are recognized as the primary dispersal unit (5). Even single tuber in a crop field can rapidly increase its population in the long run, especially when cultural practices which render less competition with the weed are employed continually, e.g., repeat use of herbicides ineffective to purple nutsedge. Even though many herbicides were found to give a good control of the weed (3), in certain situations such as in corn growing field, 2,4-D is still more accepted in some developing countries. At high rate of 4.5 kg/ha, 2,4-D was found to give a quite good result in controlling nutsedge tubers (4) but there are some disadvantages, for instance, high phytotoxicity and handling problems, especially the unpleasant smell of the chemical.

The investigation has its objectives to explore the activation of 2,4-D at lower rates by combining with ammonium sulphate or urea in the spray mixture for practical control of purple nutsedge.

MATERIALS AND METHODS

Greenhouse experiments Three experiments on 2,4-D with purple nutsedge, i.e., the combined effects with urea, combined effects with ammonium sulphate, and formulation effects of 2,4-D with urea, were conducted at Kasetsart University, Bangkok. Twenty tubers of comparable size were planted 3 cm deep in the soil mixed with compost in 20 cm diam pots. After germination, the pots were placed on the bench outdoor and exposed to sunlight about 8 hr a day. Four weeks after planting all plants were applied with herbicides on rubber conveyor at spray volume of 500 L/ha. Visual weed injury was rated every week based on 1 to 5 rating scale in which 1 = no injury and 5 = plants completely injured. Thirty days after application, all tubers were collected and germinated in plastic bags for 4 days. Only live tubers with shoots were counted. Undetermined tubers were cut in halves to see the liveliness. The experiments were set up as randomized complete block design with three replications.

Field experiments Also, three field experiments on purple nutsedge were conducted at National Corn and Sorghum Research Center, Korat, i.e., the combined effects of 2,4-D with urea and ammonium sulphate, the formulation effects of 2,4-D, and the repeated application experiment. Firstly, the land infested with purple nutsedge was prepared and supplementarily irrigated to the good growth of plants. About 4 weeks after cultivation, nutsedge plants were applied with herbicides at 500 L/ha diluent volume. Plot size was 2 m wide by 3 or 4 m long and each contained 2 fixed quadrats of 50 by 50 cm. Quadrats were selected with closely comparable number of shoots of nutsedge in a replication. Experimental design was made in randomized complete block with three replications.

RESULTS AND DISCUSSION

Combined effect experiments According to the greenhouse experiments (Table 1), it can be seen 2,4-D at 1 kg/ha inhibited growth but not very many tubers were killed, except at the very end of the rhizomes. When urea or ammonium sulphate at 10 kg/ha were added to the spray, then number of tubers were found only about half of the 2,4-D alone. Even though the additives at 5 kg/ha seem to enhance 2,4-D activity, significant difference was observed only with ammonium sulphate, but not with the urea. At higher rates of 2,4-D, activation by additives seems less and not significant, except at 2 kg/ha without and with urea. However, there could be a possibility.

Under field conditions, again a 1.5 and 2 kg/ha of 2,4-D, significant enhancement by additives was not observed either, but still there is a possible trend. The trend of urea activating 2,4-D alone or 2,4-D plus triclopyr in purple nutsedge was also observed by tuber counts in the field (8). Anyway, in this experiment it can be seen that 2,4-D at 4 kg/ha (considered as one of the standard) also resulted in the comparable number of tuber counts with 1.5 or 2 kg/ha added with additives at 10 kg/ha.

Formulation effect experiments In Table 2, the activation was even far more insignificant, although with the likely trend. Among the three formulations of 2,4-D, it seems that the salts (sodium and dimethylamine) were probably more effective against purple nutsedge compared with the ester form (butyl ester).

Repeat application experiment In Table 3, 2,4-D (sodium salt) + urea 2+10 kg/ha was found to provide about the same number of tuber counts with the high rate 2,4-D and 2,4-D + triclopyr (1.35 + 0.45 kg/ha) which the latter was also found to be quite effective few years ago (8). Glyphosate, even

Table 1. Effects of urea and ammonium sulfate on 2,4-D activity in controlling purple nutsedge.

		No. live tubers/pot[1]			No. live tubers/quad x 20cm deep		
		Greenhouse experiment[2]			Field experiment[3]		
Herbicide	Rate	With urea	With ammonium	Avg.	With urea	With ammonium	Avg.
	(kg ae/ha)	(as % of initial counts)					
2,4-D+additive	1+ 0	125 a	125 a	125	–	–	–
	1+ 5	98 ab	70 bc	84	–	–	–
	1+10	60 b-e	57 bc	59	–	–	–
2,4-D+additive	1.5+ 0	85 abc	70 bc	78	75		(75)
	1.5+ 5	57 b-e	46 c	52	62	64	63
	1.5+10	52 cde	43 c	48	59	57	58
2,4-D+additive	2+ 0	82 bcd	65 bc	74	70		(70)
	2+ 5	43 e	41 c	42	63	58	61
	2+10	33 e	33 c	33	58	52	55
2,4-D	4	23 e	–	(23)	——60——		(60)
Glyphosate	2.25	37	–	(37)	——56——		
					——ns——		
Untreated	- - -	483	485	484	——192——		(192)

[1] Means within a column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

[2] Planted (20 tubers/pot)Sept. 3,1986,herbicides applied Oct. 1, and tubers assessed Nov. 3,1986.

[3] Soil cultivated Sept. 20, 1986 with initial number of tubers ranging from 340 to 360 in a quadrat (50 x 50 cm) of soil with 20 cm deep, herbicides applied Oct. 18, and tubers assessed Dec. 6, 1986.

Table 2. Formulation effects of 2,4-D on control of purple nutsedge under greenhouse and field conditions.

		No. live tubers/pot[1]	No.live tubers/quad x20 cm deep[1]
Herbicide	Rate	Greenhouse experiment[2]	Field experiment[3]
	(kg ae/ha)	(as % of initial counts)	
2,4-D Na salt+urea			
	2+ 0	85 bc	–
	2+10	65 bc	42 c
	4+ 0	53 bc	61 bc
2,4-D amine salt (DMA)+urea			
	2+ 0	88 bc	–
	2+10	70 bc	57 bc
	4+ 0	32 c	49 bc
2,4-D ester (BE)+urea			
	2+ 0	93 bc	–
	2+10	82 bc	67 bc
	4+ 0	67 bc	73 bc
Glyphosate	2.25	52 bc	52 bc
Untreated	---	501 a	120 a

1 Mean within a column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

2 Planted (20 tubers/pot) Nov. 1, 1985. herbicides applied Nov. 30, and tubers assessed Jan. 5, 1986.

3 Soil cultivated Sept. 23, 1985, with initial number of tubers from 245 to 270 in a quadrat of soil with 20 cm deep, herbicides applied Oct. 21 and tubers assessed Dec. 9, 1985.

though with insignificant difference from other experiments, is believed to be the chemical giving the best control. This is because of, to our experience, some tubers affected by the herbicide may not show injury symptom at the time of assessment but may be killed later on. However, at this moment the chemical is rather expensive, especially when compared with 2,4-D.

Table 3. Effects of certain herbicides in controlling purple nutsedge after repeat application.

		No. live tubers/quad x 20 cm deep[1]		
Herbicide	Rate	Initial counts	After 1 st appl'n[2]	After 2 nd appl'n[3]
	(kg ae/ha)	(as % of initial counts)		
2,4-D+urea	2+10	116	64 b	48 b
2,4-D	4	113	61 b	48 b
2,4-D+triclopyr	1.35+0.45	118	67 b	54 b
Glyphosate	2.25	118	56 b	32 b
Untreated	---	119	111 a	268 a

1 Means within a column followed by the same letter are not significantly different at the 5 % level according to Duncan's multiple range test.

2 Soil cultivated April 12, 1986, herbicides applied May 19, and tubers assessed July 2, 1986.

3 Soil cultivated July 7, 1986, herbicides applied Aug. 12, and tubers assessed Sept. 26, 1986.

So far, from all experiments we can see that additive activation to 2,4-D on purple nutsedge is not so great compared with glyphosate (6), probably due to many factors including the method of design and assessment, but it does exist and can be visually observed (Figs. 1 and 2). One thing it might need in common, that is the timing of application which relates with biological activity of herbicides in the plant. At the rate 2+10 kg/ha of 2,4-D + urea in the greenhouse formulation effect experiment (Table 2) the numbers of tuber counts for the two salts were 65 and 70% of the initials. When compared with 33% of the treatments at the same rate in combined effect experiments (Table 1), it seems that there might have some other factors. It could be due to the former experiment was conducted in dry season whereas the latter carried out in wet season. This is possible, especially the time of application. Also, in Table 3 we can see at this same rate that the number of tuber counts is 64% which is relatively high compared with the data in Tables 1 and 2. This is probably because of the same reason. Glyphosate was not much activated either under dry conditions (7).

In conclusion, even though we do not obtain very much activation of urea and ammonium sulphate on 2,4-D activity in purple nutsedge, there is possibility and it might be worth to try at appropriate timing.

LITERATURE CITED

1. Bendixen, L.E. and U.B. Nandihalli. 1987. World distribution of purple and yellow nutsedge

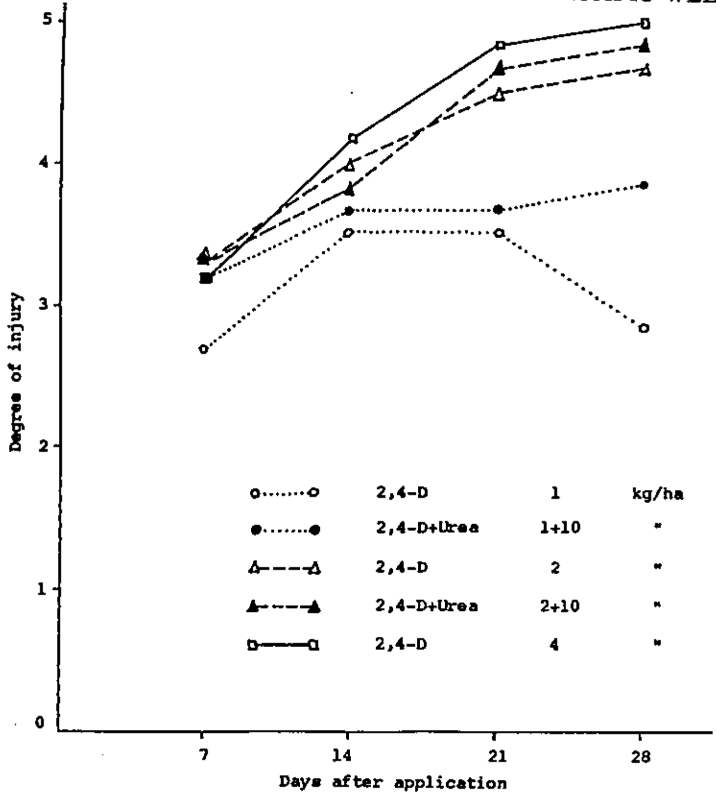

Fig. 1. Visual injury observed in purple nutsedge as affected by 2,4-D without and with urea.

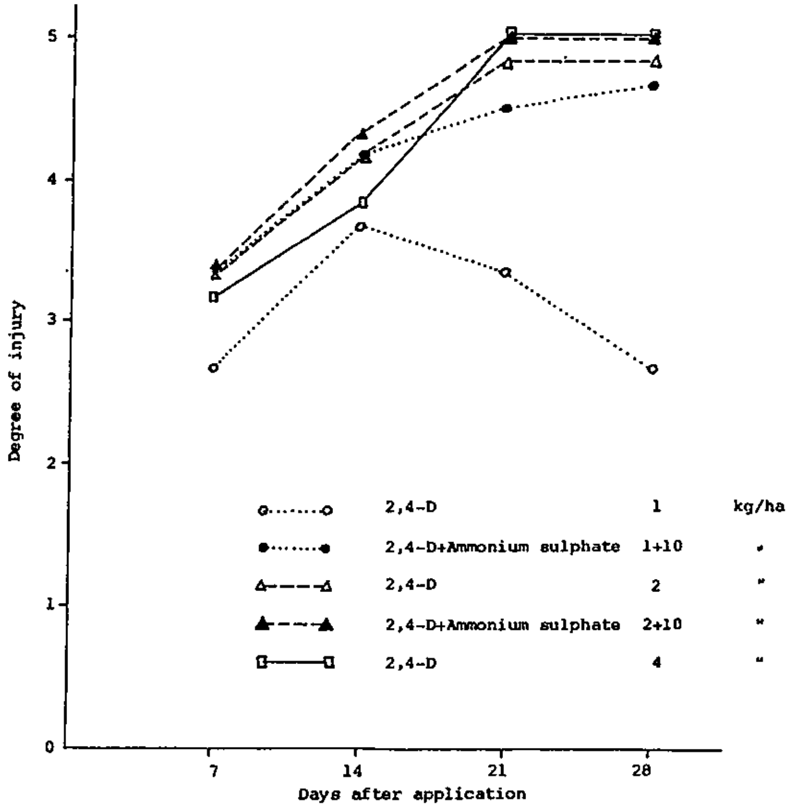

Fig. 2. Visual injury observed in purple nutsedge as affected by 2,4-D without and with ammonium sulphate.

(*Cyperus rotundus* and *C. esculentus*). Weed Technol. 1(1): 61-65.

2. Holm, L. G., D.L. Plucknett, J.V. Pancho, and J.P. Herberger. 1977. The World's worst weeds: distribution and biology. Univ. Press. Hawaii, Honolulu. p. 7.
3. Pereira, W., G. Crabtree, and R.D. William. 1987. Herbicide action on purple and yellow nutsedge (*Cyperus rotundus* and *C. esculentus*). Weed Technol. 1(1):92-98.
4. Sinha, T. D. and C. Thakur. 1970. Economical aspects of controlling nutgrass (*C. rotundus* L.) weed with 2,4-D. Indian J. Agric. Sci. 40(2):117-123.
5. Stoller, E.W. and R.D. Sweet. 1987. Biology and life cycle of pruple and yellow nutsedge (*Cyperus rotundus* and *C. esculentus*). Weed Technol. 1(1): 66-73.
6. Suwunnamek, U. and C. Parker. 1975. Control of *Cyperus rotundus* with glyphosate: the influence of ammonium sulphate and other additives. Weed Res. 15: 13-19.
7. Suwunnamek, U. and S. Cheuysai. 1981. Activation of ammonium sulfate on glyphosate for control of purple nutsedge. Weeds and Weed Control in Asia. FFTC Book Series No. 20. ASPAC, Taiwan, ROC. pp. 113-120.
8. Toa-wachiraporn, P. and U. Suwunnamek. 1984. Synergistic activity of triclopyr and 2,4-D for control of purple nutsedge (*Cyperus rotundus* L.). Proc, 1 st Tropical Weed Sci. Conf. Vol II: 413-426.

RECLAMATION OF *IMPERATA* FIELD INTO A PLANTATION BASED AGRO-PRODUCTION SYSTEM

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ABSTRACT

A long term experiment was carried out in on podsolic soil covered with *Imperata* study the applicability of several techniques of *Imperata* control with the subsequent crop establishment in the reclamation of *Imperata* field into an agricultural production system. The experimental design was split-plot. The main plot consisted of four different techniques of *Imperata* control i.e. (1) mechanical control consisted of two plowing and two harrowing (2) *Imperata* burning followed by single plowing and single harrowing, (3) two foliar application of dalapon at 6.8 kg ai/ha + 10 kg urea + 11 Teepol/ha and (4) glyphosate at 2.2 kg ae/ha. The sub plots consisted of three different types of intercropping i.e. (1) multiple cropping system with (upland rice + corn + cassava, ground nut, cowpea, (2) Legume cover crop (*Calopogonium mucunoides, Centrosema pubescens, Pueraria javanica*) and (3) herbage crops (*Stylosanthes guyanensis* + *Setaria* sp.). These treatments were block (3x), with a plot of 5000 m^2 each, and half was planted with rubber and the other half with coconuts. Foliar application of dalapon and glyphosate gave a better *Imperata* control than those of mechanical cultivation. In this second year the growth of rubber trees under multiple intercropping system was better (stem ∅ : 11.9 cm) than those under legume cover crops (11.2 cm) or herbage crop (10.9 cm), but similar trend was observed under coconuts. When the economic of multiple cropping with food crops was calculated by converting all the production input into a monetary term, it seems that the benefit of cost ratios were on average of 1.60. It is concluded that the use of herbicides (dalapon or glyphosate) to control *Imperata* followed by planting of rubber or coconuts and intercropped with multiple cropping system of food crops using zero tillage technique was quite good and economically feasible.

INTRODUCTION

The primary factor in achieving success in the transmigration programme into a plantation based agro-production system. The most important agro-production system were land, sufficient supply of water and suitable climate. If the first two mentioned factors are not properly managed, then the programmes of transmigration will end in failures. For the fulfillment of the growth needs of perennial crops, climatic factors are the environmental factors that require attention, because these factors cannot be changed.

The programme of the Government in the projects of transmigration is directed towards the use of dry land mostly on podsolic soil covered with *Imperata cylindrica* (L) Raenschil. *Imperata* is the most detrimental weed. On one hand it acts as a competitor for the crops in getting nutrients and water and in producing allelopathic substances and on the other hand *Imperata* can easily disperse itself either through the seeds or the rhizome and is a cause of fire-breakout and a home of wild pigs. According to Suryani (1970) its area of distribution is very wide (0-2700 in a.s.l.) and is estimated to be around 15 million hectares, with an increase of 150,000 ha year.

Most of the dry land outside Jawa, is of Podsolic soil, acidic in nature and of low fertility. The Red Yellow Podsolic soil covers on area of 20.6 millions ha (43.5%) in Sumatra; 16.1 million ha (29.9%) in Kalimantan; 2.0 million ha (10.3%) in Sulawesi; and 9.6 million ha (23.0%) in Irian Jaya (Directorat General of Agricultural, 1969). Hence the Red Yellow Podsolic soil forms 48.3 million ha or 29.7% of total area in Indonesia.

It seems that the technology of cultivating dry land in the tropics should receive special study based on the characters of the soil, agroclimates condition types of crops to be grown and socio-economic problems. A view that in the tropics dry land is suitable only for perennial crops has sufficient grounds because their cultivations do not need soil tillage or zero tillage or a minimum tillage. The use of legumes as cover crops is very common and so the process of regeneration of soil fertility goes on continuously because perennial crops are deep-rooted. The hydrologic function of the plants is quite satisfactory. In general it can be said that perennial crops in the tropics can perpetually maintain the natural resources of land and its fertility.

Increase in productivity of farm management in *Imperata* field can be achieved by developing mixed farming covering food crops, estate crops and herbage crops. The long term objectives of Agro-production system is the welfare of the farmers' families, so that they can improve the farming practice, from that of subsystem to a commercial farming. This end can be developed through an estate crops system, such as the Nucleus Estate Smallholder (NES) system. In this case the management of the estates is done through a cooperative by smallholder.

MATERIALS AND METHODS

The experimental plots were located in the transmigration area of Bitung (Supat), Kabupaten Musi Banyuasin, Sumatera Selatan. This applied research was carried out in the tramsmigration area, at lahan usaha II, with a vegetation of 95% *Imperata,* the field work was performed in November 1984.

The main crops consisted of the estate crops of rubber and hybrid coconuts, with intercrops of food crops, legume cover crops and herbage crops. The food crops were grown according to multiple cropping system, viz the simultaneous and the successive growing of maize, paddy, cassava, ground nuts and cowpea. The plots were arranged according a split plot design with four main plots and each main plot consisted of three sub-plots of 0.5 ha each.

These were three replications so that the experimental plots were 36 in number (4 x 3 x 3 plots) and total area of 18 ha (36 x 0.5 ha).

The treatments were as follows

Main crop rubber GT 1 clone

Planting distance of 3 m x 7 m (the experiment runs for 4-6 years).

Main plots

a. Mechanical control (twice plowing and twice harrowing)

b. *Imperata* burning following by single plowing and single harrowing

c. 6.8 kg ai dalapon + 10 kg urea + 1 ℓ Teepol/ha
d. 2.2 kg ae glyphosate/ha
Subplots
1. Maize + dry land paddy + cassava + ground nuts and cowpea (*Vigna sinensis* Endl)
2. *Calopogonium mucunoides* + *Centrosema pubescens* + *Peuraria javanica*
3. *Stylosanthes guyanensis* + *Setaria* sp.
Main crop hybrid coconuts khina I
Planting distance 9 m x 7 m (the experiment runs for 4-6 years).
Main plots
a. Mechanical control (twice plowing and twice harrowing)
b. Burning of *Imperata* single plowing and single harrowing
c. 6.8 kg ai dalapon + 10 kg urea + 1 l Teepol/ha
d. 2.2 kg ae glyphosate/ha
Subplots
1. Maize + dry paddy + cassava + ground nuts + cowpea
2. *C. mucunoides* + *C. pubescens* + *P. javanica*
3. *Stylosanthes guyanensis* + *Setaria* sp.

RESULTS

After the harvest of maize and paddy, the *Imperata* population decreased from 95% to 17-35%. The *Imperata* coverage is as in Table 1.

Table 1. Percentage of coverage of *Imperata*[1].

Treatment	After the harvest of maize and paddy
Mechanical control	28.3 ab[2]
Burning of *Imperata*	35.0 b
6.8 kg in dalapon + 10 kg Urea + 1 ℓ Teepol/ha	22.5 a
2.2 kg ai glyphosate/ha	17.5 a
LSR	5%
c.v. (%)	23.9

[1] The data were transformed to $\sqrt{x + ½}$
[2] Means in one column followed by the same letter are not significantly different at the 5% level.

The intercrops Table 2 shows the yields of intercrops (food crops, legume cover crops and herbage crops) harvested in the first year. The multiple cropping system under rubber and hybrid coconuts were maize, paddy, cassava, ground nuts and cowpea. The yields did not show any significant diffe-

Table 2. Yield of intercrops during the first year of harvest (kg/ha of the main crops).

Treatments	Rubber					Coconuts				
	Maize	Paddy	Ground nuts	Cowpea	Cassava	Maize	Paddy	Ground nuts	Cowpea	Cassava
Mechanical control	1,263	687 a[1]	638	280	8,781	860	683 a	657	277	9,828
Burning of *Imperata*	1,210	635 ab	743	283	8,095	656	729 a	457	280	6,590
6.8 kg ai dalapon + 10 kg Urea + 1 l Teepol/ha	804	447 bc	552	300	6,152	748	356 b	476	323	7,981
2.2 kg ae glyphosate/ha	925	332 c	667	309	7,323	957	363 b	571	286	9,047
LSR (5%)	n.s.		n.s.	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.
C.V. (%)	31.4	18.7	15.4	18.1	16.4	20.8	12.4	15.3	19.6	27.6

[1] Means in one column followed by the same letter are not significantly different at the 5% level.

rence between the treatments. There was no effect of the main crops on the intercrops, because the shade caused by the canopy of the main crops and the distribution of the roots had not affected the growth of the intercrops.

Mechanical tilling of the soil (a and b) and application of herbicides (c and d) statistically showed no significant difference for maize, ground nuts, cowpea and cassava, grown either in between the rubber rows or the coconuts. Only yields of paddy showed difference with the above treatments.

Mechanical tilling of the soil (a and b) gave greater yield of paddy compared to growing without tillage and with herbicide sprays (c and d).

The main crops The effect of the intercrops on the growth of rubber and plant height of coconuts, at the age of 1.5 years is given in Table 3.

Table 3. The effect of the intercrops on the main crops.

Intercrop	Rubber girth of stem (cm)	Coconut palm height (cm)
Food crops	11.9 a[1]	286.7
Legume cover crops	11.2 b	274.1
Herbage crops	10.9 b	178.0
LSR 5%		n.s.
c.v. (%)	2.1	2.3

[1] Means in one column followed by the same letter are not significantly different at the 5% level.

The effect of intercrops on rubber showed that food crops would cause greater girth of stem than legume cover crops or herbage crops.

Though statistically no significant difference was shown on the effects of intercrops on the height of the coconut palms, yet the figures in Table 3 suggested of a tendency that food crops would cause greater height than the other crops tested.

Manpower needed The experiments showed that the areas between the row for the intercrops under rubber and coconut were the same, i.e. $4/7 \times 10{,}000\ m^2 = 5714\ m^2/ha$ of rubber or coconut. Hence the manpower needed to do the job would also be the same.

The manpower available from one family is 720 mandays, comprising 300 mandys from the head of the family, 240 from the wife and 180 from three children (3 x 60 m.d.).

The manpower needed each year for the intercrops and upkeep of the main crop/ha for the treatments a, b, c, and d was respectively 282, 288, 297 and 294 mandays during the first year (Table 4). Comparison between the available and the need for manpower to adopt multiple cropping system under rubber and coconut, are capable of conducting an Agro-production system in a land of 2.4 ha.

Benefit of cost ratio Based on the selling price of the intercrops, the following ratios were obtained

Table 4. The need for manpower to grow intercrops under rubber and coconut.

Treatment	Plough + Harrow 2x				Plough + Harrow 1x				Dalapon + Urea + Teepol				Glyphosate			
	Man-days per hectare															
	A[1]	B[1]	C[1]	Total	A	B	C	Total	A	B	C	Total	A	B	C	Total
	20[2]			20[2]	13[2]			13[2]	9[3]			9[3]	6[3]			6[3]
Land clearing	10	–	–	10	14	–	–	14	9	–	–	9	9	–	–	9
Land preparation and planting	36	30	26	92	38	30	26	94	39	30	26	95	39	26	26	95
Manuring	19	6	6	31	19	6	6	31	19	8	6	33	19	8	6	33
Weeding	34	24	17	75	34	24	17	75	36	24	17	75	36	24	17	75
Pest control	6	2	2	10	6	2	2	10	6	2	2	10	6	2	2	10
Harvest	40	10	14	64	40	10	14	64	40	10	14	64	40	10	14	64
	20[2]			20[2]	13[2]			13[2]								
Total	145	72	65	282	151	72	65	288	158	74	65	297	155	74	65	294

[1] A = Planting maize, dry paddy, cassava

[1] B = Planting ground nuts

[1] C = Planting cowpea

[2] Tractor work-hours

[3] Herbicide spraying

between the benefit and the cost (B/C) under rubber for the treatments, a, b, c, and d respectively 1.64; 1.81; 1.46 and 1.48, and under coconuts 1.63; 1.52; 1.50 and 1.51 (Tables 5, 6, 7 and 8).

DISCUSSION

As mentioned before *Imperata* that has been growing for years together is very difficult to control using one method only, either mechanical or chemical without being followed by biological control such as growing food crops, legume cover crops or herbage crops, and in the long term growing perennial crops. Experimental results showed that when after the *Imperata* eradication by mechanical or chemical method, the land is let cropless, *Imperata* would soon grow again and the land would then soon be covered with *Imperata.*

The adoption of Agro-production system in dry land, i.e. successive and continuous planting activities would suppress the *Imperata* population. If one of the chain in this multiple cropping system breaks, *Imperata* will immediately appear again. To avoid failures in the multiple cropping system which will result in the break of the chain, the system should be programmed on the data of the monthly rainfall in the locality.

The present trial results gave a figure that planting with zero tillage but the *Imperata* eradicating with herbicides, will cause satisfactory growth and harvest of food crops. This method is one of the alternatives of growing food crops in a field with a slope of more than 8%. In addition the method has the added advantage in that the top soil is well preserved, because the top soil is very thin mostly in the Podsolic soil. Further, it is hoped that in the long run, multiple cropping remains will get accumulated and form a thick layer of mulch that will improve the physical and the chemical nature of the soil and the ecosystem of the soil microbes. This method simultaneously forms a step in conservation of land in the Podsolic soil, because such type of land is open to easy erosion. Criteria for land suitability for food crops is a slope of not more than 8%. Farming with a view to conserving the soil can be conducted by adopting practices of zero tillage where the main crop is considered along with the intercrops.

Growing food crops in between perennial crops, rubber and coconut, will help better growth of the main crops, because indirectly the main crop can utilize a part of the fertilizer given to the food crops.

Comparison between the available and the need for manpower to adopt multiple cropping system under rubber or coconut, then a farmer are capable of conducting an Agro-production system in a land of 2.4 ha, be it managed mechanically or chemically.

Comparison of figures of benefit of cost ratio (B/C) in intercropping under rubber or coconut shows that the practice is quite profitable.

CONCLUSION

Integrated *Imperata* control between chemical and biological gave quite better control and improve the quality of the soil. The use of systemic herbicides (dalapon or glyphosate) that effectively controlling *Imperata* followed by planting of rubber or coconuts and intercropped with multiple cropping system of food crops using zero tillage technique was quite good and economically feasible. The biological control that gradually supresses the *Imperata* population, due to the presence of crops, that continuously and successively occupy the area the whole year round.

Table 5. Yield and gross income for intercrops under rubber[1].

Intercrops	Treatment of intercrops under rubber							
	Plough + Harrow 2x		Plough + Harrow 1x		Dalapon + Urea + Teepol		Glyphosate	
	Yield per hectare	Gross income	Yield per hectare	Gross income	Yield per hectare	Gross income	Yield per hectare	Gross income
Maize	1,263	189,450	1,210	181,500	804	120,600	925	138,750
Dry paddy	687	120,225	635	111,125	447	78,225	332	58,100
Cassava	8,781	351,240	8,095	323,800	6,152	246,080	7,323	292,920
Ground nuts	638	319,000	743	371,500	552	276,000	667	333,500
Cowpea	280	182,000	283	183,950	300	195,000	303	196,950
Average of gross income 1 year :	–	1,161,915	–	1,171,875	–	915,905	–	1,020,220

[1] Yield in the form of dry maize seeds @ Rp 150/kg
Yield in the form of dry paddy seeds @ Rp 175/kg
Yield in the form of fresh cassava @ Rp 40/kg
Yield in the form of dry pods @ Rp 500/kg
Yield in the form of dry seeds @ Rp 650/kg

Table 6. Yield and gross income for intercrops under coconuts

Intercrops	Treatment of intercrops under coconuts							
	Plough + Harrow 2x		Plough + Harrow 1x		Dalapon + Urea + Teepol		Glyphosate	
	Yield per hectare	Gross income	Yield per hectare	Gross income	Yield per hectare	Gross income	Yield per hectare	Gross income
Maize	860	129,000	656	98,400	748	112,200	957	143,350
Dry paddy	683	119,525	729	127,575	356	62,300	363	63,525
Cassava	9,828	393,120	8,590	343,600	7,981	319,240	9,047	361,880
Ground nuts	657	328,500	457	228,500	476	238,000	571	285,500
Cowpea	277	180,050	280	182,000	323	209,950	286	185,900
Average of gross income 1 year :	–	1,150,195	–	980,075	–	941,690	–	1,040,155

Note: – Yield in the form of dry maize seeds @ Rp 150/kg
– Yield in the form of dry paddy seeds @ Rp 175/kg
– Yield in the form of fresh cassava @ Rp 40/kg
– Yield in the form of dry pods @ Rp 500/kg
– Yield in the form of dry seeds @ Rp 650/kg

Table 7. Cost analysis and income for intercrops under rubber.[1]

Treatments	Plough + Harrow 2x	Plough + Harrow 1x	Dalapon + Urea + Teepol	Glyphosate
Gross income				
Maize	189,450	181,500	120,600	138,750
Paddy	120,225	111,125	78,225	38,100
Cassave	351,240	323,800	246,080	292,920
Ground nuts	319,000	371,500	276,000	333,550
Cowpea	182,000	183,950	195,000	196,950
Total gross income (2)	1,161,915	1,171,875	915,905	1,020,220
Production cost	223,950	223,950	325,450	392,550
Labour cost	482,000	422,000	303,000	298,000
Total production cost (5)	705,950	645,950	628,450	690,000
Net income (2-5)	455,965	525,925	287,455	330,220
B/C Ratio	1.64	1.81	1.46	1.48

[1] Areas between the row 4/7 x 10,000 m^2 = 5,714 m^2

Table 8. Cost analysis and income for intercrops under coconuts.[1]

Treatments	Plough + Harrow 2x	Plough + Harrow 1x	Dalapon + Urea + Teepol	Glyphosate
Gross income				
Maize	129,000	98,400	112,200	143,350
Paddy	119,525	127,575	62,300	63,525
Cassava	393,120	343,600	319,240	361,880
Ground nuts	328,500	228,500	238,000	285,500
Cowpea	180,000	182,000	209,950	185,900
Total gross income (2)	1,150,195	980,075	941,690	1,040,155
Production cost	223,950	223,950	325,450	392,550
Labour cost	482,000	422,000	303,000	298,000
Total production cost (5)	705,950	645,950	628,450	690,000
Net income (2-5)	444,245	334,125	313,240	350,155
B/C Ratio	1.63	1.52	1.50	1.51

[1] Areas between the row 4/7 x 10,000 m^2 = 5,714 m^2

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AN ASSESSMENT OF THE HERBICIDE TECHNOLOGY EXTENSION PROJECT IN SUGARCANE IN K.C.P. SUGAR FACTORY COMMAND AREA IN ANDHRA PRADESH, INDIA

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ABSTRACT

Paraquat was successfully introduced in tea and coffee plantations in India during the sixties. Its introduction in sugarcane for weed control during the seventies in the KCP sugar factory command area, Krishna District, Andhra Pradesh did not result in significant farmer response in the prevailing socio-economic conditions. Herbicide technology with paraquat as the central herbicide was reintroduced in 1985-86 season as a joint project by KCP Sugar Factory and IEL Limited. The main project management inputs were improved herbicide technology with paraquat and 2,4-D sodium salt or atrazine, intensive extension methods, on-the-spot availability of herbicides and spraying service and subsidy on herbicide cost. This resulted in adoption of technology in 2832 ha during 1985-86 season as compared to average 196 ha per year in the previous 8 years. In the following 1986-87 season, in spite of reduced herbicide subsidy, the total sprayed area was higher by approximately 15%. There was a noticeable ripple effect during 1986-1987 season in the two neighbouring sugar factory areas with adoption of herbicide technology in about 1200 ha. On-the-spot availability of herbicides and spraying services have emerged as prime factors in large scale acceptance of herbicide technology in the project area. Other favourable factors include improved socio-economic conditions, higher cost of manual weed control and growers' desire to seek an effective option for timely weed control. All monitored trials during 1985-86 season have indicated a marginal increase in yield. 10 monitored trials have indicated increase in sugar recovery.

INTRODUCTION

Weeds compete with sugarcane for soil nutrients, moisture and sunlight, hampering the growth of crops and cause yield reductions up to 35% (5,6). The crop weed competition in sugarcane is severe in early stages of its growth and the weeds have to be controlled during this critical period of up to 40 to 60 days from planting (1,4). Timely weed control is essential for better crop establishment, tillering, vigorous growth, higher fertilizer efficiency and increased yield. Manual weed control is less efficient and its cost has been ever increasing. Industries offering higher wage rate have created a reluctance for jobs such as manual weeding and urbanisation has affected the labour availability.

Chemical weed control provides an answer to these problems. Literature is replete with the work on advantages of chemical weed control in sugarcane, in general, and with reference to paraquat and 2,4-D in particular. To cite a couple of such reports, paraquat and 2,4-D have given good control of weeds and gave the highest cane yield (2). Field studies on chemical weed control in sugarcane at Anakapalle Research Station (Andhra Pradesh) indicated that the weed control efficiency was highest in paraquat + 2,4-D treatments resulting in maximum cane yield and net return (3).

Paraquat was introduced for weed control in sugarcane during the seventies in the K. C. P. Sugar Factory command area (Krishna district, Andhra Pradesh). The response to chemical weed control was poor due to the prevailing socioeconomic conditions e.g. easy availability and lower cost of manual weed control coupled with unrealistic low price of cane. Survey of KCP command area indicated that this situation had changed favourably for chemical weed control. Herbicide technology with paraquat as the central herbicide was, therefore, reintroduced in 1985-86 as a joint project by KCP Sugars Ltd. and IEL Limited. The main objectives were to introduce chemical weed control in sugarcane in KCP command area, remove all constraints as far as possible in the adoption of chemical weed control and study the farmer response. The efforts and achievements of the project for two seasons i.e. 1985-86 and 1986-87 are presented here.

METHODS AND EXTENSION INPUTS

The project area comprised of three specific situations, viz: Wet-land : Deep black heavy-clay soils with poor drainage. Irrigation by canal. Other crops - rice, blackgram.
Garden-land : Black, loamy-clay to loam well drained soils. Irrigation by wells. Other crops - banana, turmeric, betelvine, vegetables.
River-bed : Alluvial well - drained soils. Irrigation by wells. Other crops - banana, turmeric, vegetables.

The weed spectrum varied from area to area with major weed species being *Echinochloa, Cyperus, Digitaria, Cynodon, Trianthema, Portulaca, Amaranthus, Parthenium, Ipomea* and *Coccinia*. In wet-land, the rice seedlings, grasses and *Cyperus* and in garden-land and river-beds the dicots and grasses pre-dominated. By controlling weeds at the time of cane emergence, a weed-free-situation could be provided for better growth and establishment of cane at its early stage of growth.

The paraquat technology developed in 1978 was upgraded with introduction of new nozzles and spraying techniques. The WFN—VLV nozzles halved the spray volume requirement from 500 L to 250 L/ha. Two-nozzle, four-nozzle and twin-down-arm booms were developed to increase the coverage per sprayer. About 150 bakpak sprayers, spare nozzles and multi-nozzle booms as required were made available for farmer use.

In plant cane, paraquat + 2,4-D sodium salt tank-mix was applied overall on emerged weeds at 10-15 days after planting (DAP). (In the pre-plant situations where excessive weed growth impedes land preparation, paraquat was sprayed, allowed to remain undisturbed for 3 days and was followed by land preparation and planting). In dicot weed pre-dominant areas paraquat + atrazine was applied. Tips of emerged canes, if any, at the time of spraying got scorched but soon recovered. Good weed control was achieved up to 25 to 30 days after application of either tank-mixture. One hoeing is normally given during 30-40 DAP. This provides complementary weed control effect. Interrow spraying wherever required was given as a directed spray at 30 to 45 DAP using a 90 cm long spray lance, avoiding the drift as far as possible. In ratoon crop, paraquat + 2,4-D was applied as directed interrow spray during 30-45 days after stubble burning/shaving.

The project organization included a project manager who was in constant link with KCP management and IEL technical staff. At the field level, the project manager was assisted by seasonally employed 4 graduate assistants and 20 field assistants belonging to local farming community who were provided with motorcycles and mopeds for quick movement into the villages under the project area. Intensive training was given to these field staff in identification of weeds, spraying technique, extension methods and in establishing field demonstrations. The farmers were contacted individually and in groups. Late evening meetings were held and the details of herbicide technology were explained to farmers by IEL and KCP experts in local language with the help of audio-visual aids. Banners and posters were displayed at strategic points in the village. Farmers' days were held in which KCP and IEL experts provided details of the project to the growers. Farmers who had used the herbicides before shared their experiences. Field visits were arranged for farmers to the demonstration plots.

The chemicals were made available to farmers through sugar factory or the cane development council. The IEL–KCP field staff trained the farmers in techniques of mixing and spraying. In addition to KCP, the local cane development council, the local sugarcane growers association and Agricultural Research Station of Andhra Pradesh Agricultural University rendered support in transfer of chemical weed control technology to farmers.

RESULTS AND DISCUSSION

The initial response from farmers was slow but encouraging. Difficult labour availability and poor efficiency of hand weeding turned them to this alternative method of weed control. The reality of achieving speedy and efficient weed control especially at early stage of cane growth by overall application made many accept the paraquat technology. Initially, some farmers were apprehensive about the scorching of the emerging cane shoots but the crop outgrew the scorching effect quickly. This removed the fear and induced the required confidence among the farmers to adopt the technology.

During year - I, a spray coverage of 2832 ha was achieved (Table 1) which is 34% of the total cane area. During year - II, despite an increase in herbicide cost, herbicide usage was higher by approximately 15% (Table 2). The extension effort by way of man days of field staff and other field support remained at approximately 60% of the quantum applied in year - I. Further, the adoption of this technology by farmers in KCP command area had a ripple effect on the farmers in neighbouring two sugar factory areas. Consequently, an additional area of approximately 1200 ha was covered outside the main project area. In an opinion poll involving 500 user farmers taken at random, 65% users found the technology to be helpful, speedy, less cumbersome and capable of effective weed control in the early stage of crop growth.

Timely weed control resulted in vigorous growth of cane, efficient utilisation of nutrients and possibly a small increase in cane yield. In 22 monitored trials during 1985-86 a marginal increase (av. 2.8t/ha) in yield over manually weeded cane has been recorded. In ten monitored trials a small increase in sugar recovery as well was noticeable (Table 3). The observations on these parameters will be repeated in 1987-88 harvest.

The present assessment revealed that there exists a scope for extending chemical weed control

Table 1. Total cane area and area sprayed with paraquat + 2,4-D/atrazine in KCP command area during year-I.

	Area under cane (ha)	Area sprayed (ha)
a) Fresh-plant	5543	–
Ratoon	2895	–
b) Pre-Plant	–	146
Fresh overall	–	1460
Fresh Interrow	–	816
Ratoon Interrow	–	410
	8438	2832

Table 2. Area under cane and area sprayed with paraquat + 2,4-D/atrazine in KCP and neighbouring sugar factory zones, during year-II.

	KCP	Two neighbouring sugar factories
A. Area under cane (ha)		
Fresh plant	5970	2366
Ratoon	5008	832
B. Area sprayed (ha)		
Pre-plant	1	1
Fresh-overall	1946	674
Fresh-interrow	1966	469
Ratoon-interrow	212	23
	3225	1167

Table 3. Data on yield and sugar recovery from ten monitored trials during 1985-86.

Treatment	Situation	Number of millable cane ('000/ha)	Yield (t/ha)	Sugar recovery (%)
A. Paraquat+2,4-D	Weet-land[1]	81.62	101.62	9.86
Farmer practice		77.50	96.75	9.87
B. Paraquat+2,4-D	Gardenland[1]	91.42	102.00	9.81
Farmer practice		89.88	99.62	9.31
C. Paraquate+2,4-D	Riverbed[2]	109.38	121.52	8.15
Farmer practice		108,08	119.10	7.88
AVERAGE				
Paraquat+2,4-D		94.15	108.38	9.27
Farmer practice		91.82	105.15	9.02

[1] Average of 4 trials [2] Average of 2 trials

technology in sugarcane in selected areas in India. On-the-spot availability of herbicides and spraying services are prime factors in the large-scale acceptance by the farmers. In the area selection, the agronomic and socio-economic factors need prime consideration. Higher cost of manual weed control, difficult availability of labour and favourable farmer attitude to new technology would contribute to faster adoption rate.

ACKNOWLEDGEMENT

Sincere thanks are due to the authors' colleagues who tirelessly involved themselves in the project. Special thanks are due to Messrs Anjinelyulu and V. Venkateswer Rao of Chellapalli Sugar Factory and Messrs Venkatramiah and Jagannatha Rao of Hanuman Sugar Factory for their keen interest and cooperation.

LITERATURE CITED

1. Arakeri, H. R. 1951. Preliminary studies on weed control with chemicals in sugarcane crop. Dec. Sug. Tech. Assoc. India, Part 1,56-61.
2. Bose, K. P. and S. Zaman. 1977. Chemical weed control in sugarcane. Indian Sug. 27(5): 253-256.
3. Rao, K. L., Raja, J. D. M., Sanandacheri and Rao Ch Hanumantha. 1987. Chemical weed control in sugarcane. Indian Sug. 36(11): 563-567.
4. Lakshmi, Kanthan M. 1973. Technology in sugarcane growing. Andhra Pradesh Agric. Univ., Hyderabad, pp. 156.
5. King, L. J. 1966. Weeds of the world biology and control. Preliminary report. Proc 26th Ank. Conv. Deccan Sug. Tech. Assoc. India 1: A66-70.
6. Gell, H. S. and O. Singh. 1972. A note on the performance of Atrazine and 2,4-D for control of *Cyperus rotundus* and other weeds in sugarcane. Indian J. Weed Sci. 4(2): 126-128.

CRITICAL PERIOD FOR PRESENCE OF WEEDS IN TOMATO (*LYCOPERSICON ESCULENTUM*) IN EAST JAVA

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ABSTRACT

The critical period for weeding tomatoes (*Lycopersicon esculentum*) was investigated. The field experiment consisted of three replications of 13 treatments differing in the period during which the crop was kept free of weeds. The critical period for weed competition was from week 4 to 8 after planting. Presence of weeds during this period resulted in a reduction in the fresh and dry weight of fruit of about 50%.

INTRODUCTION

Weeds are always present in a crop but they affect its growth and yield during the various stages of its development to a varying extent. Certain phases during the life cycle of the crop are particularly susceptible to environmental influences such as the competition from weeds for light, water and nutrients. The presence of weeds outside this "critical period" is much less damaging. This paper describes a study of the critical period for weed competition in a field crop of tomato (*Lycopersicon esculentum*) var. Marmande in East Java.

MATERIALS AND METHODS

The experiment was situated in the village Dau near Batu, East Java, at an altitude of ca 600 m, in a field of Andosol soil. It was carried out during the early part of the dry season from April 23 to June 15, 1986.

The plants were raised in a seed bed in a soil/sand/manure mix (1:1:1) and transplanted into the field on day 25. NPK fertilizer was applied to the soil as at the rate of 300 kg ha^{-1} and Bayfolan at the concentration of 10 cc l^{-1} to the foliage. Sprays for pest and disease control were applied every five days.

The treatments consisted of 12 variations of weeding, replicated three times in randomized block. In six treatments the plots were kept weeded for 2,4,6,8,10,12 weeks after planting; in the other six treatments the plants were not weeded for the same periods. The treatments are shown in Fig. 1. Each plots contained 70 tomato plants at 0.4 x 0.4 m spacing and measured 3.0 x 4.2 m.

Observations and measurements were made at two-weekly intervals in one quadrant of 0.5 x 0.5 m per plot, containing four tomato plants and the associated weeds. The vegetative growth and fruit development of the tomato plants and the composition and amount of dry weight of the weed population were measured by destructive sampling.

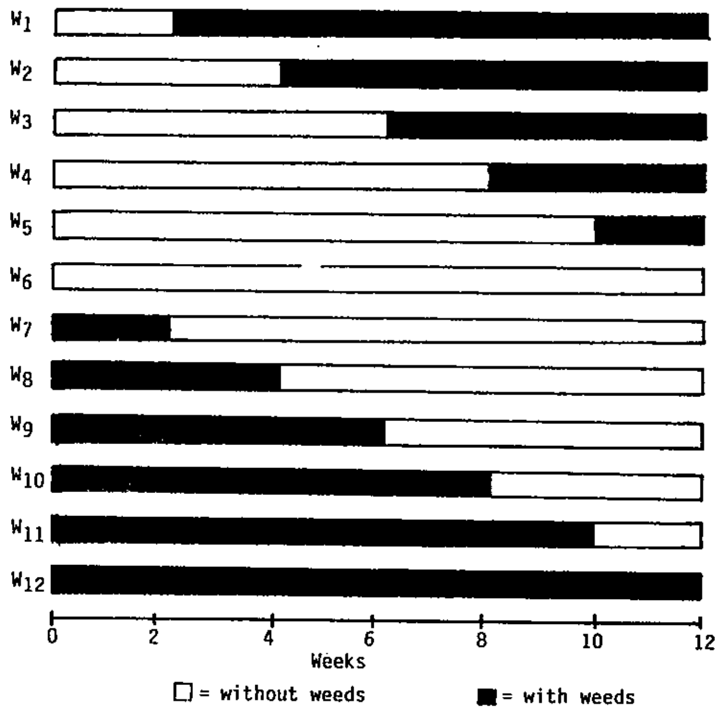

Fig. 1. Diagram illustrating the treatment.

RESULTS AND DISCUSSION

Weeds Fig. 2 (A and B) shows the amount of weeds in the various treatments. Their dry weight increased rapidly when they were allow to grow after weeding for up to four weeks, but only slowly and to a small extent after weeding was stopped at six or eight weeks. Presumably, the weeds allowed to grow at this advanced stage of crop development were suppressed by the competition from the tomato plants, similarly to the results reported by Moenandir (1) and Terry (2). Weeds allowed to grow from planting onwards developed similarly to the plots kept weedy throughout until weeding commenced. The aberrant point for treatment W10 at 10 weeks cannot be explained; it is likely to be due to weed variation between plots.

The dominant weed species present in this study was *Alternanthera sessilis* (kremah), followed by, in smaller numbers, *Portulaca oleraceae* (krokot), *Cynodon dactylon* (grinting), and *Phylantus amarus* (meniran).

Fresh weight of tomato and critical period The influence of weed infestation on the fresh weight of tomato fruit per plant is illustrated in Fig. 3. The existence of weeds during the early growth of tomato plants resulted in lower yield than the existance of weeds at the later stages when the fresh weight of fruit increased similarly to that of plants kept free of weeds throughout. This implies that at the later stages the tomato plants did not suffer severely from competition. Weaver and Tan (3) reported similar results.

When weeds were present for two weeks after planting tomato yield was not affected. The reduction in yield due to a four-week period of weed growth was not significant. However yield dropped severely when weed growth was allowed to continue from then on. When the plots were kept

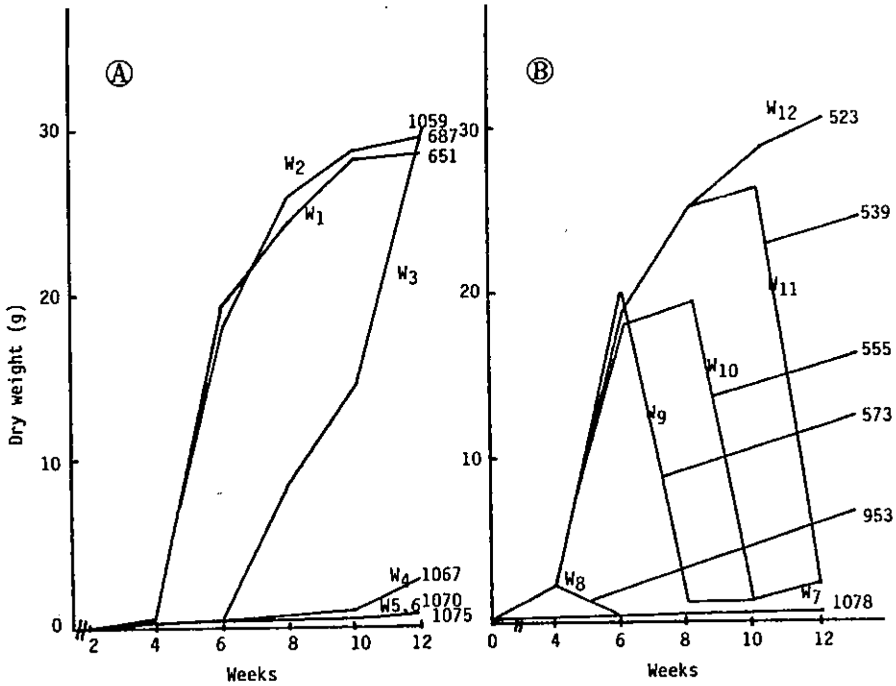

Fig 2. Dry weight of weeds at various dates of observations.

A = Weed-free period from sowing onwards.

B = Weed-free period counted from date of harvest.

For treatment identification, see Fig. 1. The values listed are yields/tomato plant (g).

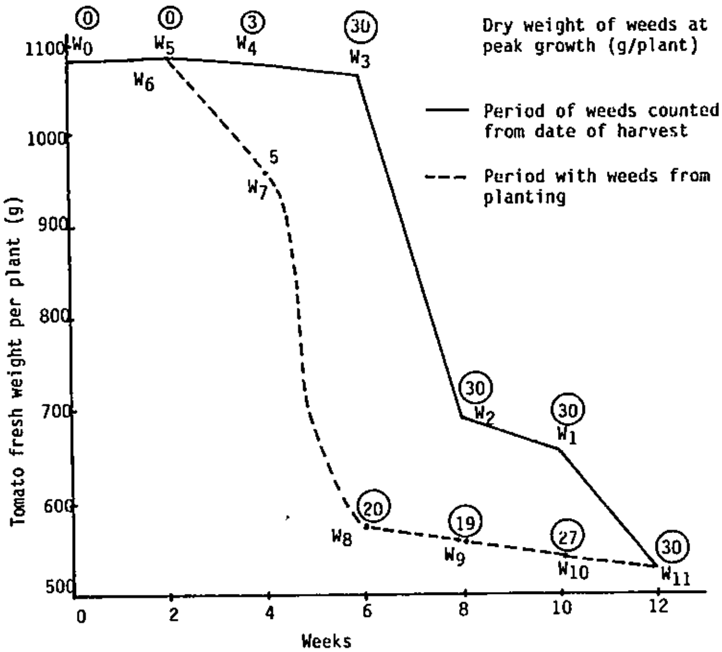

Fig. 3. The influence of the presence of weeds on the fresh weight of tomato fruit per plant. For treatment identification see Fig. 1.

weed-free for six weeks, tomato yield remained unaffected at the level of the plots kept weed-free throughtout, but the reduction of the weed-free period by two weeks caused a drop in yield of about 23%. Thus, the "critical period" during which tomatoes were particularly susceptible to weed competition was between week 4 and 8. This period coinclides with the main, linear phase of growth of the tomato plants during which the plants are obviously very sensitive to weed competition.

ACKNOWLEDGEMENT

I am grateful to Prof. P. May for advice and especially to Ms. Erny I, for providing data.

LITERATURE CITED

1. Moenandir, J. 1985. Weed crop interaction in the sugar cane plant intercropping system. Dissertation. Brawijaya University, Malang 236 pp.
2. Terry, P. J. 1981. Weed control in vegetable and horticultural crops. Training course in weed science. Biotrop. Bogor.
3. Weaver, S. T. and C. S. Tan. 1983. Critical periods of weed interferences in transplanted tomatoes (*Lycopersicon esculentum*). Growth analysis. Weed Sci. 31 : 476-481.

CRITICAL PERIOD OF CARROT (*DAUCUS CAROTA*) DUE TO EXISTENCE OF WEEDS IN EAST JAVA

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ABSTRACT

A field experiment was conducted at Batu, Malang, East Java, to test whether there was a critical period during which carrots suffered particularly due to the presence of weeds. The effect of the presence of weeds for various lengths of time and during various periods was tested between day 15 and day 120, the harvest of the carrot crop. The existence of weeds affected yield and yield components to a varying extent, but a critical period between days 30 – 45 was determined. Weeds present then affected carrot growth similarly when their present for longer periods.

INTRODUCTION

The reductions in the yield of carrots (*Daucus carota*) due to weed infestation depends on the composition and density of the weed population. Bronco and Oliviera in 1971, in Zimdahl (3) stated that weed competition during the first 1/3 of the growing period of carrots was critical. In Japan, carrot yield was reduced by about 75% when weeds was present at 5.5 weeks after sowing and covered about 50% (1980, in Seyama (2). The importance of early weeding was also stressed by Abidin (1) who found that weeding at 30 or 60 days after planting resulted in carrots with bigger diameters compared with carrots grown without weeding.

The experiment here described was designed to test how the presence of weeds for varying lengths of time and during varying stages of carrot development would affect the growth and yield of the crop and development of the weed population.

MATERIALS AND METHODS

The experiment was situated near Batu, East Java, at an altitude of ca. 700 m in a field which had carried a crop of cabbage. The carrots of an unknown local cultivar were sown at the beginning of the dry season (April 14) in rows spaced 0.15 m apart and thinned after 10 days to be 0.1 m apart in the row. The weeds were pulled by hand once a week up to harvest on August 14 in the plots to be kept weed-free at the point of time.

The experiment was laid out according to a randomized block design with three blocks, each with 16 plots. The treatments differed in the length and the timing of the period in which weeds were present or absent. (Fig. 1).

The growth of the carrots was measured every 15 days by destructive sampling by determining height, leaf area and dry weitht of the tops, and lenght, diameter, fresh and dry weight of the roots.

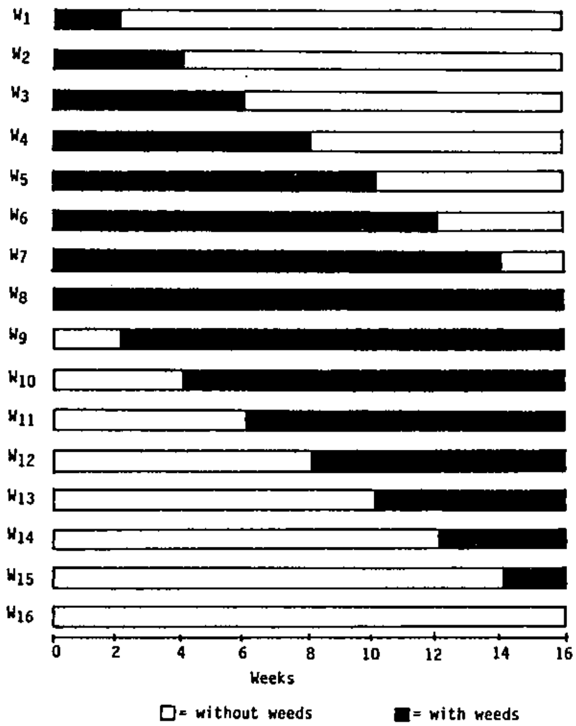

Fig. 1. Diagram illustrating the treatment.

Weed growth was measured by the dry weight of the plants present in a sample area that comprised the space taken up by 16 carrot plants in a 4 x 4 arrangement.

RESULTS AND DISCUSSION

Weed The amount of weed growth is shown in Fig. 2 (a and b). There were large differences in the weed population of the plots having weeds for the same length of time either at the beginning or the end of the growing period of the carrot crop. Weeds that developed later, when the carrot had developed a significant leaf area produced a much smaller biomass than plots where the weeds were composition from the young carrot crop. Indeed, treatment W10 which was weed-free for the first 30 days and had weeds for the remaining 90 days produced only about half of the weeds than treatment W 9 which had weeds throughout the 120 day period.

The domimant weed species was *Portulaca oleraceae* (krokot) followed by *Amaranthus spinosus* (bayam duri), *Ageratum conyzoides* (wedusan), *Eleusine indica* (lulangan), *Altemanthera sessilis* (kremah). Many other species were present in small amounts.

Yield and critical period In general, the yield of carrots was negatively related to the amount of weeds, measured as dry weight (Fig. 3). When weeds were present for first four weeks carrot yield was not reduced from that obtained in the weed-free plots. Likewise, similar yields were obtained when weed-growth was permitted to occur from six weeks after sowing onwards. However, yield was severely reduced when weeds were growing from four weeks onwards. Therefore, the period between week 4 and week 6 after sowing appeared to be critical. This agrees with the results obtained by Abidin (1). The yield reduction due to this period and other longer periods of damage by weeds was of the order 50%.

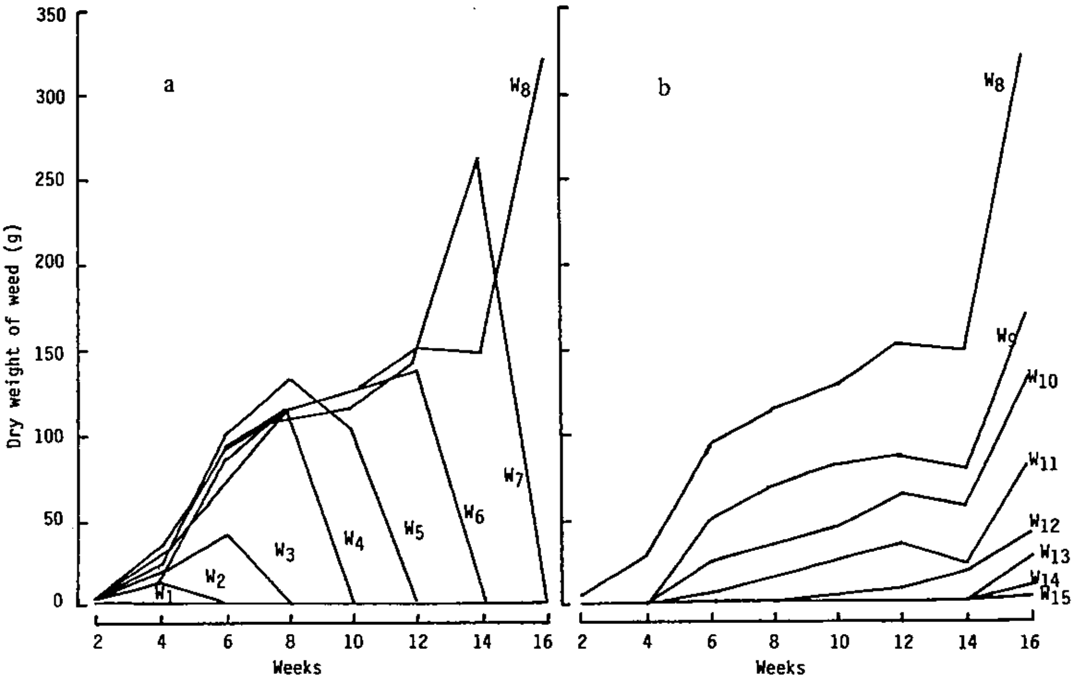

Fig. 2. Dry weight of weeds at various date of observations.

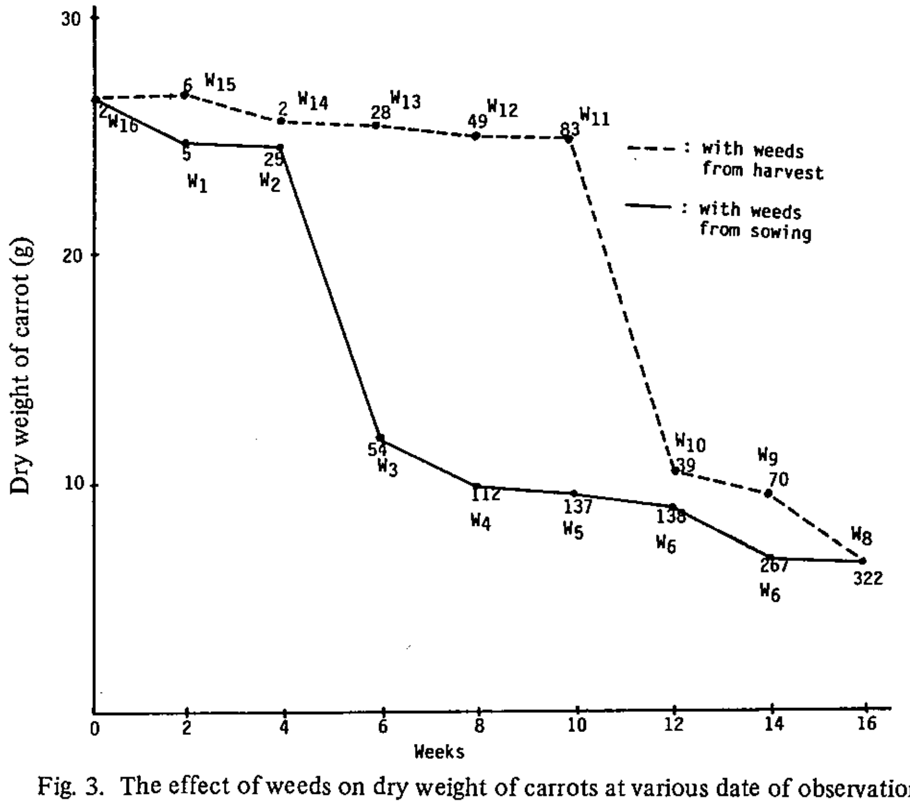

Fig. 3. The effect of weeds on dry weight of carrots at various date of observations.

ACKNOWLEDGEMENT

I wish to thank prof. P. May for his help in preparing the manuscript and also I extend r Ms Tri K. for providing data.

LITERATURE CITED

1. Abidin, Z. 1982. Pengaruh saat penyiangan gulma dan pengguna an mulsa jerami produksi wortel (*Daucus carota*) Bul. Penel. Hort. 9 (1): 23-26.
2. Seyama, N. 1981. Weed and control in Asia. FFTC China. P. 198-200.
3. Zimdahl, R. L. 1980. Weed-crop competition. A review. Publ. in U. S. A. by the IPI 195 pp.

EFFECT OF WEED COMPETITION AND METRIBUZIN ON TRANSPLANTED TOMATOES (*LYCOPERSICON ESCULENTUM* MILL.)

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ABSTRACT

Field experiments were conducted to identify the critical period of weed competition and to evaluate the effect of metribuzin on transplanted tomatoes. In the weed competition study, the results showed that tomatoes kept weed-free for 42 days after transplanting (DAT), or weeded from the 28th DAT gave yields equal to those kept weed-free for the entire growing season. The critical period of weed competition in transplanted tomato was, therefore, between 28 and 42 DAT. A single weeding during this period was sufficient to avoid yield loss. Metribuzin was good herbicide for weed control in tomato when applied as preemergence. The herbicide caused crop injury when applied after the crop was transplanted. Crop injury was higher when the herbicide was applied at 2 WAT than at 1 WAT. The herbicide had no effect on the fruit number and size of the transplanted tomatoes.

INTRODUCTION

Weed cause substantial yield loss in tomato if they are allowed to compete with the crop. The extent of loss depends on the type of weeds and intensity and duration of their infestation. In the temperate region, the losses ranged from 55 to 89% (5, 14). In the tropics, the loss was only 20% when the weed pressure (fresh weight) was low (10 t/ha), but increased to 78% when the weed competition was high (29 t/ha) (1, 2). In Indonesia, the loss was 36% (3).

Although hand-weeding is widely used by the farmers in the tropics, the practice is becoming more expensive due to the rising cost of labor. To keep this practice economically sound, research is needed to identify the critical period of weed competition as described by Neito et al. (10). This will help guide farmers to weed their land with the lowest labor requirement without inflicting significant yield loss.

Several herbicides were suggested for weed control in tomato. After evaluating seven herbicides in two years, Long (7) concluded that diphenamid, SD-11831, and trifluralin gave good weed control without crop injury when incorporated prior to transplanting. Conducting four experiments on sandy loam soil, Wilson and Davis (15) stated that diphenamid gave excellent and long lasting weed control in both direct-seeded and transplanted tomatoes, whereas trifluralin, pebulate, and DCPA with or without metobromuron provided good broad-spectrum weed control in transplanted tomatoes only. In three field trials involving eight herbicides at the Asian Vegetable Research and Development Center (AVRDC), metribuzin was found to be the only herbicide which provided consistent and excellent weed control in transplanted tomatoes (11). Metribuzin was also reported to demonstrate selective postemergence activity in tomato field (4).

The objectives of this study were to identify the critical period of weed competition in transplanted tomatoes and to determine the effect of metribuzin on the crop and weeds when applied postemergence under tropical condition.

MATERIALS AND METHODS

All experiments were conducted on sandy loam soil at AVRDC, which is located at 120° 17'E longitude and 23°7'N latitude.

Weed competition study Two trials were conducted in fall 1986 and spring 1987. Tomato cultivars TM 103 and PT 3027 were started in the greenhouse on September 26, 1986 and January 5, 1987, respectively. Seedlings were transplanted to the field on October 20, 1986 and February 19, 1987, when they had about 4 to 5 true leaves. Plots consisted of 2 rows of tomato each on 6 m long, 30 cm high bed, with 1.5 m spacing between rows and 40 cm between plants within rows. Prior to transplanting, each plot received 40 kg N/ha, 80 kg P_2O_5/ha, and 50 kg K_2O/ha. Two additional applications of 40 kg N/ha and 80 kg P_2O_5/ha were side-dressed 2 and 4 WAT. The plots were furrow-irrigated when water was needed, six times in the first trial and five times in the second trial.

The trials were conducted using a randomized complete block design with four replications. Treatments included weed infestation for 0, 14, 28, 42, 56, and 70 days after transplanting (DAT) and the plots were kept weed-free for 0, 14, 28, 42, 56, and 70 DAT. Weed removal was all done manually. Tomatoes were hand-harvested at approximately 1-week intervals, eight harvests in the first trial beginning in early January and four harvests in the second trial beginning in late April.

Study on the effect of metribuzin Field experiment was conducted in fall 1986 to determine the effect of metribuzin applied postemergence on transplanted tomato. Seeds of tomato Peto 86 were sown on October 24 and seedlings were transplanted to the field on November 11 when they had about 4 to 5 true leaves. Plots consisted of 3 rows of tomato, each 4.8 m long, with 1 m spacing between rows, and 30 cm between plants within rows. Prior to transplanting, individual plots received 40 kg N/ha, 80 kg P_2O_5/ha, and 50 kg K_2O/ha. Two additional applications of 40 kg N/ha and 50 kg K_2O/ha were side-dressed 2 and 4 WAT. The plots were furrow-irrigated six times throughout the growing season. Weed populations were counted from three 1000 cm^2 quadrats per plot.

The experiment was carried out using randomized complete block design with three replications. Treatments included weedy and weed-free check, and applying 0.5, 0.75, and 1.0 kg/ha of metribuzin as preemergence (before tomato transplanting), 1 and 2 WAT.

Tomatoes were harvested manually four times on March 2, 10, 20, and 26 from the center row of each plot.

RESULTS AND DISCUSSION

Major weeds in all trials were similar. They included jungle rice (*Echinochloa colonum* (L.) Link), goosegrass (*Eleusine indica* (L.) Geartn.), Slender amaranth (*Amaranthus viridis* L.), common purslane (*Portulaca oleracea* L.), and goosefoot (*Chenopodium ficifolium* J. E. Sm.) which was present only in the fall trials. Minor weeds included crabgrass (*Digitaria* spp.) and knotgrass (*Paspalum distichum* Am auctt.).

Weed competition study The results in 1986 showed that tomatoes kept weed-free for 42 DAT yielded as high as the weed-free check, 84.14 vs 89.26 t/ha (Table 1). Controlling weeds for longer periods failed to increase yields. On the other hand, yield was reduced by 26.8% and 21.4% when the crops were kept weed-free for only 14 and 28 DAT, respectively. Yields in the 1987 experiment were not significantly different among the weed-free treatments, regardless of the durations of the weed-free period.

Table 1. Effect of time of weed removal on the yield of tomato.

Duration of weed interference (DAT)	Tomato yield (t/ha)[1]	
	1986	1987
Weed-free		
14	65.35 ef	36.41 a
28	70.11 cde	40.63 a
42	84.14 abc	39.57 a
56	78.47 abcd	42.22 a
70	78.36 abcd	42.00 a
harvest	89.26 a	45.68 a
Weed infested		
14	85.15 ab	43.99 a
28	81.23 abc	38.86 a
42	72.84 bcd	37.14 a
56	69.43 cde	27.65 b
70	57.22 ef	18.93 c
harvest	53.95 f	20.79 bc

[1] Means within a column followed by the same letter are not significantly different at the 5% level by DMRT.

Tomato yields were reduced significantly when weed infestation was longer than 28 DAT in 1986, and 42 DAT in 1987 (Table 1). Yield reduction was 22.2% in 1986 and 39.5% in 1987, when weed competition was allowed for 56 DAT. Yield loss due to weed competition throughout the entire growing season was 39.6% in 1986 and 54.5% in 1987.

Number of tomato fruits per plant was significantly reduced when weed infestation was longer than 28 DAT in both years (Table 2). The lowest number of fruits per plant in both years came from the plots that had weed infestation for 70 DAT or longer. The number of fruits per plant were not affected by the weed-free periods in 1987, but was reduced in 1986 when the weed-free period was less than 42 DAT.

The effect of weed infestation on fruit size was less obvious (Table 2). Although fruit size was reduced by long period of weed infestations ($\geqslant$70 DAT) in 1987, it was not affected by the infesta-

Table 2. Effect of time of weed removal on fruit development of the transplanted tomato.[1]

Duration of weed interference (DAT)	Fruit size (g/fruit)		Fruit number (no./plant)	
	1986	1987	1986	1987
Weed-free				
14	52.0 a	49.1 bcd	74.4 cde	44.7 abc
28	50.8 a	55.8 a	82.8 bcd	44.2 abc
42	53.5 a	48.5 cd	94.2 ab	49.2 ab
56	52.8 a	51.8 abcd	89.4 abc	48.9 ab
70	50.1 a	52.9 abc	93.0 ab	47.5 ab
harvest	53.8 a	52.0 abcd	99.6 a	53.3 a
Weed infested				
14	53.2 a	50.1 bcd	96.6 ab	52.5 ab
28	51.7 a	50.5 bcd	94.2 ab	46.2 ab
42	52.4 a	53.9 ab	83.4 bcd	41.3 bcd
56	51.0 a	47.2 d	81.6 bcd	35.2 cde
70	47.6 a	41.2 e	72.0 de	27.6 e
harvest	50.8 a	38.8 e	63.6 e	32.0 de

[1] Means within a column followed by the same letter are not significantly different at the 5% level by DMRT.

tion in 1986.

From the above results, it was clear that tomato tolerated weed competition for 28 DAT in 1986 or required the weed-free period of 42 days to avoid significant yield loss. Therefore, the critical period of weed competition was between 28 and 42 DAT. In 1987, the crop tolerated weed competition up to 42 DAT, whereas the duration of weed-free period had no effect on yield. This suggests that a single weeding within 42 DAT is adequate to prevent yield loss. A study conducted earlier reported that the critical period was between 24 and 36 DAT (5). Weaver and Tan (14), however, stated that tomato tolerated weed interferance for 28 to 35 DAT. They also concluded that the critical period of weed competition was between 28 and 35 DAT, and weeding once during this period was enough to avoid significant yield loss. Yield difference, under the present study, was due to difference in number of fruits per plant and fruit size (R^2 = 0.99 in both years). Seventy-six to 84% of the yield difference was due to difference in number of fruits per plant while 5 to 23% was due to difference in fruit size.

Study on the effect of metribuzin Grassy and broadleaf weeds were significantly controlled by metribuzin (Table 3). Number of weeds under metribuzin treatments, both grassy and broadleaf, developed at 40 and 60 DAT were much less than those of the weedy check and were as low as the weed-free check. The number of weeds develop was not affected by the time of application of metribuzin. At harvest, all preemergence treatments had lower weed fresh weight than the weedy check. In contrast,

Table 3. Effect of metribuzin on number of weeds developed at different times and weed fresh weight at harvest.[1]

Application rate (kg/ha)	Weed fresh weight (t/ha)	40 DAT (no./m^2)		60 DAT (no./m^2)	
		Grass	Broadleaf	Grass	Broadleaf
Weedy check	6.8 a	195.6 a	398.9 a	158.9 a	308.9 a
Weed-free check	1.8 c	0.0 b	0.0 b	0.0 b	0.0 b
Preemergence					
0.50	0.8 c	3.3 b	13.3 b	8.9 b	6.7 b
0.75	1.3 c	1.1 b	0.0 b	6.7 b	24.4 b
1.00	1.8 c	14.4 b	0.0 b	15.6 b	5.6 b
Postemergence (1 WAT)					
0.50	3.9 abc	31.3 b	52.2 b	12.2 b	47.8 b
0.75	2.8 bc	7.8 b	13.3 b	6.7 b	8.9 b
1.00	2.8 bc	6.7 b	0.0 b	11.1 b	16.7 b
Postemergence (2 WAT)					
0.50	1.8 c	15.6 b	0.0 b	48.9 b	21.1 b
0.75	5.6 ab	4.4 b	1.1 b	10.0 b	7.8 b
1.00	5.4 ab	4.4 b	0.0 b	7.8 b	0.0 b

[1] Means within a column followed by the same letter are not significantly different at the 5% level by DMRT.

only some postemergence treatment, i.e. 0.75 and 1.00 at 1 WAT and 0.5 at 2 WAT, gave significantly lower weed fresh weight than the weedy check. This indicates that metribuzin gave better weed control effect when applied preemergence than postemergence. The higher weed fresh weights from plots treated with 0.75 and 1.00 kg/ha of metribuzin at 2 WAT was due to the fact that most of the crops under these treatments were severely injured and killed (Table 4), hence less crop canopy to cover the ground allowing later emerging weeds to grow without severe shading effect from the crop.

The effect of metribuzin on the crop is presented in Table 4. Tomato plants from plots treated with metribuzin were, regardless of time of application, as tall as those of the weedy check at 2 WAT. At 3 WAT, plants receiving 1.00 kg/ha of metribuzin as preemergence and 0.75 and 1.00 kg/ha as postemergence were shorter than those that did not receive any metribuzin (the checks). Plants from all metribuzin treatments, except for the 0.5 kg/ha treatment as preemergence, were shorter than the check at 4 WAT. Crop injury rating was high when metribuzin was applied postemergence, with more serious injury at 2 WAT than at 1 WAT. Higher crop injury also resulted from applying 1.00 kg/ha of metribuzin, whether preemergence or postemergence, than from lower application rates.

Table 4. Plant height at different growth stages as affected by metribuzin.[1]

Application rate (kg/ha)	Crop injury[2] rating	Plant height (cm)		
		2 WAT	3 WAT	4 WAT
Preemergence				
0.50	0.7 fg	13.1 ab	17.2 abc	22.1 ab
0.75	1.3 f	11.6 bc	16.6 a-d	20.0 bc
1.00	4.3 d	10.9 c	13.8 e	19.1 bcd
Postemergence (1 WAT)				
0.50	3.0 e	12.4 abc	16.9 a-d	21.2 bc
0.75	6.3 c	11.7 bc	15.0 cde	19.0 bcd
1.00	7.7 b	12.6 ab	14.6 de	18.3 cd
Postemergence (2 WAT)				
0.50	4.7 d	13.5 a	16.8 a-d	21.3 bc
0.75	7.0 bc	13.0 ab	16.0 b-e	20.0 bc
1.00	9.0 a	13.0 ab	15.2 cde	15.5 d
Weed-free check	0.0 g	13.9 a	18.7 a	25.2 a
Weed check	0.0 g	12.4 abc	18.2 ab	25.3 a

[1] Means within a column followed by the same letter are not significanly different at the 5% level by DMRT.

[2] Rating was done 4 WAT; 0 = no crop injury; 10 = complete crop kill.

The above results clearly show that tomato cultivar Peto 86 is susceptible to metribuzin, especially when the herbicide is applied after transplanting. This result corroborates with earlier reports conducted by Messier and Ashley (9) and Sanok et al. (12). Other cultivars tested at AVRDC were found tolerant to metribuzin (1). The varietal difference in tolerance to metribuzin was attributed to difference in rate of metribuzin absorption by roots and translocation into the shoot (6). Differential tolerance was also related to the rate of detoxification by metabolism within the tomato leaves (8, 13).

Table 5 shows the effect of metribuzin on yield, its attributes, and plant stand. Regardless of the method of application, metribuzin applied at 0.5 kg/ha did not reduce plant stand. On the otherhand, postemergence application at higher rates, i.e. 0.75 and 1.00 kg/ha and preemergence at 1.00 kg/ha reduced the plant stand significantly. This was due to severe crop injury as indicated in Table 4. Metribuzin had no effect on fruit size and number of fruits per plant. Fruit yield, however, was significantly affected by metribuzin application. Postemergence application, especially those with high rates, either at 1 or 2 WAT, reduced the yield of tomatoes, whereas the preemergence treatments did not, when compared with the weed-free check. Yield difference was due mainly to the differences in plant stand (R^2 = 0.98, with 82% of the variation in yield explainable by differences in plant stand,

Table 5. Tomato yield and its attributes and number of plant stand of the center row at harvest as affected by metribuzin[1].

Application rate (kg/ha)	Yield (t/ha)	Fruit size (g/fruit)	Fruit number (no./plant)	Plant stand (no./row)
Weedy check	53.2 bcd	45.6 a	42.5 a	14.0 abc
Weed-free check	95.1 a	50.8 a	57.3 a	15.7 a
Preemergence				
0.50	91.8 a	49.8 a	59.2 a	15.0 ab
0.75	94.8 a	48.5 a	60.9 a	15.3 a
1.00	74.2 abc	53.8 a	60.6 a	11.0 cd
Postemergence (1 WAT)				
0.50	71.7 abc	50.5 a	49.2 a	14.0 abc
0.75	67.6 abc	49.8 a	57.8 a	11.3 bcd
1.00	47.5 cd	50.8 a	67.6 a	6.6 e
Postemergence (2 WAT)				
0.50	79.2 ab	48.0 a	55.2 a	14.3 abc
0.75	63.1 bc	49.7 a	61.8 a	10.0 de
1.00	30.8 d	48.9 a	47.6 a	6.7 e

[1] Means within a column followed by the same letter are not significantly different at the 5% level by DMRT.

13% by number of fruits per plant, and 3% by fruit size).

LITERATURE CITED

1. Asian Vegetable Research and Development Center. 1982. Annual report 1981. Shanhua, Taiwan, R. O. C.
2. Asian Vegetable Research and Development Center. 1984. Progress report 1982. Shanhua, Taiwan, R. O. C.
3. Everaarats, A. P. and Yusuf Muchtar. 1979. Weed competition in cabbages and tomatoes on Java. pp. 83-86. Proc. 7th Asian-Pacific Weed Sci. Soc. Conf. Sydney, Australia, 26-30 November 1979.
4. Fortino, J., Jr. and W. E. Splittstoesser. 1974. The use of metribuzin for weed control in tomato. Weed Sci. 22: 615-619.
5. Friesen, G. H. 1979. Weed interference in transplanted tomatoes (*Lycopersicon esculentum*). Weed Sci. 27: 11-13.

6. Harrison, H. F., Jr., Prashant Bhatt, and George Fassuliotis. 1983. Response of calli and seedlings of tomato (*Lycopersicon esculentum*) cultivars to metribuzin. Weed Sci. 31: 533-536.
7. Long, J. D. 1968. Herbicide studies on transplanted tomatoes. Proc. Northeastern Weed Sci. Soc. 22: 95-97.
8. Machado, V. S. and C. Ditto. 1982. Tomato chloroplast photochemical sensitivity to metribuzin. Scientia Horticulturae 17: 9-13.
9. Messier, B. B. and A. Ashley. 1980. Effect of trifluralin on metribuzin treated tomato. Proc. Northeastern Weed Sci. Soc. 34: 110.
10. Nieto, J. H., M. A. Brondo, and J. T. Gonzalez. 1968. Critical periods of the crop growth cycle for competition from weeds. PANS 14: 159-166.
11. Sajjapongse, A., G. W. Selleck, and Y. C. Roan, 1983. Weed control for transplanted tomato. Acta Horticulturae 136: 65-72.
12. Sanok, W. J., G. W. Selleck, and J. F. Creighton, 1980. Weed control experiments in tomatoes-A three-year summary. Proc. Northeastern Weed Sci. Soc. 34: 167-169.
13. Stephenson, G. R., J. E. McLeod, and S. C. Phatak, 1976. Differentral tolerance of tomato cultivars to metribuzin. Weed Sci. 24: 161-165.
14. Weaver, S. E. and Chin S. Tan. 1983. Critical period of weed interference in transplanted tomatoes (*Lycopersicon esculentum*): Growth analysis. Weed Sci. 31: 676-481.
15. Wilson, H. P. and H. S. Davis, 1969. Weed control in direct-seeded and transplanted tomatoes. Proc. Northeastern Weed Control Conf. 23: 26-33.

TRIDIPHANE/TRICLOPYR COMBINATION FOR WEED CONTROL IN TRANSPLANTED RICE

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ABSTRACT

Field trials were conducted during 1984 to 1987 in Taiwan to define weed activities and crop response of tridiphane [2-(3,5-dichlorophenyl)-2-(2,2,2-trichloroethyl) oxirane]/triclopyr [(3,5,6-trichloro-2-pyridinyloxyacetic acid), butoxyethyl ester] combination in transplanted Japonica rice (*Oryza sativa* L. 'Tainung 67'). Comparing tridiphane and triclopyr, tridiphane was more active against barnyard grass (*Echinochloa crus-galli* Beauv. var. *oryzicola* Ohwi) and monochoria (*Monochoria vaginalis* Persl.), while triclopyr was more active against arrowhead (*Sagittaria trifolia* L.), smallflower umbrella plant (*Cyperus difformis* L.) and bulrush (*Scirpus juncoides* Roxb.). Joint action of tridiphane/triclopyr was additive based on a multiplicative survival model (MSM). Combination ratio of 1:1 appeared to be the optimum ratio for tridiphane/triclopyr mixture. A wettable powder of tridiphane and triclopyr was more phytotoxic than a granule to transplanted Japonica rice. However, application rates of equal or less than 400 g ai/ha of granule and wettable powder formulations tridiphane or triclopyr resulted in minimum crop injury. Tridiphane/triclopyr combination granule, at 300+300 and 400+400 g ae/ha and applied at 1 to 2 leaf stage of weeds, resulted in satisfactory control of paddy weeds with low or no crop injury and a significant yield increase. To ensure the performance of this herbicide granule, retention of 3 to 5 cm water level in the treated field was found necessary. A wettable powder of the same herbicide combination performed well in weed control. However, shallow water level was needed to enhance the efficacy of the wettable powder. With this proper water management, 300+300 g ai/ha tridiphane+triclopyr wettable powder resulted in satisfactory paddy weed control with an insignificant difference in efficacy among applications at 5, 10 and 15 days after transplanting (i.e. 1 to 2,2 to 3 and 3 to 4 leaf stage of weeds).

INTRODUCTION

Tridiphane and triclopyr were studied for their activities against paddy weeds and effects on transplanted Japonica rice. Twelve field trials were conducted at Pingtung and Taipei in Taiwan during 1984 to 1987 to define: 1) weed activities of tridiphane and triclopyr in paddy rice; 2) crop injury levels of these two herbicides; 3) optimum combination ratio of tridiphane/triclopyr for paddy rice use; 4) possible interactions between tridiphane and triclopyr; 5) different application windows for granular and wettable powder of tridiphane/triclopyr combination; and 6) field performance of the combination.

MATERIALS AND METHODS

Phytotoxicity of Tridiphane and Triclopyr on transplanted Japonica rice Chemicals tested were: XGA 2058 (tridiphane 1.25% G), XGA 2083 (tridiphane 20% WP), XGA 2070 (triclopyr 1.25% G) and XGA 2086 (triclopyr 20% WP). Application dosages were 200, 400 and 800 g ae/ha for each formulation.

Japonica rice (Tainung 67) seedlings were transplanted at the 3 to 4 leaf stage and treated at the 5 leaf stage. Randomized complete block design with 3 replicates was adopted. Plot size was 2 by 1 meters. An Oxford Precision sprayer with a Teejet F11003LP flat fan nozzle was used for application of wettable powder formulations. Spray volume was 1000 1/ha. Granular formulations were broadcasted manually.

Phytotoxic symptoms were rated at 10, 20 and 30 days after application and tillers/hill were counted at 30 days after application. A zero to ten scale was used for phytotoxicity ratings where zero = no effect and ten = complete kill.

Joint action of Tridiphane/Triclopyr Chemicals tested were: XGA 2083 (tridiphane 20% WP) and XGA 2086 (triclopyr 20% WP). Dosages tested were as follows:

	ppm	
mixing ratio	tridiphane	triclopyr
1:0	50, 100, 200, 400	0
0:1	0	50, 100, 200, 400
1:8	50	400
1:4	50, 100	200, 400
1:2	50, 100, 200	100, 200, 400
1:1	50, 100, 200, 400	50, 100, 200, 400
2:1	100, 200, 400	50, 100, 200
4:1	200, 400	50, 100
8:1	400	50

Randomized complete block design with 3 replicates was adopted. Plot size was 0.5 by 0.5 meters. Seeds of barnyard grass, monochoria, arrowhead, smallflower umbrella plant and bulrush were pre-germinated and sowed into plots. Each species was grown in different concrete blocks and treated at 2 to 3 leaf stage. An Oxford Microsprayer with single Teeject F11002LP flat fan nozzle was used for application. Chemicals were mixed prior to application. Spray volume was 25 ml/plot. Efficacy was evaluated visually at 7 days after application.

To test the joint action of tridiphane/triclopyr, a multiplicative survival model (MSM) and an additive dose model (ADM) recommended by Morse (1) were used to build reference models. In MSM, lack of effect (survival) resulting from administering a mixture is expressed as a proportion, the MSM equates this proportion to the product of the corresponding proportions which would survive the components of the mixture, each tested separately. In ADM, the predicted dose-response relationship for the mixture is as follows: at any particular level of response, the relative potency of the components when acting alone establish scales of equivalent doses. In terms of these effective-dose scales, if one component of the mixture is replaced, wholly or in part by the other, the predicted response is unchanged.

The dose-response of tridiphane and triclopyr when applied alone was fitted to the log-probit curve using Raymond's computer program (2). Predicted percent control of 5 tested weeds due to 50, 100, 200 and 400 ppm of tridiphane and triclopyr alone were then calculated based on this log-probit curve.

Based on MSM the predicted percent control of the tested tridiphane/triclopyr combinations were calculated according to the following formula:

$$Pm = 100 - ((100 - P1) \times (100 - P2)/100)$$

where Pm, P1 and P2 were percent control of the mixture tridiphane and triclopyr respectively.

To obtain percent control of the tested tridiphane/triclopyr combinations based on ADM, the predicted doses of tridiphane and triclopyr applied alone to cause 20, 40, 60 and 80 % control were calculated according to the forementioned log-probit curve. At the specific value (Y) of % control (20, 40,60 or 80%), the dosages required for the mixture were calculated according to the following formula:

$$Zm = (Z1 \times Z2)/(Z1 \times Q1) + (Z2 \times Q2)$$

where Zm, Z1 and Z2 are dosages of the mixture, tridiphane and triclopyr required to cause specific Y, and Q1 and Q2 are proportions of tridiphane and triclopyr in the mixture. Four points of (Y, Zm) were then fitted to the log-probit curve using Raymond's computer program. The predicted responses of the tested tridiphane/triclopyr mixtures were then calculated based on this curve.

Predicted values of MSM and ADM were then compared with observed values. Two reference models were then compared for the better fittness to the observed response. According to the model selected, combinations with responses close to the predicted responses were declared as 'additive', combinations with responses significantly less than the predicted values were declared as 'less than additive' and more than predicted values were declared as 'more than additive'.

Field performance of 1:1 Tridiphane/Triclopyr granule in transplanted Japonica rice Twelve field trials were conducted during 1984 to 1987. Among these, 8 were conducted at Pingtung and 4 were conducted in Taipei, Taiwan. Chemicals tested were: XAG 2033 (tridiphane 1.25%+triclopyr 1.25% G) and MACHETE 5G (butachlor 5% G). Tested application dosages were: 200+200, 300+300 and 400 +400 g ae/ha of XGA 2033 and 1500 g ae/ha of MACHETE 5G.

Japonica rice (Tainung 67) was transplanted at 3 to 4 leaf stage using transplanter. Randomized complete block design with 3 replicates was adopted. Plot size was 4 by 5 or 8 by 5 meters. Herbicide granules were broadcasted manually at 1 to 2 leaf stage of weeds.

Visual estimation of percent control of weeds and phytotoxicity on rice (0-10 scale) were conducted at 10, 20 and 30 days after application. Dry weight of rice grain was recorded after harvesting. For the purpose of comparison, some plots were hand weeded twice during 10 to 30 days after transplanting. Two water level regimes were studied --- 1) 3 to 5 cm water level: plots were flooded prior to application of herbicides and retained flooded for about 7 days; 2) 0 to 1 cm water level: plots were drained prior to application of herbicides and flooded at 24 to 36 hours after application. Water management during rest of growing season followed normal practice.

Field performance of 1:1 Tridiphane/Triclopyr wettable powder in transplanted Japonica rice Chemicals tested were XGA 2083 (tridiphane 20% WP) and XGA 2086 (triclopyr 20% WP). One application dosage-300+300 g ae/ha of tridiphane+triclopyr was tested.

Two field trials were conducted to evaluate performance of XGA 2083 + XGA 2086 at different application timing and water levels. Rice cultivation and experimental design was the same as just described. An Oxford Precision sprayer with three Teejet F11003LP flat fan nozzles was used for application. Spray volume was 1000 l/ha.

Four timings of application were examined: 5, 10, 15 and 20 days after transplanting. Two water level regimes were studied: 3 to 5 cm and 0 to 1 cm which were also just described. Visual estimation of percent control of weeds and crop injury were conducted at 10, 20 and 30 days after application.

RESULTS AND DISCUSSION

Phytotoxicity of Tridiphane and Triclopyr on transplanted Japonica rice Results indicated that granular formulations of tridiphane and triclopyr were less phytotoxic than wettable powder formulations (Table 1). At 400 and 800 g ae/ha application rates, both tridiphane and triclopyr wettable powder resulted in stunting and reduction of tillers. At 800 g ae/ha application rate, triclopyr 1.25% G resulted in significant reduction of rice tillers without other phytotoxic symptoms. Evident phytotoxic symptoms were not observed for tridiphane 1.25% granule at rates up to 800 g ae/ha. The following trials were thus confined within 400 g ae/ha of tridiphane and triclopyr.

Table 1. Phytotoxicity of Tridiphane and Triclopyr on transplanted Japonica rice.

Chemicals	Formulations	g ae/ha	Phyto. Rating[1]	Tillers/Hill[2]
Tridiphane	1.25% G	200	0 c	18 a
		400	0 c	18 a
		800	0 c	17 ab
	20% WP	200	0 c	17 ab
		400	0 c	16 b
		800	3 a	16 b
Triclopyr	1.25 % G	200	0 c	18 a
		400	0 c	17 ab
		800	0 c	15 b
	20% WP	200	0 c	18 a
		400	0 c	16 b
		800	2 b	15 b
untreated	–	0	0 c	19 a

[1] Phytotoxicity rating scale: 0-10, 0 = no effect and 10 = complete kill. Phytotoxicity was rated at 20 days after treatment.

[2] Tiller/hill was counted at 30 days after treatment. Means of 3 replicates. Means with the same character are not significantly different based on Duncan's Multiple Range Test at 5% significance level.

Joint action of Tridiphane/Triclopyr combination Tridiphane was more active than triclopyr against barnyard grass and monochoria, while triclopyr was more active than tridiphane against arrowhead, smallflower umbrella plant and bulrush (Table 2). Observed effects of both tridiphane and triclopyr fitted quite well to the log-probit response curve.

Table 2. Predicted (E) and observed (O) effect of Tridiphane 20% WP and Triclopyr 20% WP against *Echinochloa crus-galli* (ECHCG), *Monochoria vaginalis* (MONVA), *Sagittaria trifolia* (SAGTF), *Cyperus difformis* (CYPDF) and *Scirpus juncoides* (SCPJC).

Chemicals	ppm	% control									
		ECHCG		MONVA		SAGTF		CYPDF		SCPJC	
		O	E	O	E	O	E	O	E	O	E
Tridiphane	50	82	80	10	12	0	0	60	59	0	1
”	100	88	91	57	51	0	3	67	69	10	9
”	200	96	96	87	89	20	17	82	78	17	25
”	400	99	99	99	99	50	51	83	85	60	56
Triclopyr	50	0	0	0	1	0	0	30	29	12	7
”	100	7	8	10	11	7	5	63	64	18	28
”	200	47	43	50	46	23	28	88	89	67	64
”	400	83	86	83	85	72	69	100	90	90	89

Analysis of the joint action between tridiphane and triclopyr showed that a multiplicative survival model (MSM) fitted the response of the combination better than a additive dose model (ADM) (Table 3). This implied dissimilar action of tridiphane and triclopyr (1). MSM was thus selected as a reference model for the joint action of tridiphane/triclopyr. Comparing observed and predicted values, tridiphane and triclopyr showed a additive effect in general (TAble 3). However, a less than additive' effect was recorded on bulrush at 4:1 and 8:1 combination ratio of tridiphane+triclopyr.

Based on the MSM reference model and phytotoxic levels of the two herbicides, the best treatment for respective weed species was: barnyard grass - 400 ppm tridiphane, monochoria - 400 ppm tridiphane, arrowhead - 400+400 ppm tridiphane + triclopyr, smallflower umbrella plant - 400 ppm triclopyr and bulrush - 400 ppm triclopyr. Accordingly, in order to control all of these five major weed species, the most reasonable combination ratio should be 1:1.

Field performance of 1:1 Tridiphane/Triclopyr granule in transplanted Japonica rice Water management or irrigation method exerted a significant effect on the performance of tridiphane/triclopyr combination granule (Table 4). Efficacy was significantly better in 3 to 5 cm water level treatments than 0 to 1 cm water level treatments. It indicated that to ensure satisfactory result of tridiphane+triclopyr combination granule, retention of water in the treated plots was necessary.

Among 3 application rates, 300+300 and 400+400 g ae/ha tridiphane+triclopyr granule, applied at 1 to 2 leaf stage of weeds, resulted in satisfactory control as long as 3 to 5 cm water level was retained for about 7 days after application. Table 5 also showed that 300+300 and 400+400 g ae/ha tridiphane+

Table 3. Predicted effect based on MSM and ADM and observed effect (Obs.) of Tridiphane/Triclopyr mixture against *Echinochloa crus-galli* (ECHCG), *Monochoria vaginalis* (MONVA), *Sagittaria trifolia* (SAGTF), *Cyperus difformis* (CYPDF) and *Scirpus juncoides* (SCPJC).

ppm		Ratio	% control														
			ECHCG			MONVA			SAGTF			CYPOF			SCPJC		
S[1]	S[2]		Obs	MSM	ADM	Obs	MSM	ADM	Obs	MSM	ADM	Obs	MSM	ADM	Obs	MSM	ADM
50	400	1:8	97	97	99	90	87	99	70	69	60	100	99	86	90	90	68
50	200	1:4	90	88	97	60	53	92	20	28	29	95	95	81	67	64	44
100	400	"	99	99	99	92	93	99	70	70	67	100	99	88	90	90	76
50	100	1:2	85	82	91	20	22	65	10	5	10	85	85	75	30	39	26
100	200	"	96	95	97	72	74	94	30	30	41	98	97	84	60	67	60
200	400	"	95	95	99	98	98	99	75	75	78	100	99	90	90	92	87
50	50	1:1	83	80	82	10	13	31	0	1	4	73	71	69	10	8	16
100	100	"	90	91	89	60	57	75	7	8	23	90	89	79	40	35	46
200	200	"	98	98	97	95	94	97	40	41	61	98	98	86	75	73	78
400	400	"	99	100	99	100	100	99	80	85	90	100	100	93	95	95	96
100	50	2:1	90	91	91	50	52	49	0	3	12	75	78	76	20	16	38
200	100	"	96	97	97	90	90	87	20	21	45	93	92	86	47	46	72
400	200	"	99	99	99	99	99	99	70	65	82	99	98	93	83	84	93
200	50	4:1	95	96	97	87	89	73	17	18	38	83	84	85	40	30	68
400	100	"	99	99	99	98	99	96	60	54	77	95	95	93	10	68	91
400	50	8:1	99	100	93	90	99	93	55	51	64	95	94	94	40	54	90

[1] S1 = Tridiphane 20% WP

[2] S2 = Triclopyr 20% WP

Table 4. Efficacy of Tridiphane/Triclopyr granule (XGA 2033) against *Echinochloa crus-galli* (ECHCG), *Monochoria vaginalis* (MONVA), *Sagittaria trifolia* (SAGTF), *Cyperus difformis* (CYPDF) and *Scirpus juncoides* (SCPJC) in transplanted Japonica rice.

Tridiphane+Triclopyr (XGA 2033) g ae/ha	Water level (cm)	% control (30 DAA)[1]				
		ECHCG	MONVA	SAGTF	CYPDF	SCPJC
200 + 200	0 – 1	83 c	76 d	52 c	80 d	34 d
300 + 300	0 – 1	96 ab	88 c	69 b	90 c	75 c
400 + 400	0 – 1	97 a	95 ab	73 a	95 b	80 b
200 + 200	3 – 5	96 ab	92 b	–	90 c	97 a
300 + 300	3 – 5	98 a	93 b	–	97 a	97 a
400 + 400	3 – 5	97 a	97 a	–	98 a	97 a

[1] Means of 4 field trials. Means with the same character are not significantly different based on Duncan's Multiple Range Test at significance level of 5%. Weeds were at 1 to 2 leaf stage at time of treatment.

Table 5. Comparison of Tridiphane/Triclopyr granule (XGA 2033) and butachlor granule (MACHETE 5G) - their efficacy in paddy weed control and effects on transplanted Japonica rice.

Chemicals	g ae/ha	Weed Control[1] (%)	Injury[2]	Yield[3] (Kg/Ha)
tridiphane+triclopyr 2.5%G	200 + 200	85 d	0 c	6284 a
"	300 + 300	95 bc	0.1 b	6284 a
"	400 + 400	97 ab	0.4 a	6200 a
butachlor 5% G	1500	97 ab	0.3 a	6265 a
handweeding	0	100 a	0 c	6221 a
untreated	0	0 e	0 c	3888 b

[1] Overall weed control. Means of 6 field trial results.

[2] 0 - 10 rating scale. 0 = no effect and 10 = complete kill. Means of 8 field trial results.

[3] Dry weight. Means of 4 field trial results.

[4] Means with the same character are not significantly different based on Duncan's Multiple Range Test at 5% significance level.

triclopyr granule gave satisfactory weed control with minor injury to the transplanted Japonica rice and significant yield increase. The performance was equivalent to 1500 g ae/ha MACHETE 5G.

Field performance of 1:1 Tridiphane/Triclopyr wettable powder in transplanted Japonica rice Water management and application timing affected the performance of tridiphane/triclopyr combination wettable powder (Table 6). Treatments in plots drained prior to application (0 to 1 cm water level) resulted in better efficacy than plots flooded with 3 to 5 cm water. Exposure of weed foliage to the spray apparently gave better foliage absorption of herbicides and better efficacy. The results also indicated that with proper water management (i.e. shallow water level at time of treatment) 300+300 g ae/ha wettable powder of tridiphane/triclopyr combination applied at 5 to 15 days after transplanting can achieve satisfactory control of paddy weeds with minimum crop injury.

Table 6. Efficacy of 300+300 g ae/ha Tridiphane/Triclophy wettable powder (XGA 2083+XGA 2086) against *Echinochloa crus-galli* (ECHCG), *Monochoria vaginalis* (MONVA), *Sagittaria trifolia* (SAGTF), *Cyperus difformis* (CYPDF) and *Scirpus juncoides* (SCPJC) in transplanted Japonica rice.

Water Level (cm)	Appli. Time (DATr)	% control (30 DAA, 300+300 g ae/ha)[1]				Phyto. Rating[1] (0-10)
		ECHCG	MONVA	CYPDF	SCPJC	
3-5	5	85 b	90 b	95 c	96 a	1 a
"	10	73 c	95a	97 ab	90 b	1 a
"	15	57 d	87 b	92 d	90 b	0 b
"	20	37 e	68 d	78 e	73 c	0 b
0-1	5	91 a	88 b	95 c	92 b	1 a
"	10	92 a	95 a	98 a	92 b	0 b
"	15	90 ab	90 b	96 bc	92 b	0 b
"	20	77 c	73 c	80 e	75 c	0 b

[1] Means of 3 replicates. Means with the same character are not significantly different based on Duncan's Multiple Range Test at significance level of 5%. Weeds were at 0-1, 2-3, 3-4 and 4-6 leaf stage at 5, 10, 15 and 20 days after transplanting (DATr).

LITERATURE CITED

1. Morse, P. M. 1978. Some comments on the assessment of joint action in herbicide mixtures. Weed Science 26: 58-71.
2. Raymond, M. 1985. Programme D'analyse log-probit, Laboratorire de Genetique, Institute des sciences de L'Evolution, U. S. T. L. Place E. Bataillon 34060 Montpellier Cedex, France.

APPLICATION OF TETRAPION IN TAIWAN FOREST PLANTATIONS

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ABSTRACT

Under the warm and humid climate on Taiwan, weeds are very luxuriant and diversified. Survival and growth of forest plantings depend highly on the effort of weed control. For many years only tetrapion has found and used as a promising herbicide because of its selectivity and easy to apply in the forestry. Some fifteen years results on the research of tetrapion in forest plantations are summarized in this report. However, the selectivity of tetrapion was limited to few species of grass, to find out additional promising herbicides and incorporate with the use of tetrapion need a further screening and study. For a total weed control approach, working out a weeding program in a labor-saving system is essential to achive a sound silvicultural goal.

INTRODUCTION

Taiwan mainly belongs to a subtropical climate. However, southern Taiwan reflects an identical tropical nature. Due to the steeply inclined terrain, there are warm to cold temperate regions in the mountainous area. Forest occupying 52 percent of the total Taiwan land area consists of various forest types distributed over the changed climatic condition. Good part of the forest land especially in the cut-over area are dominated by the grass of Eulalia (*Miscanthus* sp.) and Yushan cane or arrow bamboo (*Yushania niitakayamensis*) which are very difficult to control by slashing. It is also an expensive operation when labors are used. The authors had done a series of research on weed control by tetrapion in the forest and their results are summarized and to be presented at this Conference. It hopes that such technical information can be useful to countries where a similar problem of weed control might occur.

GENERAL INFORMATION OF FRENOCK

Tetrapion of frenock, the trade name of 2,2,3,3-tetrafluoropionate sodium (TFP for short) is a herbicide belonging to halongenated aliphatic acid. It is a Japanese dveloped herbicide manufactured by Sankyo to be considered as a most unique herbicide to control the weed species in Graminea (1). Tetrapion is soluble in water, aceton, metanol and organic solutions. Formulation of granular type 10% ai is commonly used in Taiwan. The action mechanism of tetrapion is that the chemical mainly absorbed first by root and translocated into stem and foliage of the plant not very much through the foliage downward. It inhibits the function of enzyme in the process of metabolism. Takematsu et al. (9) note that the residual action of tetrapion in the soil lasts considerably long. However, it is subjected to leaching due to less soil adsorption capacity. The penetration of tetrapion to plants is found much through roots than foligae. Toxicity of tetrapion is very low and no irritating to the skin and eyes. The acute oral LD_{50} for female mouse is 9,800 mg/kg, and fish is 1,000 ppm up for carp TLM_{50}.

In Japan (11), sodium chlorate has been used extensively over many years as a major herbicide for weed control in forestry. It can kill the weeds effectively of a wide range of species and hardly to get resprouting after application for more than two years. Because of its effectiveness in weed control a problem of erosion could occur over the bare land when weed cover was removed. Therefore, ecologically it is not sound. On the other hand, tetrapion has the advantage of protecting soil by the suppressed weeds that cover the forest floor which even makes no harm to the growth of plantations. However, in Taiwan we (3) found that a succession of weed vegetation would result from grass to the broad-leaved weeds two years after the application of tetrapion. This was not true when sodium chlorate was applied.

Takematsu et al. (9) explains that tetrapion, in terms of the mode of action, is similar to DPA and TCA which also belong to aliphatics. Nevertheless, tetrapion is unique in its selectivity and noteworthy from the point that it provides as outstanding effect on Eulalia at far lower dosage as compared to DPA. In Japan, tetrapion has been confirmed to be a promising weedkiller applicable safely in the forestry owing to its extremely high selectivity in its herbicidal action. Dr. Takematsu had gone studies on tetrapion for various crops, his results reveals that tetrapion in soil is slightly lower than DPA, and it reaches downward by rain water in the soil and absorved by timber trees. Tetrapion is a compound stable in soil and plant, absorbed continuously and gradually revealing slow action.

APPLICATION OF TETRAPION IN FORESTRY

In Japan (1) the commonly used herbicide in forestry has been sodium chlorate. Tetrapion became the second major one in forest weed control after it was formulated and manufactured around 1970's. Due to its high selectivity compared to sodium chlorate to many grass species and low rate of dosage to be applied in the field, it has been extensively used to control forest weeds such as *Sasa* sp. and Eulalia for pre-emergence treatment prior to planting. Post-planting application of tetrapion can only done when plantations are two to three years old. According to Takematsu et al. (9), the selectivity of tetrapion among plants is Graminea > broad-leaved weeds, and the tolerance of forest trees is in the following order : Japanese cypress (*Chamaecyparis obtusa*) > Japanese cedar (*Cryptomeria japonica*) > pine (*Pinus* sp.). Tetrapion is typical in its action to cause growth stoppage leaving tubular leaves which are to be extended after germination as do DPA or TCA. Tetrapion exhibits good control against nutsedge (*Cyperus rotundus*). In Japan (11), the dosage of tetrapion application has been 30 kg/ha for 10% ai granular type. Residual effect on weeds was about three years.

Tetrapion was introduced to Taiwan little after 1970 by Sankyo on tetrapion trial in an acacia plantation obtained good control result of Eulalia. It was found that continued rain for three days after four of application caused no reduction of tetrapion effectiveness on weed control. A study conducted (10) compared five herbicides applied on a forest land dominated by Yushan cane and Eulalia in the higher altitude. The herbicides tested included TCA, DPA, sodium chlorate, Hyvar-x and tetrapion with three levels of dosage for each herbicide. The granular tetrapion showed no significant result on the control of weed possibly because the heavy litter and humus layer on the forest floor intercepted the herbicide from moving downward into the soil. However, a similar study revealed a different result. The authors (4) conducted a study on an alpine forest land covered mainly with Yushan cane and Eulalia.

Three major herbicides: sodium chlorate, tetrapion and DPA+2,4,5-T were applied. The result of this study showed that tetrapion as well as other herbicides tested were all good in weed control. However, the effectiveness of tetrapion was little slow than other two herbicide treatments. A low dosage of 40 kg/ha for tetrapion showed good control as well as high dosage of 60 kg/ha, but planted pines were injured by the high dosage treatment. The application of herbicide was done after the dense cover of weeds was mowed. This save the herbicide and encouraged the movement of tetrapion into the soil. In another study (5), both granular types of sodium chlorate (50% ai) and tetrapion (10% ai) were used with a rate of 50–150 kg/ha and 30–50 kg/ha respectively. Good control of Yushan cane was obtained from the moderate dosages of both herbicides. Tetrapion showed very good control on Yushan cane and Eulalia but not on broad-leaved weeds however, sodium chlorate was good on both groups of weeds. The effective period for the promised herbicides was about two years. A similar study (7) in a moderate high altitude forest where both grass and broad-leaved weeds were grown. The result showed that sodium chlorate (200–300 kg/ha) was good for both groups of weeds while tetrapion (40–60 kg/ha) was good only for grass and not very much for broad-leaved weeds. A shifiting of weed vegetation from grass to broad-leaved weed was found in the tetrapion plots. This caused another but different weed problem started about two years after application of tetrapion that need to be solved with other means of weed control. From an ecological study of Yushan cane (3) showed that nitrogen content in the rhizome of Yushan cane was lowest during July. So it was suggested that the best time for applying tetrapion would be July of the year when the growth of Yushan cane could be effectively suppressed by tetrapion. In that sudy, result revealed in the first year that the control of weed was not significantly different between dosages (30–50 kg/ha) applied. But in the second year, high dosage plots showed a better control of Yushan cane than the lower ones but more broad-leaved weeds such as *Rubus* sp. *Polygonum* sp. and *Digitaria* sp. were seen in the open spots resulted from the application of high dosage tetrapion.

TETRAPION AND LABOR–SAVING FORESTATION PROGRAM

Forestation is an labor-intensive work. It is especially true in Taiwan (6). Twenty years ago Taiwan had relatively cheap labors but it is not true after the rapid growth of industril development during the past fifteen years. Labors in the rural and mountainous area had been migrated into cities and worked in the factories. This resulted a shortage of labor force in the mountainous area where an extensive forestation program has been undertaken. Therefore, forestation implementation has been encountered problems on both short labor supply and high wages. To accomplish an economic forestation program it is essential to save labor and reduce the cost in all aspects of silvicultural works. Labor-saving approach (8) was developed especially because of the needs for weed control in the establishment of forest plantations. In fact, hand weeding has been a major practice of weed control in the past even up to the present. More than fifty percent of planting budget spent in the operation has been under the expenditure of weed control. Therefore, weed control based on labor-saving approach becomes a major concern in Taiwan forestry program. Direct labor-saving i.e. replaced labor with machinery and herbicides have intensively studied and implimented by the Council of Agriculture and Forestry Research Institute (6,8).

In Taiwan, weeding done by labor requires at least two to three times a year up to the fifth year after planting. Weeding with slasher has been a common practice in Taiwan forestry. Slasher weeding is not only a toilsome work but it is difficult to do on the steep terrain. The efficiency will be greatly reduced when slashing Yushan cane and Eulalia. Brush cutter has been replacing man-power on the gently slopes showed fairly good result in reducing the hardship of work and number of labor required up to one third (6). Because the plant tissue of Yushan cane and Eulalia are very hard and strong machine cut with brush cutter can be very effective to the lowest ground that slashing can not (4). However limitations are on the steep slopes or/and on planting site with a heavy rocks or slash accumulation of the forest floor that make difficult for the machine to operate. In order to solve this problem, steep slopes can be leveled up by constructing a transversal path, there a better use of either brush cutter or herbicide can be achieved (8). In the weed control program brush cutter and herbicides used either jointly or separatley have been considered as a good combination of labor-saving system.

Due to a high diversity of weed vegetation distributed in Taiwan forest, weed control with herbicides encountered a complicated and difficult problem to solve. Herbicides used for the last ten years has concentrated solely on tetrapion. Other promising herbicides tested mostly wettable power types are difficult to use in the mountainous forests. It is mainly because the difficulty of getting water to dilute the herbicide and weary of spraying. Therefore, research on the possible herbicides other than tetrapion would be still needed in order to control a diversified weed vegetation. In Taiwan, unless an economically feasible ways of labor-saving operation can be developed, forestation program will be very difficult to accomplish.

DISCUSSION

From the past research on tetrapion application in Taiwan forestry guide-line for a safe and economic use of this herbicide can be summarized as follows. It is advisable to use tetrapion for preparation of site dominated by Yushan cane and/or Eulalia prior to planting. Application of tetrapion after mowing the weeds is much preferable because it would help encourage a better control result and more herbidide can be saved. In order to avoid herbicidal pollution in the water supply system location of planting sites should be not close to the main streams. Tree planting can be carried out not less than three months after tetrapion application. When tetrapion to be used for weed control in the established conifer plantations, planted trees should exceed at least two years old. Hardwood tree species like acacia or ash seem more susceptible to tetrapion than conifers, cares must be taken when tetrapion is used.

Weed control with tetrapion has been economically and ecologically feasible in Taiwan forestation program because it has been proved to be very effective in the control of certain grass for at least two years and there is a significant reduction in weeding cost by using tetrapion. Takematsu et al. (9) also said that tetrapion was noteworthy and found rare among herbicides for upland paddy and forestry use. It plays an important role in labor-saving management for Japan forestry. According to Yamajima (11), 60 percent of body energy and 50 percent of the wage for weeding could be saved by the application of tetrapion compared to hand weeding.

In the tetrapion treated area a succession of weed vegetation from grass to broad-leaved weeds would always occur, this is the handicap of using tetrapion. It is to say that tetrapion alone can not control the weed problem completely. For a total weed control, tetrapion should be incorporated with other herbicide or/and means of weeding to attain the goal. Mechanical weeding with brush cutter still be necessary to include in weed control operation. For example, mowing the weeds before application to tetrapion is needed. Broad-leaved weeds can be recovered by using brush cutter two years after tetrapion application. For the convenience of doing weeding, construction of transversal path may be necessary on the steep slopes. Promising herbicidal trials should be continued to carry on and find out a better herbicide to use. A Japanese newly developed herbicide: HW–505 (zytron 30% + frenock 50%) should be introduced and worth testing. Because HW–505 has the possibility to kill grass, broad-leaved weed and some woody shrubs, that just what Taiwan really is needed in solving its forest weeding problems of highly diversified weed vegetation.

LITERATURE CITED

1. Kato, Yoshitada. 1982. Forest herbicides: Past, present and future, Ringyo Gijutsu No. 479 p 13-18, Japan Forest Tech. Accoc. (Japanese).
2. Kunho, J. K. and C. C. Yi. 1971. Report of Frenock trial. Taiwan Forestry Bureau, pp. 66 (In Chinese).
3. Kuo, Pao-chang and Ming-hsun Chang. 1984. Ecology and control of *Yushania niitakayamensis*, Quart. J. Chinese Forestry 17(1): 33-55. (Chinese, English summary).
4. Kuo, Pao-chang and Un-ching Rin. 1973. Chemical weeding studies on planting sites dominated by arrow bamboo and Miscanthus in Tashueshan forest District, J. Agri. Assoc. of China, New Series No. 83, p. 54-64, (Chinese, English summary).
5. Kuo, Pao-chang and Un-ching Rin. 1975. Control of arrow bamboo with Frenock and sodium chlorate, Tech. Bull. No. 116, Expt. Forest of Nat'l Taiwan Univ. p. 315-321 (Chinese, English summary).
6. Kuo, Pso-chang and Un-ching Rin. 1976. Labor-saving forestation, No. 1. Forestry series for developing and coordinating forestry, ministry of economic affairs pp. 58, (in Chinese).
7. Kuo, Pao-chang and Chung-yung Yu. 1976. Study on the effectiveness of herbicides on forest land dominated by *Yushania niitakayamensis* in Shan-ling-chi, Quar, J. Chinese Forestry, 9(2): 45-50, (Chinese, English summary).
8. Rin, Un-ching. 1977. Development of labor-saving silviculture in Taiwan, 3. Forestry No. 6. Expt. Forest, Nat'l Chung-hsing University, p. 34-43.
9. Takematsu, Tetsuo, Makoto Konnai and Yasutome Takeuchi. 1971. Fundamental study for RFP, a herbicide of aliphatic acid derivative. Bull. 8(1): 179-185, Coll. Agric. Utsunomiya Univ. Japan.
10. Wang, Tse-kuang and Pao-chang Kuo. 1972. The effects of herbicides on the control of arrow bamboo sites, Tech. Bull. No. 104 Expt. Forest, Nat'l Taiwan Univ. p. 20 (Chinese, English summary).
11. Yamajima, Kiichi 1974. Rational applicaton of herbicide: Frenock. Midori No. 6, p. 1-6 Japan (Japanese).

FIELD CHARACTERIZATION OF THE CONFUSED SPECIES *CRASSOCEPHALUM CREPIDIOIDES* AND *ERECTITES VALERIANIFOLIA* IN INDONESIA

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ABSTRACT

Crassocephalum crepidioides (Benth.) S. Moore (synonym *Gynura crepidioides* Benth.) and *Erectites valerianifolia* (Wolf) DC. are important weeds in tea plantation in Indonesia. Both species belong to family Asteraceae. *C crepidioides* was introduced to Indonesia from tropical Africa through Ceylon, currently estabished itself in Sumatra, Java and other part of Indonesia. *E. valerianifolia* was introduced accidentally with the coffee bean from Brazil. The two species are confused in Indonesia because they have the same local name and they are very similar. The distinguishing features of these two species are elaborated. The distribution of *C. crepidioides* and *E. valerianifolia* in Indonesia are also discussed.

INTRODUCTION

Crassocephalum crepidioides (Benth.) S. Moore (synonym *Gynura crepidioides* Benth.) and *Erectites valerianifolia* (Wolf) DC. are important weeds in Indonesian tea plantations. Tamarini (6) indicated that in West Java *C. crepidioides* is an important weed at the young tea plantations, which is having the density of 70.5 individuals/m^2 and the SDR (Some Dominance Ratio) is 17.50%.

Unfortunately the two species *C. crepidioides* and *E. valerianifolia* are confused, because they have the same local name. Moreover some handbooks (5) and pamphlets also confused these two species, the one species may found under the other's name and vice versa.

The aim of these study was to facilitate easy means to distinguish *C. crepidioides* and *E. valerianifolia* and to analyse their present distribution in Indonesia.

MATERIALS AND METHODS

The present study is based on examination of herbarium specimens of *C. crepidioides* and *E. valerianifolia* preserved in Herbarium Bogoriense (BO) and BIOTROP Herbarium (BIOT).

The distribution in Indonesia was recorded and all other information found on the labels was also noted.

RESULTS AND DISCUSSION

C. crepidioides

Origin *C. crepidioides* was firstly found in Indonesia at the area of Hedan (North Sumatera) in 1926 introduced from tropical Africa through Ceylon (1). In a letter from J. C. Vallete, Pematang Siatar, December 1932 to Dr. Spruit, Cinnyiruan Plantation, West Java in connection with the enquiry on the identification of this species. It was recorded that in 1927 the seed of *C. crepidioides* was sent from Pinang Ratus Plantation Pematang Siantar, North Sumatera to Ciater Plantation, West Java and the plant was grown there. The next year the seeds were sent to Sukanegara, Serang Sari and Cukul Plantations in West Java. In December 1930 it was sent to Gunung Mas Plantation, West Java, at the end of 1931 it was sent to Medini, Semarang, Central Java for the same purpose. In 1932 *C. crepidioides* can be found abundahtly at Kayu Enak Plantation, Lumajang, East Java.

After that it has been run several localities and become a common weed.

Habitat The plants can be found in agricultural field, river and roadsides, waste places, coffee, cinchona, tea and rubber plantation, volcanic soil.

Distribution The distribution of *C. crepidioides* in Indonesia is presented in Fig. 1. Nowadays it can be found in the islands of Sumatera, Kalimantan (Borneo), Sulawesi (Celebes), Bali, Sumbawa and part of Maluku (Holuccas) islands. It was found at the 16 provinces of Indonesia (Table 1).

Table 1. The distribution of *C. crepidioides* and *E. valerianifolia* in Indonesia based on specimens studies at the Herbarium Bogoriense and BIOTROP Herbarium.

Provinces		Species	
		C. crepidioides	*E. valerianifolia*
Sumatera	Aceh	+[1]	+
	North	+	+
	West	+	+
	Bengkulu	+	+
	South	+	+
	Lampung	+	+
	West	+	+
Java	Central	+	+
	East	+	+
Kalimantan	West	+	+
	Central	–	+
	East	+	–
	South	+	+
Sulawesi	South	+	+
	South East	–[2]	+
	Central	–	+
	North	–	–
Maluku	–	+	+
Nuse	West	+	+
Tenggara	East	+	+

[1] + present, [2] – absent

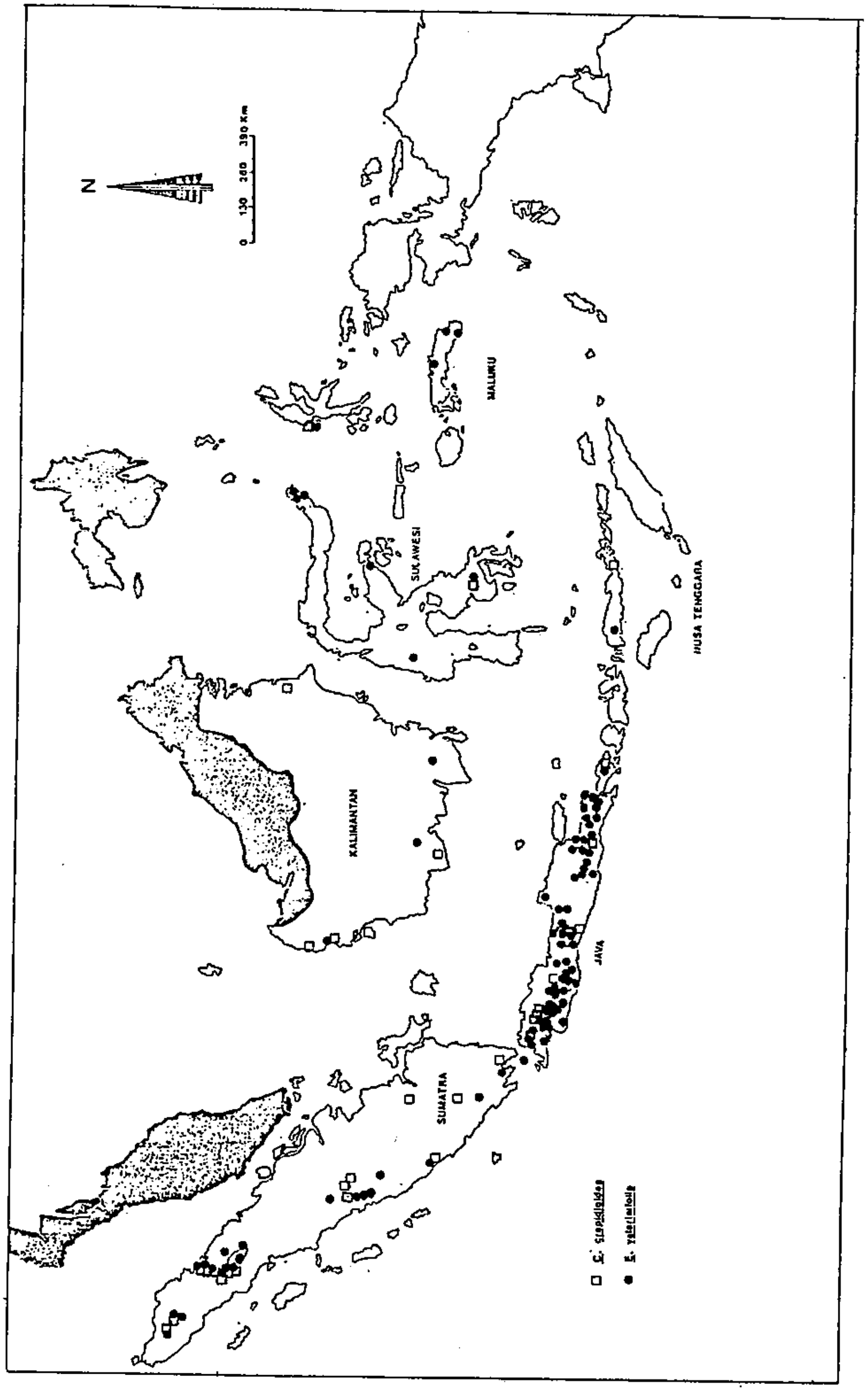

Fig. 1. Distribution of *C. crepidioides* and *E. valerianifolia* in Indonesia.

The specimens were found in an altitude varying from (15-200)-2500 m above sea level. Backer and van den Brink (2) reported that in Java it was found at the altitude between 250-1550 m above sea level. Henty and Prichard (3) reported that in Papua New Guinea *C. crepidioides* was found from low altitude to over 2500 m.

Local name In different localities, *C. crepidioides* has been referred to different local names (Table 2). In west Java it called as sontoloyo, sintrong and jukut jamalok. In central Java it calles as jewor.

The local name of sintrong in West Java for *C. crepidioides* is the same as the local name for *E. valerianifolia* which became the source of the confusion.

Utilization *C. crepidioides* are little utilized, although it was reported that it is used as vegetables and eaten by livestock (Backer, 1977).

Distinct characters Each plant of *C. crepidioides* in green house condition is able to produce 29 flowers with approximatily 4379 seeds (6). The seeds having papus of 10-11 mm long and very easily distributed by wind soon after its detached from the flower. It flowers all seasons of the year and the high productivity of the seeds make the plants spread very fast.

The difference of *C. crepidioides* can be seen from *E. valerianifolia* at the Table 3.

The leaves often irregularly pinnately lobed, the involucral bract green with dark brown. *C. crepidioides* having a bisexual flower and there is no ray flowers. The corolla is yellow and reddish brown at the top. The achenes are shorter than that of *E. valerianifolia.* Pappus having a silky white colour. The height of the plant can reach up to 1 m, shorter than *E. valerianifolia* which reach 2 m.

E. valerianifolia

Origin *E. valerianifolia* is native to tropical America and accidentally introduced in 1845 with coffee beans from Brazil. The oldest specimen of *E. valerianifolia* at the Herbarium Bogoriense dated 1891 from the collection of Koorders (21328).

Habitat The habitat of *E. valerianifolia* is the same with *C. crepidioides* which has been mentioned above.

Distribution There are approximately 180 herbarium specimens of *E. valerianifolia* if compared to 54 specimens of *C. crepidioides* in the Herbarium Bogoriense.

It can be found in the islands of Sumatera, Java, Kalimentan, Sulawesi, Bali, Sumbawa and part of Maluku. *E. valerianifolia* was found at 19 provinces in Indonesia (Fig. 1).

At present time it seems that the distribution of both species is still expanding due to the rapid spread of the plants.

The specimens were found in an altitude varying approximately from few-2500 m above sea level. Backer and van den Brink (2) reported that in Java, it was found at the altitude between (20-2200 m). Henty and Pritchard (3) reported that in Papue New Guinea *E. valerianifolia* was found at the altitude of 100-2000 m above sea level.

Local name *E. valerianifolia* has more local names than *C. crepidioides.* Both in Java and outside Java such as North Sulawesi, Aceh, North, West and South Sumatera (Table 2) people give it different name.

The various local name in Javanish i.e.: minjing, semoung giland, lingko, doblang, brobos, koroyono. In Sundanis it is called sintrong, sapaga, bolostrong and jalantir. In Madura it is called saladri and kemandin coco. In Sumatera it is called sawi hutan, sabi rendang, ambong-ambong, si kampong, sintrong and rumput lomook.

Table 2. Local names of *C. crepidioides* and *E. valerianifolia* based on specimen study at the Herbarium Bogoriense.

Species	Locality			Local name
	Islands	Province	Location	
C. crepidioides	Java	West Java	Rawa Gede, Cibodas	sontoloyo
			Arjuna, Papandayan	sintrong sumatra
			Lembang	sintrong
			Cikepuh	jukut jamalok
			Bogor	sintrong
		Central Java	Purwokerto	jewor
E. valerianifolia	Sulawesi	North Sulawesi	Pakuure, Lolumbulan, Manado	rukut intim
	Java	East Java	Pancur, Prajekan, Situbondo	minjing (Java) saladri (Madura)
		West Java	Gunung Malabar	sintrong
			Bogor	sintrong, sapaga
			Cinyiruan, Bandung	sintrong
			Cidadap, Cibeber	sintrong
			Rancawaleini, Gunung Patuha	sintrong
			Gunung Gede	bolostrong
			Tasikmalaya	jalantir

(Table 2, Continued)

	Central Java	Purwokerto, Banyumas	sembung gilang
		Dieng plateu, Banyumas	lingko
		Sepakung, Telomoyo,	
		Ambarawa, Semarang	doblang
Java	East Java	Tretes, Gunung Arjuna	Brobos
		Sempol, Kalijari,	
		Tangkil, Pasuruan	Koroyono
		Besuki	Kemandin coco (Madura)
Sumatera	Aceh	Gunung Teuetsagu	sawi hutan
	North Sumatera	Karang-karang, Kabanjahe	sabi rendang
	West Sumatera	Gunung Talang, Laras Talang	Ambong-ambong
		Gunung Malintang	Si Kampong
	South Sumatera	Ranau, Palembang	sintrong
		Kota Gadang, Kerinci	rumput lombok

Table 3. Differences between *C. crepidioides* and *E. valerianifolia* (2, 3).

	C. crepidioides	*E. valerianifolia*
Leaves	 Elleptic, oblong or obovate elleptic, often irregularly pinnately lobed or pinnatifid irregularly serrate 8 – 18 x 2.5 – 5 cm	 Oblong, pinnately lobed pinnati partite, sometimes with a large terminal lobed (lobes oblong or eleptic, very acutes, acutely dentate) 4 – 18 x 2.5 – 9 cm
Involucral bract	green with dark brown 8 – 12 mm	green 8 – 10 mm
Corolla	yellow with reddish brown top corolla disk flower 9 mm long	yellow with reddish violet top corrola marginal flower 7 mm long
Achenes	2 mm	3 mm
Pappus	silky white 10 – 12 mm	Upper half reddish violet, lower down white
Plant height	0.40 – 1.00 m	0.30 – 2.00 m

Utilization The utilization of *E. valerianifolia* is the same with *C. crepidioides* if can be used as vegetables and eaten by livestock.

Distinct characters The leaves of *E. valerianifolia* is different with *C. crepidioides.* It is pinnately lobed, pinnati partite, deeply cut leaves (Table 3). The involucral bract is green where as in *C. crepidioides* is green with dark brown. It is having marginal flowers and disk flowers, *C. crepidoides* is only having disk flowers. The marginal flower filiform and female, the disk flowers much broader and bisexual. The corolla is yellow with reddish violet colour at the top instead of reddish brown colour for *C. crepidioides.* The height of the plant can reach 2 m often much branched in the upper half.

CONCLUSION

The confusion between *C. crepidioides* and *E. valerianifolia* in Indonesia should be clarified. The leaves, involucral bract, flowers and the height of the plant can be differentiated, between the two species. Both species has been distributed widely in Indonesia and the distribution is still extending.

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LITERATURE CITED

1. Backer, C. A. 1939. The genera Gynure and Crassocephalum in Java. Mededeelingen van het Botanish Museum en Herbarium van de Rijks universiteit te Utrecht No. 58. Extrait de Recucil des Trovaux botaniques neerlandais. Vol. XXXVI.
2. Backer, C. A. and R. C. Bakhuizen van den Brink. 1965. Flora of Java. Vol. II. N. V. P. Noordhoff-Groningen, The Netherlands.
3. Henty and Pritchard. 1973. Needs of New Guinea and their control. Botany Bull. No. 7. Dep. Forests, Div. Botany, LAE. P. N. G.
4. Ochse, J. J. and R. C. Bakhuizen van den Brink. 1977. Vegetables of the Dutch East Indies. A. Asher & Co. B. V. - Amsterdam.
5. Soedarsan, A. Basuki, S. Wirjahardja and M. A. Rivai. 1983. Guidance in identification of some important weed species in plantation crops. Directorate General of Estate Crops, Dep. Agric., Jakarta, Indonesia.
6. Tamarini, E. 1987. Studies on the population of *C. crepidioides* at tea plantation West Java and its space occupation. Thesis, Bogor Agric. Univ. (In Indonesia).

A LABORATORY STUDY OF HERBICIDAL CONTROL OF *PHRAGMITES AUSTRALIS*

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ABSTRACT

The effect of herbicides and herbicide mixtures on *Phragmites australis* were assessed with the purpose of selecting a herbicide treatment for the control of that weed species in arable crops. Aminotriazole was found to be very effective for the control of *Phragmites* but its lack of selectivity limits its use to preplanting of the crop. Fluazifop-butyl (Fusilade) was very effective in controlling the weed and preventing regrowth, and was considered to be the most effective herbicide for post emergence control of *Phragmites australis* in soybean and cotton that we tested.

INTRODUCTION

Phragmites australis (Cav.) Trin. is one of the most widely distributed of weeds (1) and is characteristic of wet or badly drained soils. It is a major weed of cotton, wheat, sugar beet and maize in the Xinjiang province of north west China. This perennial grass weed is difficult to control because it has a vigorous growth habit and regenerates rapidly from rhizomes and rhizome fragments.

The herbicides used in this study were selected because they have been recommended for perennial grass weed control. Dalapon has been widely used for the control of many tropical grasses including the rhizomatous perennial *Imperata cylindrica* in Indonesia. Aminotriazol is recommended for the control of *Elymus repens* prior to sowing many crops in the UK (List of approved products and their uses for farmers and growers 1982), and asulam is used for the control of *Sorghum halepense* (Herbicide handbook of the weed science society of America). Fluazifop-butyl is a representative of the new generation of grass selective herbicides which have shown high levels of safety for broad leaved crops (2).

MATERIALS AND METHODS

Plants were grown from three node rhizome fragments collected in the south of England. The young plants were grown in 13 cm diameter pots in sandy loam soil in a greenhouse. When the plants were eleven weeks old and well established with at least three shoots per pot, they were cut back to five leaves per shoot. the plants were sprayed one week after cutting back.

Dalapon was supplied as Dowpon by Dow Chemical Co.; Asulox, formulated asulam, and Target, a mixture of asulam and dalapon, were supplied by May and Baker; Aminotriazol was supplied by A. H. Marks and Fluazifop-butyl, formulated as Fusilade, was supplied by ICI. The surfactant Agral 90 was added to all spray solution at a final concentration of 0.1%. All solutions were applied to the plants in a volume of 200 litres per hectare using a fan jet nozzle (LP 0280) at a pressure of 2 bar in a Mardrive spraying cabinet. Each herbicide and herbicide mixture was used at three rates based on the manufacturers recommended rates.

The plants were assessed visually for herbicide damage at 8, 15, 22 and 30 days after spraying using a 0 (no damage) to 100 (dead) scale. At 30 days the plants were visually assessed for the last time and then each shoot was measured to determine height above soil level. Finally the plants were cut at soil level, dried at 70°C and weighed to determine the dry weight. The rhizomes and other tissues remaining in the pots were grown on for a further 30 days and the number and length of new shoots measured.

RESULTS

Visual assessments at four intervals after herbicide application are given in Table 1. The most severe damage was caused by aminotriazol and its mixtures, followed by dalapon and Fusilade, with asulam the least effective. Damage caused by Fusilade was still increasing at 30 days but all the other treatments, including Fusilade mixtures, reached their maximum level of activity within 22 days. No further studies were made with Asulox and Target because they had so little effect.

The subjective visual assessments were confirmed by the dry weight measurements (Table 2) but the relative activities of the herbicides on plant height were reversed, with Fusilade the most active and aminotriazole less effective than dalapon, however much of the growth of aminotriazol treated plants was chlorotic (Table 3).

Aminotriazole at all three rates and Fusilade at the two highest rates were effective in preventing regrowth from the rhizomes (Table 4). None of the herbicide mixtures showed any advantages over the individual herbicides.

The herbicides were applied to cotton and soybean plants growing at the 4/5 leaf stage. All the aminotriazole and dalapon treatments at the lowest rates caused unacceptable damage but Fusilade, even at the highest rate, gave no visible damage. Aminotriazole caused no damage to germinating cotton seeds when applied seven days pre-sowing.

DISCUSSION AND CONCLUSION

For control of *Phragmites australis* in a non cropping or preplant situation, aminotriazol is the most effective herbicide. It has a rapid effect on the existing top growth and prevents subsequent regrowth. It is much more effective than dalapon but both these herbicides lack selectivity for cotton. Fusilade is slower to show its effect on *Phragmites,* the mature leaves apparently surviving for up to 30 days, but all the indications are that growth of new leaves stops rapidly after it is applied. Fusilade is particularly effective in stopping regrowth and is highly selective to cotton. The herbicide mixtures were disappointing and gave no apparent synergy, only the lowest rate of aminotriazole and Fusilade (0.5 + 0.125 kg/ha) may be worth further investigation as a possible way of reducing the cost of Fusilade and the phytotoxicity of aminotriazole while retaining good regrowth control.

Table 1. The effect of herbicides on *Phragmites australis.*

Herbicide	Rate kg ai/ha	Percentage damage[1] days after treatment 8	15	22	30
	1.0	63	77	80	73
Aminotriazole	2.0	73	80	87	77
	4.0	73	87	90	90
	1.2	0	10	10	10
Asulox	2.4	10	10	10	10
	3.6	10	10	13	13
	2.55	20	20	20	20
Dalapon	5.1	47	53	43	37
	7.6	53	53	50	50
	0.25	0	10	10	10
Fusilade	0.5	5	13	30	30
	1.0	5	20	30	40
Aminotriazole	0.5 + 1.275	63	70	73	63
+	1.0 + 2.55	70	83	87	83
Dalapon	2.0 + 3.825	67	73	80	77
Aminotriazole	0.5 + 0.125	57	63	60	43
+	1.0 + 0.25	73	77	77	73
Fusilade	2.0 + 0.5	77	80	87	83
Dalapon	1.275 + 0.125	3	10	20	17
+	2.550 + 0.25	17	17	40	30
Fusilade	3.825 + 0.5	30	40	47	43
	1.27	0	3	7	10
Target	2.54	20	27	33	33
	5.08	27	30	37	37

[1] Data are visual assessments and are means of three replications.

Table 2. The effect of different herbicides on the dry weight of *Phragmites austrialis* after 30 days.

Herbicide	Rate kg ai/ha	Percentage dry weight[1]	Standard error
Aminotriazole	1.0	24.2	3.1
	2.0	21.7	4.2
	4.0	18.3	0.8
Dalapon	2.55	65.5	16.6
	5.1	38.8	5.2
	7.6	39.8	4.6
Fusilade	0.25	95.3	18.2
	0.5	51.4	7.4
	1.0	59.2	11.6
Aminotriazole + Dalapon	0.5 + 1.275	29.4	5.4
	1.0 + 2.55	19.2	2.3
	2.0 + 3.825	24.7	3.6
Aminotriazole + Fusilade	0.5 + 0.125	39.7	5.8
	1.0 + 0.25	32.2	4.6
	2.0 + 0.5	35.9	2.2
Dalapon + Fusilade	1.275 + 0.125	92.8	6.3
	2.550 + 0.25	57.9	8.9
	3.825 + 0.5	40.5	2.4
Untreated		100.0	14.4

[1] Data are the dry weights of plants at the end of the herbicide treatment and are the mean of three replicates.

Table 3. The effect of different herbicides on the height increase of *Phragmites australis* after 30 days.

Herbicide	Rate kg ai/ha	Percentage increase[1]	Standard error
Aminotriazole	1.0	19.2	8.6
	2.0	14.7	6.1
	4.0	18.4	3.3
Dalapon	2.55	27.7	5.9
	5.1	12.1	5.2
	7.6	17.6	2.3
Fusilade	0.25	5.5	1.4
	0.5	3.7	0.1
	1.0	2.5	0.9
Aminotriazole + Dalapon	0.5 + 1.275	34.0	6.1
	1.0 + 2.55	12.4	4.9
	2.0 + 3.825	10.7	1.3
Aminotriazole + Fusilade	0.5 + 0.125	3.8	3.5
	1.0 + 0.25	1.8	1.4
	2.0 + 0.5	5.7	1.7
Dalapon + Fusilade	1.275 + 0.125	4.7	1.4
	2.550 + 0.25	4.7	1.7
	3.825 + 0.5	5.4	1.2
Untreated		76.3	9.6

[1] Data are the difference in height during the 30 days following herbicide treatment and are the mean of three replicates.

Table 4. The regrowth of *Phragmites australis* two months after herbicide treatment[1].

Herbicide	Rate kg ai/ha	Number of shoots	S. E.	Height of shoot	S. E.
Aminotriazole	1.0	0	0	0	0
	2.0	1.7	1.7	4.2	4.2
	4.0	0	0	0	0
Dalapon	2.55	25.3	9.2	18.7	5.8
	5.1	4.3	2.2	10.7	8.1
	7.65	2.3	1.5	2.9	2.4
Fusilade	0.25	15.0	5.3	43.2	4.2
	0.5	0	0	0	0
	1.0	0	0	0	0
Aminotriazole + Dalapon	0.5 + 1.275	5.0	1.5	6.2	0.6
	1.0 + 2.55	1.7	1.2	2.6	1.5
	2.0 + 3.825	0	0	0	0
Aminotriazole + Fusilade	0.5 + 0.125	3.3	0.9	10.4	2.1
	1.0 + 0.25	3.0	0.6	6.6	2.4
	2.0 + 0.5	3.0	1.7	5.7	3.2
Dalapon + Fusilade	1.275 + 0.125	19.7	3.3	34.7	9.5
	2.550 + 0.25	13.0	5.6	15.3	8.1
	3.825 + 0.5	0	0	0	0
Untreated		12.3	1.2	41.3	7.1

[1] Data are the mean of three replicates. Height is from soil surface to the top of the longest shoot.

LITERATURE CITED

1. Holm, L. G., D. L. Plucknett, J. V. Pancho and J. P. Herberger. 1977. The worlds worst weeds.
2. Plowman, R. E., W. C. Stonebridge and J. N. Hawtree. 1980. Fluazifop-butyl, a new selective herbicide for control of annual and perennial grass weeds. British Crop Prot. Conf. Weeds 17: 29-37.

WEED CONTROL IN RICE – SOYBEAN ROTATION

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ABSTRACT

Glasshouse studies showed that *Echinochloa crus-galli, Leptochloa chinensis, Echinochloa colona, Jussaea linifolia; Fimbristylis miliacea* and *Cyperus difformis* growing with rice were controlled by 0.75kg/ha oxadiazon (3-(2,4-dichloro-5-isopropoxy phenyl)-5-t-butyl-1,3,4-oxadiazolin-2-one) and by 0.20 kg/ha oxyfluorfen (2-chloro-4-trifluoromethylphyl 3-ethoxy-4-nitropyl ether). *Jussaea linifolia, Cyperus difformis* and *Fimbristylis miliacea* were controlled by 2,4-D (2,4-dichlorophenoxy acetic acid)/ 0.75kg/ha in rice with slight injury to the rice but no harm to soybean planted 30 days after herbicide application. In soybean, excellent control of *Echinochloa crus-galli, Leptochloa chinensis, Echinochloa colona,* and good control of *Digitaria adscendens, Dactyloctenium aegyptium,* and *Eleusine indica* were obtained from 0.25 kg/ha fluazifop-butyl (butyl 2-[4-(5-trifluoromethyl-2-pyridyloxy) phenoxy] propionate) and very good control of *Amaranthus spinosus* and *Jussaea linifolia* was obtained with 0.25 kg/ha fomesafen (2, chloro-4-trifluoromethylphenyl 3-methyl phenoxy carbamoyl-4-nitrophenyl ether). There was no injury to the soybean crop, nor to the rice planted 30 days after the soybean herbicides application. In the subsequent field studies, 0.75kg/ha of 2,4-D, 0.75kg/ha of oxadiazon and 0.20kg/ha of oxyfluorfen were applied 10 days after planting pre-germinated rice under 10 cm water depth. Oxyfluorfen and oxadiazon showed very promising control of most of the weeds except *Monochoria vaginalis* with slight injury to the rice. These treatments gave maximum yield of up to 4.01 and 3.93 t/ha respectively. 2,4-D did control *Monochoria vaginalis* but gave no control of grassy weeds. The yield of 2,4-D treated rice was 3.85 t/ha compared with 2.80 t/ha for the untreated control. When soybean were planted directly into the rice stubble as no-tillage, 0.25 kg fluazifop-butyl, 0.25 kg fomesafen and 0.25kg fluazifop-butyl + 0.125 kg fomesafen/ha were sprayed at the 2-trifoliate leaf stage of soybean. Fluazifop-butyl was very promising for *Echinochloa crus-galli, Echinochloa colona, Leptochloa chinensis* and *Eragrostis interrupta;* fomesafen for *Bergia ammannioides* and *Ammania baccifera* and fluazifop-butyl + fomesafen for most of the weeds. The herbicides oxadiazon and oxyfluorfen that had been applied to the rice crop continued to give some weed control in the succeeding soybean crop.

INTRODUCTION

Weeds are a problem in rice production (12, 17). Growing conditions encourage year round growth of weeds which caused 34, 45, and 67% yield reduction in transplanted rice, direct-seeded rice and upland rice respectively (11). Direct seeded rice is becoming increasingly attractive as the cost of labour rises (11). Herbicides offer the most practical, effective and economical way of reducing weed competition, crop losses and production losses (11). 2,4-D, bentazon, oxadiazon and oxyfluorfen are used widely to control weeds in rice (1, 5, 11, 21, 26). Crop rotation in which a broad leaved crop is grown alternately with rice is believed to be another means of reducing yield losses by weeds (17).

Soybean is emerging as a valuable crop in South East Asia (19). Many of the weeds that are the main problems in soybean (15, 18) are different from those of wet land rice because the two crops are grown under different conditions of soil moisture. Soybean can be grown successfully as a crop after rice in many parts of the world (10, 16, 22, 24, 25). In cropping systems where two crops are grown in close succession the effect of weed control on a particular crop is usually more pronounced when weed control in the previous crop is poor than when it is good (8, 13). Weeds in the dry season crop were reduced, namely *Eleusine indica* (L.) Gaertn, *Digiitaria sanguinalis* (L.) Scop., *Amaranthus spinosus* (L.) and *Cyperus rotundus* (L.) were the most reduced and *Echinochloa colona* (L.) and *Portulaca* (L.) were moderately reduced when they were grown after wet land rice (13). Smith and Fran (23) reported that rice rotated with soybean in a 2 year cycle was free of *Echinochloa crus-galli* (L.) Beauv., *Oryza* spp. and *Cyperus iria* (L.) when grown on land heavily infested with these weeds after 10 years of continuous rice growing. Similar results were with *Scirpus maritimus* (L.) when upland crops were rotated with wet land rice. Herbicide control of weeds in soybean has been demonstrated with fluazifop-butyl for grass weeds (2, 20) and with fomesafen (14) for broadleaved weeds, both applied post-emergence to the soybean.

The selection of herbicides in rice as the first crop must be restricted to those not toxic to the later soybean crop. Oxadiazon and oxyfluorfen can be used safely in both crops and have long persistence in the soil (3, 7). 2,4-D is harmful to soybean (6) but is degraded before soybean is planted. Trials were set up to evaluate herbicides for a wetland rice, dryland soybean cropping system. Attention was also given to methods of planting the soybean rapidly after harvesting the rice to take advantage of residual water in the soil.

MATERIALS AND METHODS

Glasshouse studies Rice seeds and 6 species of weeds, *Echinochloa crus-galli* (L.) Beauv., *Leptochloa chinensis* (Linn.), *Echinochloa colona* (L.) Link., *Jussaea linifolia* Vahl., *Fimbristylis miliacea* (L.) Vahl. and *Cyperus difformis* Linn. were planted together in 10cm diameter plastic pots containing John Innes compost no. 1 and placed in a trough to maintain a 2cm depth of water above the soil level. All this work was done in a glasshouse at Imperial College at Silwood Park with a temperature between 12-30°C and the humidity usually above 60%. The photoperiod was a minimum of 14 hours maintained by a combination of natural daylight and 400-watt mercury vapour lamps. The herbicides 2,4-D (2,4-dichlophenoxy acetic acid), bentazon (3-isopropyl 1H-2, 1, 3-benzothia, zin-4-(3H)-one 2, 2-dioxide), oxadiazon (3-(2,4-dichloro-5-isopropoxyphenyl)-5-t-butyl-1, 3,4-oxadizolin-2-one) and oxyfluorfen (2,-chloro-4-trifluoromethylphenyl 3-ethoxy-4-nitrophenyl ether) were applied at two rates as a solution in a volume of 5 ml per pot at 10 days after emergence of the rice. The experiment was designed as a randomized complete block with 3 blocks and 3 replications. Assessments of weed control and rice toxicity were at 15 days after herbicide application using the EWRC scoring method. Rice plants and escaped weeds were harvested 30 days after herbicide application, the water was drained and seeds of soybean and 8 species of weeds, namely *Leptochloa chinensis* (L.) Nees, *Echinochloa crus-galli* (L.)

Beauv., *Echinochloa colona* (L.) Link., *Digitaria adscendens* (HBK) Henr., *Eleusine indica* Gaertn., *Dactyloctenium aegyptium* (L.) P. Beauv., *Amaranthus spinosus* Linn. and *Jussaea linifolia* Vahl. were planted. The germination of soybean and weed control were assessed 15 days after planting.

In a second series of trials soybean seeds cv SJ 5 were planted in pots with the same eight species of weeds used in the rice experiment and thinned to 10 plants per pot. When the soybean plants were at the 2-trifoliate leaf stage, fluazifop-butyl (butyl 2-[4-(5-trifluoromethyl-2-pyrilyloxy) phenoxy] propionate) or fomesafen (2,-chloro-4-trifluoromethyl 3-methylphenoxycarbamoyl-4-nitrophenyl ether) was applied at four rates, 0.125, 0.250, 0.500 and 0.750 kg/ha. A Mardrive sprayer cabinet was used to apply the herbicides in a volume equivalent to 300 l/ha. The experiment was designed as a randomized complete block with 3 blocks and 3 replications. Weed control and soybean toxicity were assessed 15 days after herbicide application. Soybean plants and escaped weeds species were harvested 30 days after herbicide application and rice seeds and 6 species of paddy weeds were planted into the soil. The germination of rice seeds and the grade of weed control were then assessed 15 days after planting.

Field studies Rice seeds were soaked in water for 1 day and then transferred to a moist sack for two days. The pre-germinated seeds were broadcast in a well prepared muddy soil at the rate of 75 kg/ha. Ten days after planting, the paddy was flooded to a 5-10 cm depth of water and the selected herbicides, 2,4-D, oxadiazon, and oxyfluorfen, were applied at the rates of 0.750, 0.750 and 0.20 kg/ha respectively by mixing with sand as a carrier and spreading over the plots by hand. Hand weeding was included for comparison as well as an untreated control. The experiment was designed as 4 x 5 factorial, plot size 3m x 8m with 4 replications. Kind and dry weight of weeds, number of panicle/sq.m and yield were recorded. After harvest, soybean seeds were immediately planted at a spacing of 25cm x 5cm and 5 seeds/hill which were later thinned to 3 plants per hill. When the soybean plants were at the 2-trifoliate leaf stage, fluazifop-butyl, fomesafen and fluazifop-butyl + fomesafen were sprayed by knapsack sprayer at the rates of 0.250, 0.250 and 0.250 + 0.125 kg/ha respectively. Kind and dry weight of weeds and yield of soybean were assessed. These field studies were conducted at Chainst Rice Experiment Station, Rice Research Institute, Department of Agriculture, Thailand.

RESULTS AND DISCUSSION

Glasshouse experiments Weed control was assessed 15 days after application of herbicides in rice by counting the number of weeds that survived (Table 1), oxadiazon was the most promising herbicide, giving 100% control of all the treated weeds. Oxyfluorfen was also promising and give 100% control of all the weeds except *Fimbristylis miliacea.* 2,4-D gave good control of *Cyperus difformis, Fimbristylis miliacea* and *Jussaea linifolia* while bentazon showed little effect on the grassy weeds but gave fair control of *Cyperus difformis* and *Jussaea linifolia.* Oxadiazon tended to be very toxic to rice at 15 days, especially at the rate of 1.0 kg/ha, which confirms the results from Amoral and Gomez (4), but there was a high recovery at the later stage. Oxyfluorfen was also toxic to rice particularly at the high rate of 0.40 kg/ha which was similar to the results of Singh and Blandari (21). 2,4-D also tended to be toxic to rice at the higher rate.

Rice plants and surviving weeds were all harvested at 30 days after planting, then soybean and 8 species of weeds were sown. The number of weeds and soybean plants were recorded 15 days after

Table 1. Number of escaped weeds (percentage of control) and rice toxicity, at 15 days after herbicides application[1].

No Herbicide	Rate kg/ha	E. cr	E. co.	L. ch.	C. dif.	F. mil.	J. li	R. T.
1. Bentazon	1.00	9.22 ± 1.56 (6.73)	7.11 ± 2.09 (11.1)	9.11 ± 1.05 (25.6)	8.89 ± 2.20 (57.49)	2.33 ± 1.00 (31.02)	4.00 ± 2.45 (68.56)	1.00
2. Bentazon	2.00	8.11 ± 1.27 (11.1)	6.11 ± 1.20 (23.6)	7.44 ± 2.24 (25.6)	6.67 ± 2.50 (57.49)	3.00 ± 1.41 (31.02)	3.11 ± 1.27 (68.56)	1.0
3. Oxadiazon	0.75	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	1.8
4. Oxadiazon	1.00	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	2.2
5. 2,4-D	0.75	8.11 ± 1.96 (11.1)	4.78 ± 4.02 (40.4)	6.55 ± 3.75 (34.5)	0 (100)	0 (100)	0 (100)	1.1
6. 2,4-D	1.00	8.00 ± 1.67 (19.2)	5.00 ± 2.50 (27.5)	5.44 ± 4.10 (45.6)	0 (100)	0 (100)	0 (100)	1.7
7. Oxyfluorfen	0.20	0 (100)	0 (100)	0 (100)	0 (100)	1.44 0.89 (75.11)	0 (100)	1.2
8. Oxyfluorfen	0.40	0 (100)	0 (100)	0 (100)	0 (100)	2.11 1.05 (78.18)	0 (100)	2.2
9. Untereated check	–	9.74 ± 0.44 .	8.00 ± 2.45	10.00 ± 1.00	15.33 ± 1.94	9.67 ± 1.22	9.89 ± 1.27	1.0
L.s.d. 0.05		1.53	1.78	1.65	1.60	0.78	1.45	
0.01		2.05	2.37	2.31	2.15	1.03	1.93	

[1] E. cr. = *Echinochloa crus-galli*, E. co. = *Echinocloa colona*, L. ch. = *Leptochloa chinensis*, C. dif. = *Cyperus difformis*, F. mil. = *Fimbristylis miliacea*, J. li. = *Jussaea linifolia* and R.T. = rice toxicity by EWRC.

planting, the number of soybean tended to be nearly the same as the untreated control (Table 2). The number of weeds in pots previously treated with oxadiazon and oxyfluorfen were reduced, confirming the data of Ambrosi (3) who found that oxadiazon had a long persistence in the soil. 2,4-D and bentazon showed no significant effect on weeds in the soybean crop.

In the soybean herbicides trial, fluazifop-butyl and fomesafen were used at 0.125 0.250 0.500 and 0.750 kg/ha. Promising grassy weeds control was obtained from fluazifop-butyl (Table 3), *Echinochloa crus-galli* and *Echinochloa colona* being especially well controlled. There was, however, good control of the grassy weeds *Leptochloa chinensis, Eleusine indica, Dactyloctenium aegyptium* and *Digitaria adscendens* at 0.125 kg/ha but better control at the higher rates (Table 3). Fomesafen showed control of *Amaranthus spinosus* and *Jussaea linifolia* at the rates of 0.250-0.750 kg/ha but there was no control of grassy weeds. None of the rates of fluazifop-butyl and fomesafen caused toxicity to soybean at 21 days after planting. When rice and weeds were planted after harvesting the soybean and weeds, the number of rice plants and paddy weeds were assessed 15 days after planting and tended to be the same as in the untreated control. There was also little effect on weeds that were grown after soybean (Table 4).

Field studies In the first crop of the field trial, kind and dry weight of weeds were sampled 2x25 sq.m. each treatment at 50 days after planting; most of the grasses, broadleaved weeds and sedges (Table 5) were almost absent from treated oxadiazon and oxyfluorfen (Fig. 1), this confirmed the work that had been done in the glasshouse and by others (9, 21, 26). 2,4-D controlled sedges and broadleaved weeds effectively but not grasses and fern (Fig. 1). For rice yield in terms of filled grain, oxadiazon gave more effective control than other herbicides and had a higher number of panicle/sq.m. (Fig. 2), but the rice plants were stunted when the heights of the plants at harvesting were assessed (Fig. 2). Oxadiazon gave the same final yield as oxyfluorfen and 2,4-D.

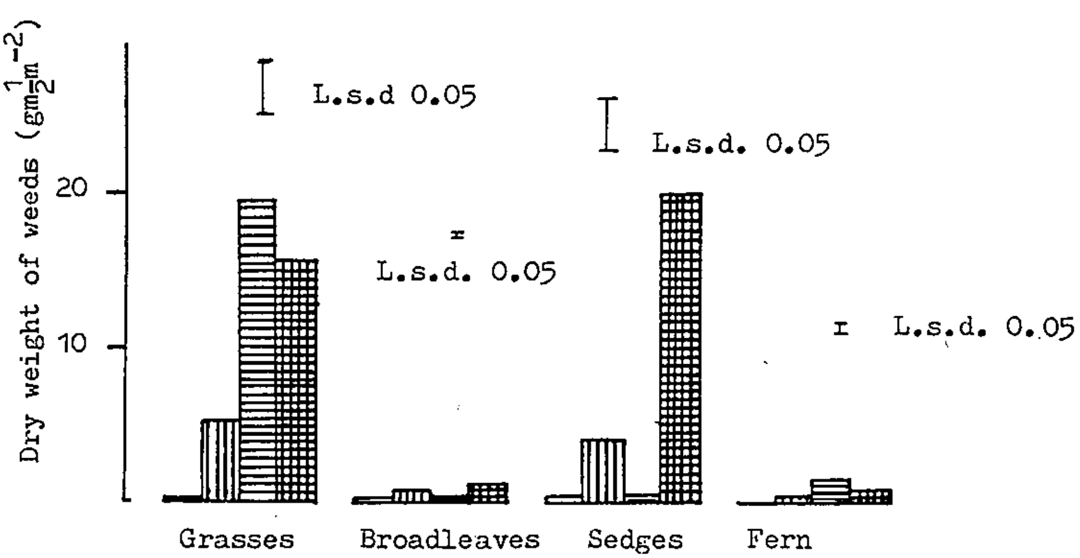

Fig. 1. Dry weight of weeds in rice at 50 days after seeding.

Table 2. Number of weeds and soybean 15 days after seeding in pots in which rice was grown.[1].

No Herbicide	Rate kg/ha	E. cr.	E. co.	L. ch.	E. in.	Da. a.	Di. a.	A. s.	J. li.	Soybean
1. Bentazon	1.00	8.22	8.78	7.78	9.78	9.00	9.67	5.11	9.56	4.33
		± 3.38	± 1.86	± 4.32	± 1.85	± 3.46	± 1.22	± 0.78	± 1.89	± 0.50
		(19.57)	(3.74)	(28.59)	(12.07)	(22.89)	(0)	(16.37)	(8.53)	(90.78)
2. Bentazon	2.00	9.33	9.11	8.89	10.67	9.89	7.56	5.44	9.67	4.67
		± 1.00	± 1.45	± 2.31	± 1.01	± 1.61	± 4.44	± 1.01	± 1.41	± 0.50
		(8.71)	(0)	(18.38)	(4.06)	(4.36)	(11.85)	(10.97)	(7.38)	(97.70)
3. Oxadiazon	0.75	1.10	0	0	0	0	0	±11.44	± 1.11	± 4.78
		± 0.92						1.23	0.79	0.44
		(89.24)	(100)	(100)	(100)	(100)	(100)	(76.44)	(89.37)	(100)
4. Oxadiazon	1.00	1.78	0	0	0	0	0	0	0	± 4.55
		± 0.67								0.52
		(82.68)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(95.39)
5. 2,4-D	0.75	8.44	8.89	9.56	11.11	9.33	6.58	4.11	9.56	4.44
		± 1.94	± 1.36	± 3.74	± 1.05	± 1.11	± 2.49	± 2.57	± 0.89	± 0.72
		(17.42)	(2.42)	(12.22)	(0)	(9.69)	(32.20)	(32.74)	(8.43)	(93.08)
6. 2,4-D	1.00	8.44	7.22	8.11	10.67	9.22	8.22	5.55	10.44	3.89
		± 2.40	± 2.54	± 2.80	± 1.00	± 2.90	± 1.85	± 1.13	± 1.33	± 0.78
		(17.42)	(20.75)	(25.46)	(4.06)	(10.75)	(10.91)	(9.17)	(0)	(81.34)
7. Oxyfluorfen	0.20	4.00	11.11	1.78	1.22	0	4.33	0	1.33	4.67
		± 1.22	± 0.78	± 1.48	± 1.20		± 1.87		± 0.71	± 0.50
		(60.86)	(87.82)	(83.73)	(89.02)	(100)	(55.18)	(100)	(87.26)	(97.70)
8. Oxyfluorfen	0.40	0.67	0	2.00	0	0	0	0	0	4.78
		± 0.50		± 1.73						0.44
		(93.45)	(100	(71.62)	(100)	(100)	(100)	(100)	(100)	(100)
9. Untreated check	–	10.22	9.11	10.89	11.11	10.33	9.67	6.11	10.44	4.78
		± 1.20	± 1.54	± 1.05	± 1.05	± 1.41	± 1.87	± 1.61	± 1.01	± 0.44
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
L.s.d. 0.05		1.89	1.68	2.19	1.41	1.83	1.78	1.40	1.43	1.08
0.01		2.53	2.24	2.93	1.89	2.44	2.38	1.87	1.91	1.44

[1] E. cr. = *Echinochloa crus-galli*, E. co. = *Echinochloa colona*, L. ch. = *Leptochloa chinensis*, E. i. = *Eleusine indica*, Da. a. = *Dactyloctenium aegyptium*, Di. a = *Digitaria adscendens*, A. s. = *Amaranthus spinosus*, J. li. = *Jussaea linifolia*.

Table 3. Number of weeds and soybean toxicity at 21 days after herbicide application in soybean[1].

No Herbicide	Rate kg/ha	E. cr.	E. co.	L. ch.	E. in.	Da. a.	Di. a.	A. s.	J. li.	Soybean toxicity
1. Fluazifop-butyl	0.125	0 (100)	1.67 ±0.71 (83.40)	5.00 ±1.58 (50.00)	6.00 ±1.22 (40.00)	4.44 ±1.74 (55.63)	4.78 ±2.38 (52.30)	10 (0)	10 (0)	1.00
2. Fluazifop-butyl	0.250	0 (100)	1.22 ±0.44 (87.80)	1.78 ±1.09 (82.30)	0 (100)	2.67 ±1.92 (73.40)	0 (100)	10 (0)	10 (0)	1.00
3. Fluazifop-butyl	0.500	0 (100)	0 (100)	0 (100)	0 (100)	2.22 ±1.39 (77.80)	0 (100)	10 (0)	10 (0)	1.00
4. Fluazifop-butyl	0.750	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	10 (0)	10 (0)	1.00
5. Formesafen	0.125	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	4.89 ±1.05 (51.20)	6.44 ±1.94 (35.60)	1.00
6. Formesafen	0.250	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	1.89 ±0.92 (81.20)	2.2 ±0.97 (78.00)	1.00
7. Formesafen	0.500	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	1.11 ±0.60 (88.90)	2.44 ±1.01 (75.60)	1.00
8. Formesafen	0.750	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	0 (100	1.56 ±0.72 (84.60)	1.00
9. Untreated check	–	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	10 (0)	
L.s.d. 0.05		–	0.78	1.10	0.91	1.48	1.17	0.90	1.28	
0.01		–	1.03	1.47	1.22	1.98	1.57	1.20	1.71	

1 E. cr. = *Echinochloa crus-galli*, E. co. = *Echinochloa colona*, L. ch. = *Leptochloa chinensis*, E. in = *Eleusine indica*, Da. a = *Dactyloctenium aegyptium*, Di. a = *Digitaria adscendens*, A. s. = *Amaranthus spinosus*, J. li. = *Jussaea linifolia*.

Table 4. Number of weeds and rice grown as followed soybean at 15 days after seeding.[1]

No Herbicide	Rate kg/ha	E. cr.	E. co.	L. ch.	C. dif.	F. mil.	J. li.	Rice
1. Fluazifop-butyl	0.125	9.33 ± 1.00 (5.67)[2]	8.89 ± 1.45 (7.02)	8.78 ± 1.09 (11.32)	11.78 ± 1.20 (0.03)	10.00 ± 1.12 (9.09)	9.67 ± 2.24 (12.09)	4.11 ± 0.93 (92.56)
2. Fluazifop-butyl	0.250	9.00 ± 1.22 (0.00)	9.56 ± 1.13 (2.58)	9.78 ± 1.09 (1.21)	11.22 ± 1.30 (5.56)	10.55 ± 1.24 (4.09)	9.33 ± 1.09 (15.18)	4.11 ± 0.78 (92.56)
3. Fluazifop-butyl	0.500	9.89 ± 1.16 (0)	8.56 ± 1.51 (10.48)	9.22 ± 1.56 (6.78)	10.44 ± 1.67 (12.12)	10.56 ± 2.01 (4.09)	10.00 ± 1.12 (9.09)	4.04 ± 0.73 (100)
4. Fluazifop-butyl	0.750	9.33 ± 1.32 (5.67)	9.11 ± 1.05 (4.61)	9.33 ± 1.22 (5.67)	11.11 ± 1.27 (6.48)	10.00 ± 1.67 (9.09)	10.33 ± 1.00 (6.09)	4.22 ± 0.67 (95.04)
5. Formesfen	0.125	9.33 ± 0.50 (5.67)	9.11 ± 1.26 (4.61)	9.33 ± 1.67 (5.67)	10.44 ± 1.74 (12.12)	9.56 ± 1.67 (13.18)	10.67 ± 1.73 (3.09)	4.33 ± 0.53 (97.52)
6. Formesafen	0.250	9.89 ± 1.54 (0)	8.89 ± 1.36 (6.91)	9.22 ± 1.20 (6.78)	10.78 ± 1.30 (9.34)	9.33 ± 1.67 (5.18)	10.56 ± 2.01 (4.09)	4.22 ± 0.85 (95.04)
7. Formesafen	0.500	9.11 ± 1.96 (7.89)	9.33 ± 1.22 (3.30)	9.56 ± 1.33 (3.34)	10.89 ± 1.27 (8.33)	9.56 ± 1.01 (13.18)	9.67 ± 1.73 (12.18)	4.00 ± 0.87 (90.09)
8. Formesafen	0.750	8.78 ± 1.20 (13.320	8.78 ± 0.97 (8.06)	9.22 ± 1.79 (6.78)	10.78 ± 2.37 (9.34)	9.22 ± 1.48 (6.18)	9.78 ± 1.39 (11.18)	4.11 ± 0.60 (92.56)
9. Untreated	–	9.89 ± 1.26 (0)	9.56 ± 0.89 (0)	9.89 ± 1.05 (0)	11.89 ± 1.36 (0)	11.00 ± 1.11 (0)	11.00 ± 1.32 (0)	4.44 ± 0.52 100)
L.s.d. 0.05		1.63	1.62	1.75	1.75	1.78	1.78	1.26
0.01		2.18	2.16	2.35	2.35	2.37	2.39	1.69

[1] E. cr = *Echinochloa crus-galli*, E. co = *Echinochloa colona*, L. ch. = *Leptochloa chinensis*, C. dif. = *Cyperus difformis*, F. mil. = *Fimbristylis miliacea*, J. li. = *Jussaea linifolia*.

[2] Letters in bracket for weeds as percentage of control when compared with untreated check and for rice as percentage of germination of control.

Table 5. Weed composition in field-grown rice.

Type of weeds	Weed species
Grasses	*Echinochloa crus-galli* L. Beauv.
	Echinochloa colona (L.) Link
	Leptochloa chinensis (L.) Nees
Broadleaves	*Sphenoclea zeylanica* Gaertn.
	Monochoria vaginalis Burm. Z. Presl.
	Lindernia anagallis Burm. f. Pennell
	Jussaea linifolia Vahl.
	Rotala indica (Willd.) Koehne
	Ammania baccifera L.
Sedges	*Cyperus difformis* L.
	Cyperus pulcherrimus Willd. ex Kunth
	Fimbristylis miliacea (L.) Vahl.
	Scirpus juncoides Roxb.
Fern	*Marsilea crenata* Presl.

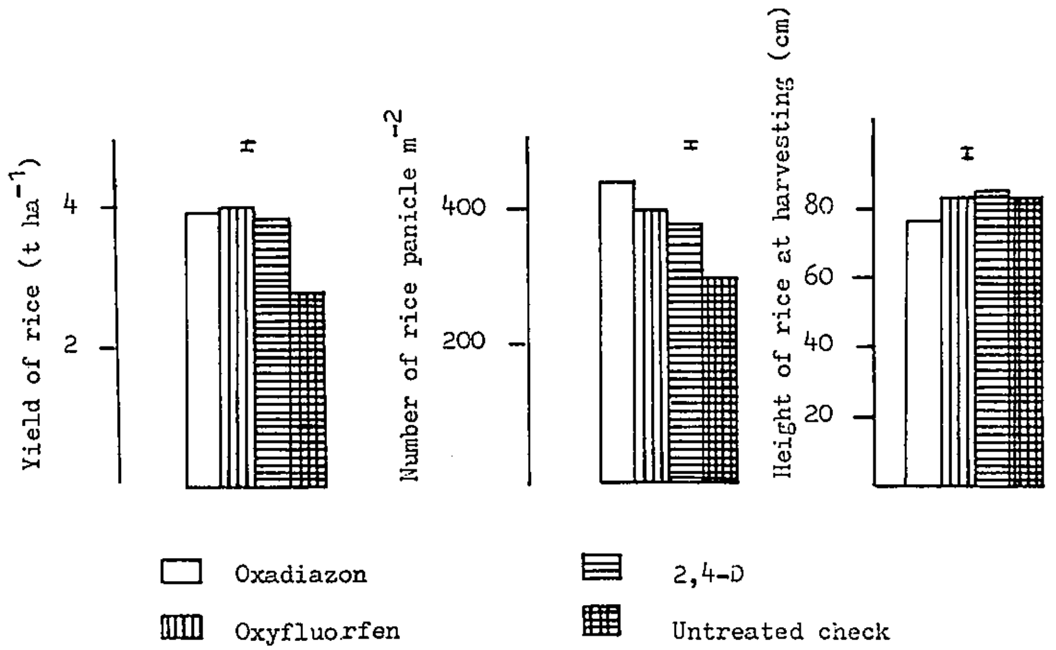

Fig. 2. Yield, number of panicle m^{-2} and height of rice.

After the rice had been harvested, soybean was immediately planted in the rice hill straw without any tillage. Twenty-five days later fluazifop-butyl, fomesafen and fluazifop-butyl + fomesafen were sprayed. Kind and dry weight of weeds were checked at the flowering stage of weeds (55 days after planting). Fluazifop-butyl did control the grasses *Echinochloa crus-galli, Echinochloa colona, Eragrostis interupta, Leptochloa chinensis* and *Dactyloctenium aegyptium* (Table 6) which was the same as the results from the glasshouse work and confirmed the work of Plowman et al. (20) but did not have any effect on volunteer rice, broadleaved weeds and fern (Table 6). Fomesafen effectively controlled the broadleaved weeds *Bergia ammannioides, Jussaea linifolia* and *Heliotropium indicum* (Table 6) when compared with the untreated check (Fig. 3). Fluazifop-butyl + fomesafen showed the same control of grassy weeds but gave better control of broadleaved weeds, sedges and fern (Fig. 3) and tended to give a higher yield than fluazifop-butyl (Fig. 5).

Herbicides applied to the rice crop had a residual effect on the succeeding soybean crop. All weeds but especially the broadleaved species and sedges were reduced by previous treatments with oxadiazon and oxyfluorfen (Fig. 4) which supported the work that had been done in the glasshouse. The trend for grassy weeds was the same as with broadleaved and sedges (Fig. 4) but not for ferns. Oxadiazon and oxyfluorfen applied to rice gave higher yields of soybean than the untreated checks (Fig. 6). From these results it is concluded that previous herbicide treatments can have an effect on the weed population and yield in a subsequent soybean crop.

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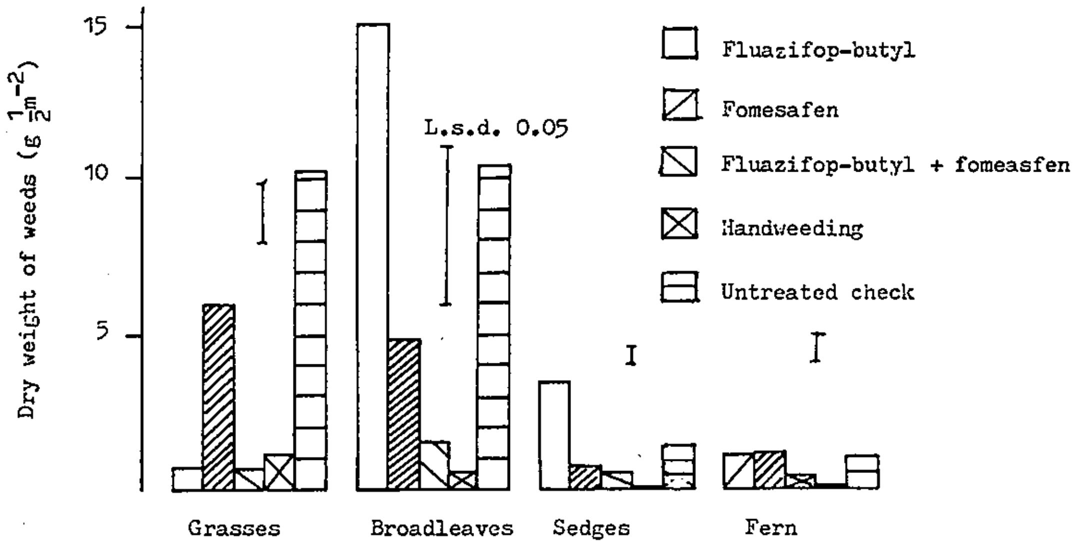

Fig. 3. Dry weight of weeds in soybean at 55 days after seeding.

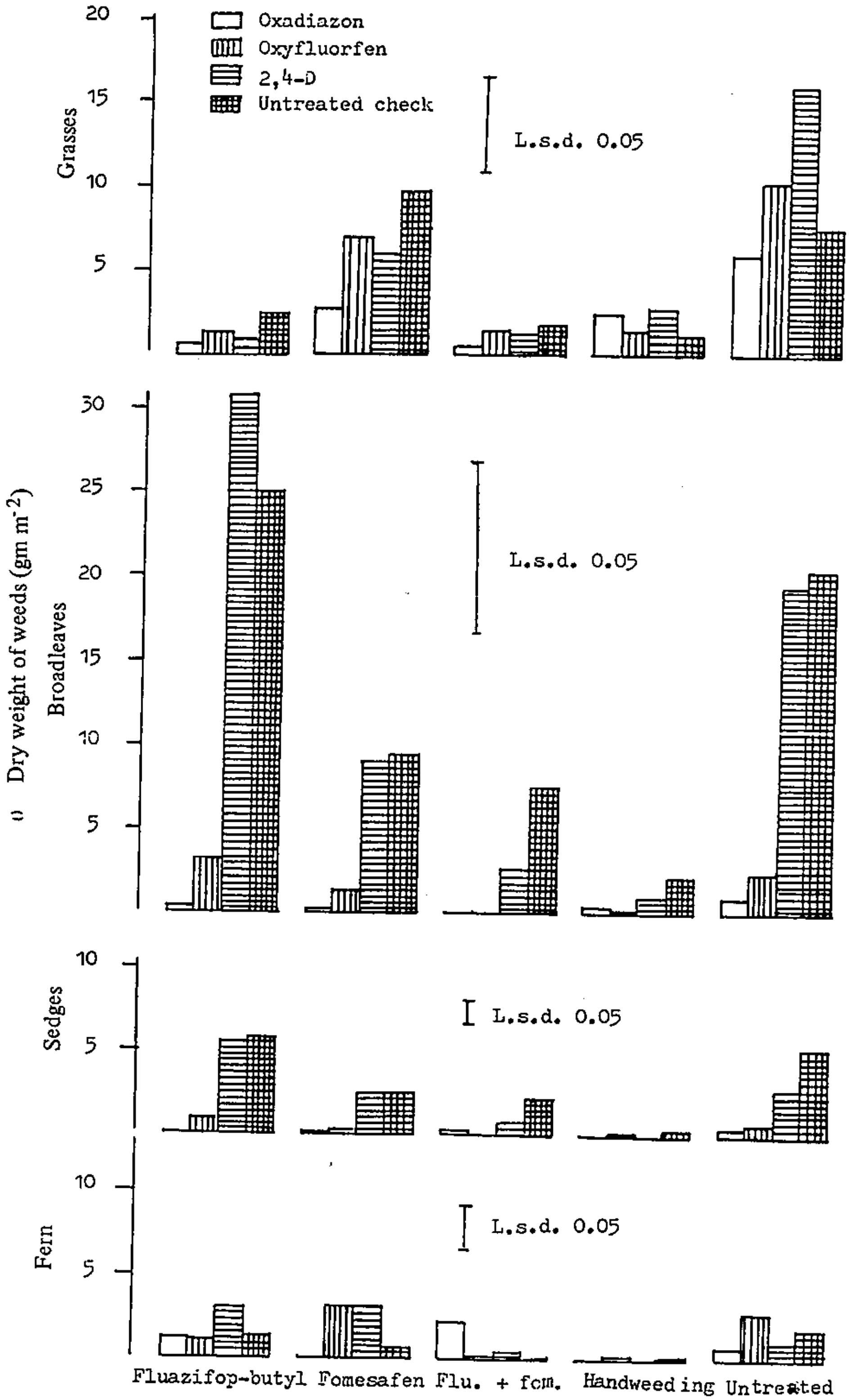

Fig. 4. Dry weight of weeds in soybean at 55 days after seeding.

Table 6. Weed composition in field-grown soybean.

Type of weeds	Weed species
Grasses	Rice *Echinochloa crus-galli* L. Beauv. *Echinochloa colona* (L.) Link *Eragrostis interupta* (Lam.) Doell. *Leptochloa chinensis* Nees *Dactyloctenium aegyptium* (L.) P. Beauv. *Cynodon dactylon* (L. L. Rich) Pers.
Broadleaves	*Bergia ammannioides* Roxb. *Jussaea linifolia* Vahl. *Heliotropium indicum* L. *Spaeranthus africanus* L.
Sedges	*Cyperus pulcherrimus* Willd. ex Kunth *Fimbristylis miliacea* (L.) Vahl. *Cyperus kyllingia* Endl.
Fern	*Marsilea crenata* Presl.

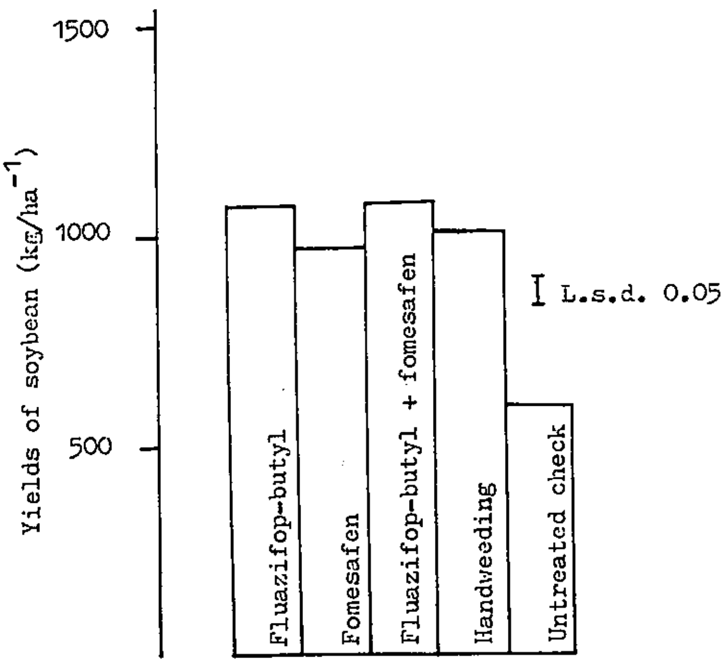

Fig. 5. Yields of soybean from treated herbicides.

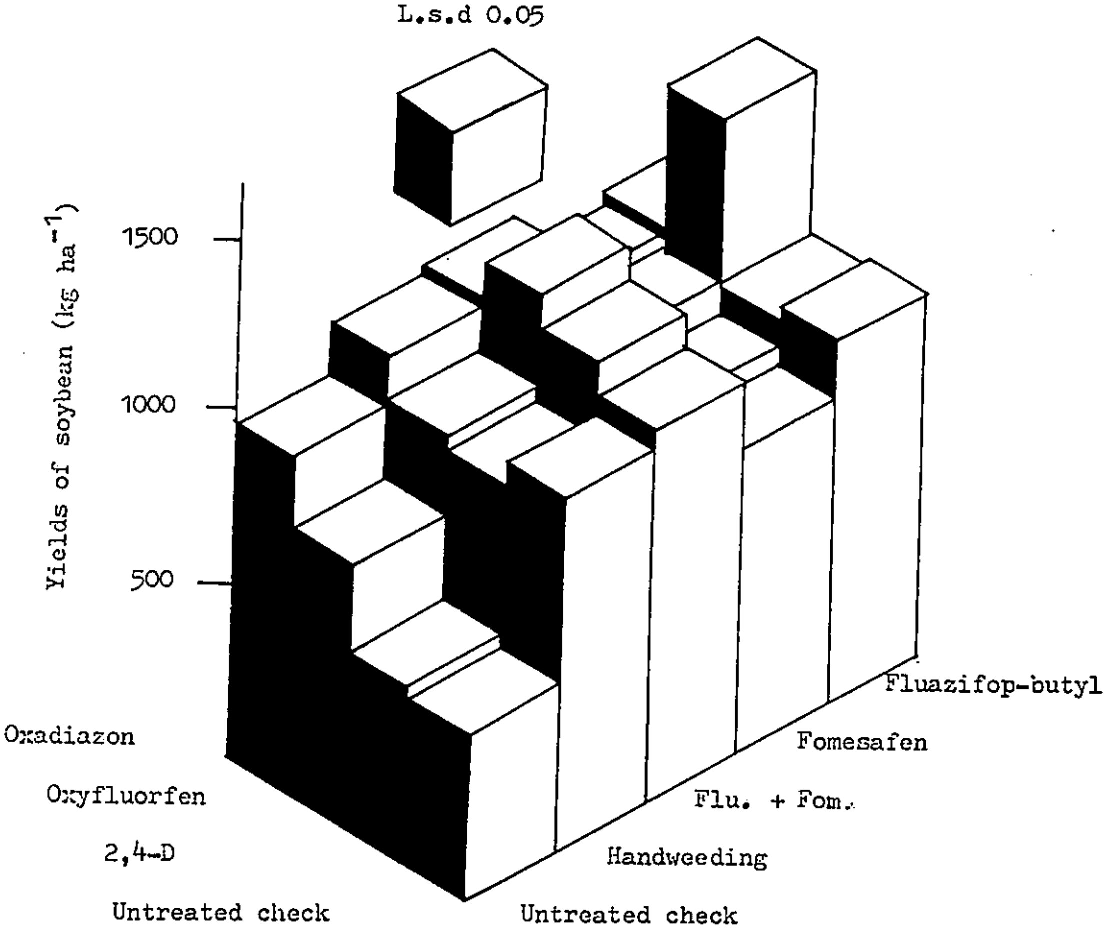

Fig. 6. Yields of treated soybean as a followed crop of rice which previously herbicides application was made.

LITERATURE CITED

1. Akobundu, I. O. 1981. Weed control in direct-seeded lowland rice under poor water control conditions. Weed Res. 21: 273-278.
2. Almedia, F. S., V. F. Oliveria and J. M. Filho 1983. Selective control of grass weeds in soybean with some recently developed post-emergence herbicides. Trop. Pest Management 29: 261-266.
3. Ambrosi, D., P. C. Kearney and J. A. Macchia. 1977. Persistence and metabolism of oxadiazon in soils. J. Agric. Chem. 25: 868-872.
4. Amoral, A. S. and A. S. Gomez. 1982. Effects of soil type and herbicides on the emergence of rice

seedlings. Abstracts of the XIV Brazilian Congress on herbicides and herbaceous weeds. VI Cong. Latin American Weed Assoc. (ACAM), Campinas.

5. Anderson, R. N., W. E. Lueschen, D. D. Warnes and W. W. Nelson 1974. Controlling broadleaf weeds in soybeans with bentazon in Minnesota. Weed Sci. 22: 136-142.
6. Barker, M. A., L. Thompson Jr. and R. P. Patterson. 1984. Effect of 2,4-D on soybean (*Glycine max).* Weed Sci. 32: 299-233.
7. Biroli, C., S. Kodirah and B. Croci. 1980. A new versatile selective herbicide. Proc. British Crop Prot. Conf. Weeds 165-172.
8. Burnside, O. C. and D. R. Carlson. 1983. Weed control in a lowtill (*Avena sativa)*-soybean (*Glycine max*) rotation. Weed Sci. 31: 853-856.
9. Chang, W. L. 1973. Chemical weed control practice for rice in Taiwan. PANS 19: 514-522.
10. Cheng, C. P. 1977. Soybean production in multiple cropping systems. ASPAC Ext. Bull. 86, 17p.
11. De Datta, S. K. 1986. Principles and practices of rice production. John Wiley and Sons. 618pp.
12. Grist, D. H. 1965. Rice. Longman. 548pp.
13. Harwood, R. R. and R. T. Batilan. 1974. Integrated weed management II. Shifts in composition of the weed community in intensive cropping systems. Phillipp. Weed Sci. Bull. 1: 37-39.
14. Kitchen, L. M., B. J. Hook and J. L. Godley. 1984. A comparison of soybean overtop broadleaf herbicides in Louisiana (Abstract). Proc. Southern Weed Sci. Soc. 37th annual meeting Champain, Illinois, USA, 77-78.
15. Knake, E. L. and F. W. Slife. 1962. Competition of *Setaria faberrii* with corn and soybeans. Weeds 10: 26-27.
16. Moody, K. 1976. Weed control in Asian soybeans. Expanding use of soybeans, International Soybean Programme 10: 69-73.
17. Moody, K. 1977. Weed control in rice. Lecture prepared for the participants attending the Fifth Biotrop Weed Sci. Training Course at the Rubber Res. Inst. of Malaysia, Kuala Lumpur, Malaysia, 14 Nov. to 13 Dec. 1973, 44p.
18. Nangju, D., H. C. Wien and B. Ndimande. 1980. Improved practices for soya bean seed production in the tropics. Seed Production, Proc. Nottingham Easter School in Agric. Sci. Sutton Bonington, London, Butterworths, 427-448.
19. Norman, A. G. 1978. Soybean physiology agronomy and utilization. Academic Press, New York, San Francisco, London.
20. Plowmann, R. E., W. C. Stonebridge and J. N. Hawtree. 1980. Fluazifop-butyl a new selective herbicide for the control of annual and perennial grass weeds. Proc. British Crop Prot. Conf. Weeds 17: 29-37.
21. Singh, O. P. and R. K. Bhandari. 1985. Relative efficiency of different herbicides in transplanted rice. Indian J. Weed Sci. 17, 47-49.
22. Seetisarn, M. 1977. Farm and aggregate-level description of multiple cropping. Symposium on Cropping systems Res. and Development for the Asian Rice Farmer, IRRI, Los Banos, Philippines, 139-150.
23. Smith, R. J. Jr. and R. E. Frans. 1968. Herbicide management in rice and soybean rotation, Southern Weed Sci. Soc. Abstract, 21.

24. Somatmadja, S. and O. O. Hidajat. 1979. Status, production potential and agro-genecological consideration of soybean improvement in Indonesia. Abstract of World Soybean Conf., Westview Press, 124p.
25. Thiam, T. B. 1979. Prospects for soybeans in South East Asia, Abstract of World Soybean Conf., Westview Press. 124p.
26. Tiwari, J. P., C. R. Bisen. and K. K. Trivedi. 1985. Herbicides to control weeds in paddy nursery. Abstracts Annual Conf. of Indian Soc. of Weed Sci.

WEED MANAGEMENT IN UPLAND RICE MONO–CROPPING SYSTEM

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ABSTRACT

Field experiments were conducted at the research farm of Banaras Hindu University, during the monsoon seasons of 1984 and 1985 to study the comparative efficiency of thiobencarb as pre-emergence alone and its combination with post-emergence treatments of herbicide, manual and mechanical weeding on weed growth and rice grain yield. In general, combined methods of weed control were more effective in respect to weed control and enhancing rice yield than their separate application. Thiobencarb as pre-emergence 1.5 kg ai/ha followed by one hand weeding at 20 days was more effective in controlling weeds growth and increasing grain yield than that of thiobencarb alone and its combination with mechanical weeding (20 DAS), and 2,4-D 1.0 kg ai/ha (20 DAS) and mechanical weeding twice (15 and 30 DAS). *Echinochloa* spp was predominant weed flora of experimental field and its population was relatively less during sceond year in the treatments which had better control of this weed during first year. Sedges population increased in succeeding year, however, broad leaved weeds population, remained almost constant during the experimental period, irrespective of treatments.

INTRODUCTION

In eastern part of India, rice under rainfed upland conditions is the major crop of summer monsoon season. But due to short period of rainy season (about 100 days) farmers are able to harvest only one crop of rice in a year as residual moisture left after harvest of rice is not adequate to meet the demand of next season crops. Under the situation, rice is followed after rice as mono-cropping system. In cropping system the effect of weed control in the previous crop is poor than when it is good. Good weed control reduces weed seed reserves (3). Growing the same crop of dryseeded rice continuously on the same piece of land tends to increase the particular group of weeds (1). Moody (5) reported that weed problems increases in mono-cropping system when the same crop and the same control practices are used over years. On contrary, various weed management practices applied over time eliminate troublesome grasses and sedges with low level of inputs (3). Herbicides controlled weeds more effectively than did cultural practices (2).

Most of the weed control researches on upland rice has been done on a single crop of rice. No doubt results from these studies are quite useful and have been applied successfully to some extent. But in actual practice farmers grow the rice crop year after year in the same piece of land and employed weeding and cultural practices over time. Since the weed population is affected by these practices, therefore, weed control researches should be done of the whole cropping system rather than on a single crop in isolation in order to have more meaningful and applicable results.

In this paper an effort has been made to determine the effect of continuous use of some cultural, herbicidal and combined methods of weed control on weed growth and rice grain yield.

MATERIALS AND METHODS

Field experiments were conducted during summer monsoon seasons of 1984 and 1985 at the research farm of Banaras Hindu University, Varanasi, India. The soil was sandy clay loam having pH 7.4, organic C 0.38%, available P 16 kg/ha and available K 178 kg/ha. The experiment was laid out in a randomized block design and replicated thrice. The first crop of rice was sown on July 13, 1984. The second season crop of rice was sown on July 7, 1985 in the same lay out and at the same place.

The rice cultivar Akahsi was used as test variety which is short duration (90–100 days) and recommended for upland rainfed conditions. Recommended dose of N.P.K. at the rate of 90, 18 and 25 kg/ha were applied in the form of urea, single super phosphate and potassium chloride, respectively. Rice was seeded at 100 kg/ha in rows 30 cm apart.

The weed control treatments in rice were on weeding, two hand weeding (20 & 40 DAS), thiobencarb (S-(4-chlorobenzyl) N,N-diethylthiocarbamate) 1.5 kg/ha preemergence alone, thiobencarb 1.5 kg as pre-emergence followed by one hand weeding (20 DAS), thiobencarb 1.5 kg preemergence followed by one mechanical weeding (20 DAS), thiobencarb 1.5 kg preemergence followed by 2,4-D (2,4-Dichlorophenoxy acetic acid (sodium salt) 1.0 kg/ha (20 DAS), and mechanical weedings (15 and 30 DAS). Rain falls received during the cropping season, July, August, September and October in 1984 were 206.2, 292.5, 247.6 and 14.6 mm, and in 1985 were 449.7, 285, 95.3 and 23.6 mm, respectively.

Weed samples were collected from 0.25 m^2 quadrats/plot 70 days after sowing, separated into grasses, sedges and broad leaved weeds, dried in hot air oven at 80°C for 36 hours and weighed.

Yield attributes were recorded only of 1985. Grain yield (at 14% moisture) was recorded from the net plots and converted into kg/ha.

RESULTS AND DISCUSSION

The abundant weed species in experimental area were: *Echinochloa colona* (L.) Link, *E. crusgalli* (L.) Beauv, *Cynodon dactylon* (L.C. Rich) Pers., *Eleusine indica* (L.) Gaestn, *Cyperus rotundus* L., *Cyperus iria* L., *Fimbristylis milliaceae* (L.) Vahl., *Amaranthus viridis* L., *Phyllanthus niruri* L., *Ammania baccifera* (L.), *Commelina benghalensis* L., *Eclipta alba* (L.), Hassak., *Euphorbia hirta* L., and *Corchorus aculangulus* Lam.

Table 1 shows that *Echinochloa* spp. was the most abundant weed species in experimental field. The maximum reduction of this weed was in two hand weedings and thiobencarb + one hand weeding. Treatments, thiobencarb alone and thiobencarb with 2,4-D or one mechanical weeding reduced the *Echinochloa* spp. more in comparison to two mechanical weedings, but their effectivity was poor in comparison to thiobencarb + one hand weeding treatment. Amongst weeding treatments two mechanical weeding had maximum number of this weed species. Further, *Echinochloa* spp. population was lower in second year as compared to first year in all the treatments. The results closely agree with the findings of Horwood (3) who reported that in cropping system the effect of weed control in a particular crop is more pronounced when weed control in the previous crop is poor than when it is good and good weed control reduces weed seed reserves.

Table 1. Effect of continuous use of same weeding treatment on population of grassy, sedges and broadleaved weeds (70 DAS).

	Grassy (m^{-2})				Sedges (m^{-2})		Broad leaved (m^{-2})	
	Echinochloa spp.		Other grassy weeds					
	1984	1985	1984	1985	1984	1985	1984	1985
Weedy check	382	297	132	179	179	267	101	118
Two hand weedings	65	46	12	18	26	37	9	15
Thiobencarb	213	144	56	73	37	91	39	41
Thiobencarb + One hand weeding	111	57	26	25	35	49	33	34
Thiobencarb + One mechanical weeding	208	136	52	61	33	75	34	35
Thiobencarb + 2,4-D	201	119	28	39	32	65	32	27
Two mechanical weedings	233	161	69	81	40	65	52	43
(P = 0.05)	12	15	6	5	8	10	7	4

The population of other grassy weeds and sedges were significantly lowered down under varying weeding treatments over unweeded control, but their population increased from first year to second year, irrespective of treatment. The maximum sedges population was in weedy check and followed by thiobencarb alone application. Result confirms the finding of Richard (6) and Singh (7). The result also indicated that although thiobencarb was effective against sedges and grassy weeds, but it could not provide season long weed control as compared to combine methods of weed control treatments. It might be due to short period of persistence effect of thiobencarb.

Results on broad leaved weed population indicate that different weeding regimes significantly reduced these weeds, and maximum reduction was observed in two hand weedings and minimum in two mechanical weedings. No marked variation was obtained from first year to second year in this group of weeds under any of the treatments. Thus, it indicated that herbicide alone or with combination of other herbicide or mechanical weeding did not give any carryover effect on broad leaved weeds.

A significant difference was observed in total weed population and weed dry weight under different weed control treatments, lowest being in two hand weedings and highest in weedy check (Table 2). combined methods of weed control had maximum reduction than repeated mechanical weeding and thiobencarb alone application. It was also observed that total weed population and dry weight of weeds were lower in second year than first year except weedy check. It is because of carry over effect of weeding treatments. In upland rice, an application of combination of herbicides followed in 3 or 4 WK by hand or hoe weeding gave satisfactory weed control in several countries (1).

Yield and yield attributes of rice varied among different weeding treatments. The maximum grain yield 2790 and 3290 kg/ha was recorded in two hand weeding and minimum grain yield 1380 and 1960 kg/ha in weedy check during 1984 and 1985, respectively (Table 2). Two hand weedings and grain yield at par with combined application of thiobencarb + one hand weeding and significantly more than other treatments. In chemical and cultural treatments, thiobencarb application with one hand weeding produced grain yield 2680 and 3160 kg/ha in first and second year, respectively, which was significantly more than the plots treated with thiobencarb alone and two mechanical weedings during both the years, and with the combined application of weed control methods, thiobencarb + 2,4-D and thiobencarb + one mechanical weeding during first year only. Results closely related with the findings of De Datta (1) who reported that a hand weeding followed by herbicide application not only gave satisfactory weed control but also high grain yield.

Results also indicated that grain yield was higher in second year than first year of experiment.Better grain yields under the treatments were the effect low weed population and weed dry weight (Tables 1 and 2), and higher yield attributing characters (Table 3). The combined methods of weed control did not vary with each other in second year, while there was significant variation amongst them in first year. This was probably due to fact that firstly, weed seeds left by the treatments in previous season crop was not so much which could give rise to weed population and weed dry weight to bring the treatment differences at significant level and secondly, even less effective treatments showed more effectiveness during second year than that of first year as it might have carried residual effect of first year. Merlier (4) also reported that best weed control in rice is obtained with regular/sequential application of herbicide or herbicide mixture. Application of various weed management over time also eliminate troublesome grasses and sedges (3).

Table 2. Effect of continuous use of same weeding treatment on total weed population, weed dry weight (70 DAS) and grain yield.

	Weed population (m^{-2})		Weed dry weight (gm^{-2})		Grain yield (kg/ha)	
	1984	1985	1984	1985	1984	1985
Weed check	794	860	302	317	1380	1960
Two hand weedings	112	116	56	47	2790	3290
Thiobencarb	345	349	155	124	2280	2750
Thiobencarb + One hand weeding	205	165	69	53	2680	3160
Thiobencarb + One mechanical weeding	327	307	145	89	2340	2880
Thiobencarb + 2, 4–D	293	248	146	101	2420	2860
Two mechanical weedings	394	350	173	125	2330	2770
(P = 0.05)	24	28	18	16	180	370

Table 3. Effect of continuous use of same weeding treatment on yield and yield attributes (1985).

	Number of effective tillers (m^{-2})	Number of non-effective tillers (m^{-2})	Filled grains/ panicle (No)	Unfilled grains/ panicle (No)	Length of the panicle (cm)	1000 grain weight (g)
Weedy check	66.00	10.75	25.80	9.55	13.94	20.75
Two hand weedings	206.50	3.15	60.25	6.12	18.04	25.50
Thiobencarb	177.00	6.50	46.20	5.50	16.04	23.00
Thiobencarb + One hand Weeding	213.75	4.25	51.25	6.56	17.35	24.75
Thiobencarb + One mechanical weeding	181.00	6.00	43.52	5.60	16.24	23.25
Thiobencarb + 2, 4–D	192.50	5.57	50.57	6.02	17.03	23.75
Two mechanical weedings	160.00	6.75	36.65	5.10	15.84	22.13
(P = 0.05)	5.19	0.62	1.87	0.44	0.19	0.47

LITERATURE CITED

1. De Datta, S. K., K. Moody and S. Sankaran. 1986. *In* Progress in upland rice research. Int. Rice Res. Inst. Los Banos Philippines. Pages 447-460.
2. Dowler, C.C., E.W. Hauser and A. W. Johnson. 1974. Crop herbicide sequences on a Southern Coastal Plain Soil. Weed Sci. 21: 500-505.
3. Harwood, R. R. and R. T. Bantilan. 1974. Integrated weed management. II. Shifts in composition of the weed community in intensive cropping systems. Philippine Weed Sci. Bull. 1(2): 37-59.
4. Merlier, H. 1983. Weed control research in dryland rice in the lvory Coast, Pages 139-146 in Weed control in rice. Int. Rice Res. Inst., Los Banos, Philippines.
5. Moody, K. 1982. Weed control in dryland crops after rice. Report of a workshop on cropping system in Asia. Pages 75-84, Int. Rice Res. Inst. Los Banos, Philippines.
6. Richard, E.P. Jr., T.C. Miller and D.H. Bowman. 1982. Control of barnyard grass in rice with thiobencarb. Weed Abstr. 31(7).
7. Singh, R.P. and R.K. Singh. 1983. Weed control in upland rice as affected by weed control treatments. Proc. Asian Pac. Weed Sci. Soc. Conf. 9th Manila pp. 203-209.

POST–EMERGENCE WEED CONTROL IN SOYABEANS IN THAILAND WITH FLUAZIFOP BUTYL AND HALOSAFEN

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ABSTRACT

Chemical weed control in Thai soyabeans is a relatively new development. Alachlor is applied preemergence, but the unpredictable start of the monsoon may lead to crop loss following planting. Farmers therefore minimise costs by reducing application rates thus shortening the period of weed control and necessitating inter-row sprays of paraquat. The selective graminicide fluazifop-butyl has been available in Thailand for three years, but the lack of complementary products for broad-leaved weed control has prevented its widespread adoption in soyabeans. Halosafen is a new diphenyl ether herbicide for selective post-emergence control of broad-leaved weeds in soyabean. Trials in Thailand have demonstrated that a wide range of broad leaved weeds can be controlled with halosafen. It mixes well with fluazifop-butyl, enabling broad spectrum weed control to be obtained with a single application. Expenditure on chemical weed control is incurred at a time when crop survival is much more assured than in the current preemergence technique.

INTRODUCTION

In 1986, approximately 250,000 hectares of soyabean (*Glycine max*) were grown in Thailand yielding 0.3m tonnes of beans. Although this represents a 50% increase in area and 100% increase in yield compared with 1976, the large national deficit of animal feedstuffs can only partly be made good by imports of oil and cake. There is, therefore, pressure to increase production of soyabeans in place of crops in surplus such as cassava. Although some further growth in the area planted can be expected, most of the balance must be met by further increases in productivity. Good weed control will play a key role in this process.

The main soyabean crop in Thailand is rain-fed, and establishment is therefore dictated by the start of the monsoon rains. Herbicides have been adopted by Thai farmers, but until recently only pre-emergence materials, e.g. alachlor, were available. With an unpredictable start to the season, farmers are normally reluctant to invest heavily in a weed control programme in advance of securing a crop. This often leads to reduced rate applications after crop emergence-either inter-row spraying or hand weeding.

The post-emergence graminicide fluazifop-butyl has been available in Thailand for three years, but the lack of a complementary herbicide to control broad-leaved weeds has limited its use in soyabean.

Fomesafen, a diphenyl ether herbicide for post-emergence broad-leaved weed control in soyabean, was first described by Colby et al. (1). Seth et al (3) reported short term phytotoxicity to Thai soyabean following mixed treatments of fluazifop-butyl and fomesafen. Subsequent work has demonstrated that this level of crop injury is generally unacceptable to Thai farmers. Thus, recent work has focused on halosafen, a close analogue of fomesafen, but with improved crop safety features. Halosafen is being developed by ICI.

This paper describes the properties of halosafen and reports on trials carried out with this compound in mixture with fluazifop-butyl in Thailand.

MATERIALS AND METHODS

Chemical, physical, and toxicological data

Common name	Halosafen
Code name	PP 748
Registered trade mark	'Torus'
Chemical name	5-(2-chloro-6-fluoro-,α,α,α-trifluoro-p-tolyloxy)-*N*-ethylsulphonyl-2-nitrobenzamide.
Vapour pressure	$< 1 \times 10^{-8}$KPa at 25°C.
Solubility	Water 27 mg/l at pH 4.5.
Toxicology	Acute oral LD_{50} rat male 1561 mg/kg, female 2258 mg/kg.

Acute oral LD_{50} rat $>$ 2000 mg/kg.

Halosafen is practically non-irritant to rabbit skin and moderate irritant to rabbit eyes. It is not a skin sensitiser. Chronic studies are in progress.

Residues in crops Halosafen is rapidly degraded in soyabean. No determinable residues have been found in beans following applications of up to 250 g/ha with harvest intervals ranging from 45-141 days.

Formulations Two forumlations have been tested in Thailand. 250g/l SL aqueous solution of the sodium salt of halosafen. 125g/l SL aqueous solution of the sodium salt of halosafen also containing 300g/l non-ionic surfactant.

Other products Fluazifop-butyl. This compound has been available in Thailand as a 350g/l EC of the racemic mixture of R and S enantiomers ('Onecide), the registered trade mark of Ishihara Sangyo Kaisha Ltd). Only the R enantiomer shows biological activity and shortly a new formulation (SL118) will be introduced containing 150g/l of the resolved R enantiomer (=fluazifop-P-butyl) with a vegetable oil built into the formulation.

Standards used in trials were all commercially available products in Thailand.

Biological Trials Field trials were conducted during 1985 and 1986 at various locations in the Petcha-boon and Sukothai districts of Central Thailand. Plots were 2m x 5m in size, arranged in randomised block designs with four replicates. Chemical treatments were applied by knapsack sprayer fitted with a flood nozzel. A weeding agent was routinely added to the spray solution. Spray volume was 500 l/ha, except where this parameter was varied in one trial (125 l/ha).

Applications were generally made when weeds were at the 2-4 leaf stage of growth; the corres-ponding growth stage of the crop was 1-2 trifoliate leaves. Combination treatments were mixed immediately prior to spraying. Where hand weeded treatments were included, one clean weeding was carried out 2-4 weeks after crop emergence.

Visual assessments of crop injury and weed control were made at 1, 2 and 4 weeks after treatment (WAT). Weed control was expressed as % reduction in weed growth compared with untreated plots. Phytotoxicity to soyabean was assessed according to a grading 1-5 where 1 = No phytotoxicity, 2 = Slight phytotoxicity, 3 = Moderate phytotoxicity, 4 = Severe phytotoxicity, 5 = Crop death.

Some trials were continued until harvest. Yields were assessed as fresh weight of beans (kg/ha).

RESULTS

Spectrum of activity Halosafen applied post-emergence was highly active against the broad-leaved weeds (BLW) as follows:

Ageratum conyzoides	(Ac)	**Euphorbia geniculata*	(Eg)
Amaranthus spinosus	(As)	*E. hirta*	(Eh)
A. viridis	(Av)	**Ipomoea* sp.	(Ip)
Boerhavia erecta	(Be)	*Physalis minima*	(Pm)
Celosia argentea	(Ca)	Sesame (volunteer)	(Sv)
**Cleome viscosa*	(Cv)	*Tridax procumbens*	(Tp)
Commelina benghalensis	(Cb)		
Corchorus aestuans	(Ce)		

Those species asterisked have in some instances shown regrowth after initial scorch. *Paedaria* sp (Pa) was tolerant. Halosafen does not control grass weeds or the sedge *Cyperus rotundus* (Cr).

Fluazifop butyl controlled the range of grasses encountered at the various trial locations.

Brachiaria reptans	(Br)	*E. crus-galli*	(Ecg)
Dactyloctenium aegyptium	(Da)	*Eleusine indica*	(Ei)
**Digitaria adscendens*	(Dg)	**Leptochloa chinensis*	(Lc)
Echinochloa colonum	(Ec)		

The species asterisked showed some regrowth, where applications have been made under adverse growing conditions.

Doses required for selective weed control The efficacy of halosafen and fluazifop-butyl applied both alone and in mixture to a mixed grass/broad-leaved weed population in a trial at Sukothai in 1985 is shown in Table 1.

The herbicides applied alone had a transient effect on overall weed control (grass and broad-leaved weeds). Those weeds not controlled rapidly colonised the space left by the susceptible species. However, the mixture treatments gave high levels of control owing to the complementary spectrum of each component. Little advantage was evident from increasing rates above 125g/ha for fomesafen and 250g/ha for fluazifop-butyl. Good herbicidal efficacy was reflected in high yield; the mixture treatments provided a threefold increase in weight of harvested beans over untreated plots.

Phytotoxic symptoms were generally seen on soyabean at 1 week after treatments containing halosafen were applied. Symptoms were noted as necrotic spotting on expanded trifoliates and malformation of young leaflets. Later emerging leaves were unaffected, and no check to growth was apparent. The phytotoxicity was slight in all treatments except those mixtures containing halosafen at a rate of 250g/ha, where it was assessed as moderate. Given a weed control rate for halosafen of 125g/ha or less, a reasonable margin of safety existed, and indeed where farmers were shown the trials selectivity was acceptable to them.

Effect of additional wetting agent on crop safety and herbicidal activity Since the earlier 250g/l halosafen formulation contained no built-in wetter, two trials were conducted at Petchaboon in 1985 to assess the performance of the non-ionic surfactant 'Synperonic NX' at 0.1% v/v. Results are shown in Table 2.

Table 1. Effect of herbicides applied alone or in mixture on crop injury, weed control, and yield of beans at harvest.

Herbicides	Dose (G/Ha)	Injury[1] 1WAT	4WAT	% Weed Control[2] (4WAT)	Yield (Kg/Ha)
halosafen (250g/l)	63	1	1	5	619
halosafen (250g/l)	125	2	1	5	690
halosafen (250g/l)	250	2	1	33	753
fluazifop butyl (350g/l)	250	1	1	7	981
fluazifop butyl (350g/l)	375	1	1	12	994
halosafen+fluazifop butyl	63+250	2	1	83	1207
halosafen+fluazifop butyl	125+250	2	1	92	1811
halosafen+fluazifop butyl	250+250	3	1	91	1375
halosafen+fluazifop butyl	63+375	2	1	94	1415
halosafen+fluazifop butyl	125+375	2	1	95	1863
halosafen+fluazifop butyl	250+375	2	1	95	1581
Untreated					545

[1] Soyabean variety : SJ4

[2] Weeds present : grasses – Br, Ec; BLW – As, Ca, Eg, Ip

Table 2. Effect of adding a wetter to Halosafen/fluazifop-butyl mixtures (Means of 2 trials).

Compounds	Dose (G/Ha)	± Wetter	Crop Injury[1] 1WAT	Weed Control[2] 4WAT
halosafen (250g/l)+fluazifop-butyl (350g/l)	63+250	–	2	70
halosafen (250g/l)+fluazifop-butyl (350g/l)	125+250	–	2	78
halosafen (250g/l)+fluazifop-butyl (350g/l)	63+375	–	2	80
halosafen (250g/l)+fluazifop-butyl (350g/l)	125+375	–	2	86
halosafen (250g/l)+fluazifop-butyl (350g/l)	63+250	+	2	82
halosafen (250g/l)+fluazifop-butyl (350g/l)	125+250	+	2	83
halosafen (250g/l)+fluazifop-butyl (350g/l)	63+375	+	2	85
halosafen (250g/l)+fluazifop-butyl (350g/l)	125+375	+	2	88

[1] Soyabean variety : SJ4 & 5

[2] Weeds present : Grasses – Br, Dg, Ecg; BLW – Eg, Eh, Pa, Sv, Tp

The addition of wetting agent produced no observable increase in crop injury, but gave a small improvement in overall weed control. The lower rate mixture of halosafen (63g/ha) + fluazifop-butyl (250g/ha) was the most responsive treatment to added wetter.

Effect of spray volume In Thailand, herbicides are normally applied at mid-high volume (400-500 l/ha). In 1986 two trials were conducted at Sukothai to examine the effect of using a lower spray volume (125 l/ha). Results are shown in Table 3.

Table 3. Effect of spray volume on herbicidal activity of Halosafen/Fluazifop-butyl mixtures (Means of 2 trials).

Compounds	Dose (G/Ha)	Volume (L/Ha)	Crop Injury[1] 1WAT	Crop Injury[1] 2WAT	% Weed Control[2] 4WAT
halosafen (125g/l)+fluazifop-butyl (350g/l)	63+250	125	2	1	74
"	94		2	1	80
"	125		2	1	85
"	63+250	500	2	1	66
"	94		2	1	75
"	125		2	1	80

[1] Soyabean variety : Pak Bung

[2] Weeds present : Grasses – Dg, Ec, Ei; BLW – Be, Cv, Eg, Ip, Pm

Reducing volume from 500 to 125 l/ha had no adverse effect in terms of crop injury. There was a small but consistent improvement in weed control for the lower spray volume.

Effect of technical material and formulation of Fluazifop-butyl on herbicidal performance of mixtures

For rate selection in trials it was assumed that the racemic mix is half as active on a gramme for gramme basis as the straight R-enantiomer (2). Results of a comparative trial carried out at Sukothai in 1986 are shown in Table 4.

The results show some improvement in weed control for the mixture containing the new formulation (SL118). Given a theoretically equivalent active ingredient, it is assumed that the difference is due to the formulation ingredients in SL118, notably the vegetable oil.

Effect of weed growth stage A trial conducted at Sukhothai in 1986 examined the effect of growth stage on the efficacy of resolved fluazifop-P-butyl/halosafen mixtures. Results are shown in Table 5.

In this trial the growth stage of the weeds at application did not markedly affect herbicidal activity. Only with the lowest rate combination was there a slight reduction in efficacy against the more advanced growth stage weeds.

Comparison with pre-emergence standards Three trials were carried out in 1985 to compare the mixtures with applications of two pre-emergence compounds alachlor and metolachlor. Results are shown in Table 6.

Four weeks after post-emergence treatments were applied, levels of weed control with the halosafen /fluazifop-butyl mixtures remained high. At this time persistence of the pre-emergence treatments was breaking. These differences in weed control were reflected in higher yields for the post-emergence

Table 4. Effect of form of Fluazifop-butyl on herbicidal performance of mixtures with Halosafen.

Compounds	Dose (G/Ha)	Crop Injury[1]		Weed[2] Control
		1WAT	2WAT	4WAT
halosafen(125g/l)+fluazifop-P-butyl (150g/l)	63+ 63	2	2	72
"	125+ 63	2	1	82
"	63+125	2	1	91
"	125+125	2	1	93
halosafen+fluazifop-butyl (350g/l)	63+125	2	1	40
"	125+125	2	1	82
"	63+250	2	1	85
"	125+250	2	1	91

[1] Soyabean variety : Pak Bung

[2] Weeds present : Grasses – Ec; BLW – Cv, Eg, Ip

Table 5. Effect of weed growth stage on efficacy of Halosafen/Fluazifop-P-butyl mixtures.

Compounds	Dose (G/Ha)	% Weed[1] Control (4WAT)	
		3–5 lvs	4–6 lvs
halosafen (125g/l) + fluazifop-P-butyl (150g/l)	62.5+125	99	98
"	125 +125	100	98
"	62.5+62.5	98	88
"	125 +62.5	98	94

[1] Weeds present : Grassess – Ec, Ei; BLW – Av, Ac

Table 6. Comparative activity of Halosafen/Fluazifop-butyl mixtures against pre-emergence standards (Means of 3 trials).

Compounds	Doses (G/Ha)	% Weed[1] Control (4WAT[2]) mean	range	Yields (Kg/Ha) mean
halosafen (125g/l)+fluazifop-butyl (350g/l)	63+250	81	68–90	1229
"	125+250	92	87–95	1428
"	63+375	85	77–91	1379
"	125+375	91	90–93	1449
alachlor (45EC)	1500	49	8–85	1082
metolachlor (40EC)	1200	34	0–83	989
hand weeded		63	30–98	1422
untreated		0	0	838

[1] Weeds present : Grasses – Da, Ec, Ecg; BLW – Ac, As, Av, Ca, Cb, Ce, Cv, Eg, Ip; Sedge – Cr.
[2] Assessment time in relation to post-emergence treatment date.

treated plots, comparable to hand weeded plots.

The ranges shown in Table 6 demonstrate the consistency of performance achieved with the higher rate post-emergence mixtures. The very wide variation in activity shown by the pre-emergence treatments was due to dry conditions at one location.

DISCUSSION

Trials over two years in Central Thailand have demonstrated that high levels of weed control can be achieved selectively following post-emergence applications of halosafen/fluazifop-butyl mixtures. The compounds applied alone were ineffective against the mixed grass/broad leaf weed populations encountered here, although most species were susecptible to one or other of the compounds. Whilst slight injury was observed on soyabean, symptoms were transient and considered acceptable by local farmers. Herbicidal activity is improved by addition of wetter, and may benefit from vegetable oil.

The effectiveness of the mixtures appears reasonably robust across variations in growth stage, spray application technique and formulation, and more consistent than pre-emergence treatments of acetanilide herbicides.

With slight acute toxicity and no detectable residues at harvest, it is concluded that halosafen is a suitable candidate for combining with fluazifop-butyl to give broad spectrum post-emergence weed control in soyabean. Levels of weed control and ultimate crop yield are comparable with or better than existing weed control practices in Thailand. However, with a post-emergence timing, the farmer treats only when the crop is established and the extent of the weed pattern is visible. There is no requirement for a follow-up treatment.

LITERATURE CITED

1. Colby, S.R., J.W. Barnes, T.A. Sampson, J.L. Shoham and D.J. Osborn. 1983. Fomesafen- A new selective herbicide for post-emergence broad leaved weed control in soyabean. Proc. 10th Inter. Cong. Plant Prot., 295-302.
2. Dicks, J.W. 1985. PP005-the R-enantiomer of fluazifop-butyl. Proc. British Crop Prot. Conf. Weeds. 271-280.
3. Seth, A.K., D.W.R. Headfore, R.E. Dhanaraj and T. Chavalit. 1983. Fomesafen (PP021)- A new herbicide for the control of broad-leaved weeds in leguminous crops in Asia-Pacific Region. Proc. 9th Asian Pacific Weed Sci. Soc. Conf. 376-388.

THE ALLELOPATHIC POTENTIAL OF TORPEDOGRASS (*PANICUM REPENS* L.)

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ABSTRACT

The allelopathic potential of water extracts and dried soil-incorporated shoot and rhizome material of torpedograss, on selected crop and weed species was examined in laboratory and glasshouse experiments. Both aqueous extracts of shoot and rhizome significantly reduced the percentage germination of two crop species, namely chilie (*Capsicum annum* var. *grossum*) and brinjal (*Solanum melongena*) and two weed species, *Tridax procumbens* and *Chrysopogon aciculatus*. Mustard (*Brassica juncea*) also showed considerable sensitivity but only to rhizome extracts, and the weed *Achyranthus aspera* showed sensitivity to both shoot and rhizome extracts but to a lesser extent. However, the seed germination of crop species okra (*Hibiscus esculentus*), tomato (*Lycopersicon esculentum*), mung bean (*Phaseolus aureus*), winged-bean (*Psophocarpus tetragodolobus*), bitter-gourd (*Mormodica charantia*), radish (*Raphanus sativa*), and cabbage (*Brassica oleracea* var. *capitata*), and weed species *Euphorbia hirta, Amaranthus viridis* and *Hyptis capitata* were not significantly affected by shoot and rhizome extracts. Both shoot and rhizome extracts also caused significant reductions in the elongation of shoot and radicle in seedlings of brinjal, chillie and *Tridax procumbens* after 28 days of growth in petri-dishes. Dried residues of shoot and rhizome material incorporated into a heavy and light soil at different concentrations and incubated for 1,2,3 and 4 months, also inhibited the growth of sensitive species. The residual bioactivity in the soil assayed by germination of seeds, effects on shoot and radicle elongation, and fresh weight of seedlings of the more sensitive indicator species, produced evidence that *Tridax* and chillie were considerably sensitive to the decomposing residues of torpedograss in soil. Seed germination and seedling growth were most affected by shoot and rhizome residues that have been in the soil for one month. Phytotoxicity of the residues decreased with increased incubation, and was also found to be proportional to the concentration of the plant material initially incorporated into soil.

INTRODUCTION

The term "Allelopathy" was introduced by Molish in 1937 and refers to "all biochemical interactions, stimulatory and inhibitory among plants, including micro-organisms". Allelopathy, is currently enjoying a great deal of attention by weed scientists in the search of alternative weed control strategies. It is recognized as an important mechanism of plant interference which is mediated through the addition of chemicals to the plant environment (15, 18). It is now generally accepted that weeds may interfere crop production not only through competition, but also through allelopathy, and that certain weed species or some of their plant parts release into their environment allelopathic substances that increase their competitive ability (7, 15, 18, 21).

Numerous recent studies have considered the exact role of allelopathy in agriculture (2, 10, 16, 21). Studies with a variety of weed species have shown that exudates from subterranean plant parts (4, 7), water extracts (1, 12, 13) or decomposition products of plant residues in soil (3, 5, 6, 10, 17, 20) display allelopathic potential.

There is considerable evidence now accumulated to suggest that some of the more aggressive perennial weed species, such as quackgrass (*Agropyron repens* (L.)Beauv.) (5,9,14, 20) and johnsongrass (*Sorghum halepense* L.) (1, 7) may impose allelopathic influences, particularly through toxins released from their residues. Quackgrass has been studied intensively for its allelopathic potential, and many of these investigations have confirmed the biologically active chemicals are released from decaying residues of rhizomes. Recent work by Weston and Putnam (22) indicates that living quackgrass or its residues can seriously reduce the N–fixing potential of several legumes. Abdul-Wahab and Rice (1) reported that johnsongrass rhizomes or leaves in soil, inhibited the germination and development of most seedlings of seven weed species studied.

Torpedograss (*Panicum repens*) is an important perennial weed problem in many agroecosystmes in Sri Lanka. It is considered as the biggest weed problem in tea plantations, and also in coconut estates. It has become very troublesome in vegetable cultivation, particularly in the mid-and high elevations. The weed has a very wide distribution in the island and occurs in heavy infestations in home gardens, lawns, playing-fields from where it spreads to useful cultivable land. The control of torpedograss has been extremely difficult due to its extensive rhizome system and its ability to regenerate very rapidly from fragmented rhizome pieces. In fields heavily infested with perennial weeds such as torpedograss, roots of cultivated crops or other weeds are likely to come close to decaying subterranean parts in the upper layer. If bioactive substances are formed, released and are able to move in the soil, their ecological significance is obvious. It is probable that in addition to competitive effects and the possible production of allelopathic substances by living plants, harmful decaying products of residues increase the noxiousness of perennial weeds.

The objectives of the present study were: (a) to determine the inhibitory potential of torpedograss shoot and rhizome extracts to several common weed and crop species, and (b) to determine the effect of decay time and concentration of soil incorporated torpedograss shoot and rhizome residues on the germination and seedling growth of selected species.

MATERIALS AND METHODS

Plant materials The experiments used a clone of torpedograss that has been growing in the University of Colombo premises, and named CO. Plants from naturally established heavy stands were harvested for both shoot and rhizome material. These were washed free of soil and prepared for extraction.

Torpedograss shoot and rhizome extracts Fresh shoot material and rhizome (including roots attached to them) were extracted by blending 150 g of tissue in 300 ml of water for 5 - 10 mins in an electrical blender. The extracts were then filtered through Whatman No. 1 paper, and in addition to the stock extract solution 1:2 and 1:4 dilution prepared of each.

Experiment I. Inhibition of weed and crop seed germination by aqueous extracts The effects of torpedograss shoot and rhizome extracts on the germination of a variety of crop and weed species were evaluated by placing 25 mature seeds of each species on filter-paper lined petri-dishes, and treating the dishes with 6 ml of either the shoot or the rhizome test extracts. The experiment consisted of three concentrations of each tissue extract, viz. 125, 250 and 500 mg/ml of shoot or rhizome material, and control treatments in which distilled water was used to wet the filter-paper in the dishes. The petri-dishes were kept under continuous light supplied by four fluorescent tubes, in a growth room which had a temperature fluctuation of 28-30°C. On day 7, the % seed germination of each species was recorded. The entire experiment was repeated.

Experiment II. Influence of shoot and rhizome extracts on seedling growth of selected species In this experiment the toxicity of the torpedograss shoot or rhizome extracts on the seedling growth of three species which were found to be sensitive in Expt. I was further investigated. The plant species were: brinjal (*Solanum melongena* L.), chilli (*Capsicum annum* L. var. *grossum* L.) and the weed *Tridax procumbens* L. The method used and the treatment concentrations were the same as in Expt. I, except that each petri-dish received 6 ml of freshly prepared extract, once in every 7 days until end of experiment at 28 days. Shoot length and radicle length of each seedling of all species were carefully measured at 28 days and the degree of inhibition of shoot or radicle elongation obtained in relation to control treatments. This experiment too was repeated.

Both Expt. I and II used three replicate petri-dishes per treatment and the dishes were completely randomized on the growth room bench, under continuous light.

Experiment III. Influence of soil-incorporated and decaying shoot or rhizome residues, on seed germination and seedling growth of sensitive species This experiment investigated the toxicity ofthe residues of torpedo grass shoot and rhizomes on the germination and seedling growth of brinjal, chillie and *Tridax*. Two types of soil, viz. a moderately heavy clayloam (45% sand, 24% silt, 25% caly and 4.7% organic matter) and a lighter soil prepared by mixing 3 parts of washed quarry sand with one part of garden soil, were used in the study. Shoot and rhizome material, freshly collected from an established torpedograss stand within the University premises were air-dried for 36 h and mixed with the two soils to give residue concentrations of 0, 1, 3, 6 or 10% w/w for shoot, and 0, 2, 4 or 10% w/w for rhizomes. Before mixing, the air-dried plant residues were broken up into small pieces which were smaller than 1 cm. Batches of soil (8 kg per batch) incorporated with shoot or rhizome residues were put into double-layered polyethylene bags and kept in the glasshouse for decomposition of residues to occur. Fifty ml of water was supplied at 3-day intervals to keep the soil just moist and once-a-week the bags were shaken for mixing of the soil. After the residues had decayed for 1, 2, 3 or 4 months, samples were taken out for testing of bioactivity. Small plastic pots (7.5 cm diam.) were filled with treated or untreated soil and four seeds of each of the test species planted in each pot, at a depth of 1 cm. The pots were placed in the glasshouse and watered lightly every day. Once in 7 days, each pot was supplied with 20-ml of a nutrient solution (Long Ashton formula). The influence on % germination was determined using the results of the five replicate pots and comparing with the germination in untreated soils. Subsequent effects on seedling growth were also determined by following the progress of seedlings up to 28 days after germination of seeds. Measurements of shoot and root elongation and fresh weight of seedlings were made at 28 days, and compared with control treatments. This experiment used five replicate pots per treatment whcih were completely randomized on the glasshouse bench.

All data were subjected to analyses of variance and mean separation by the Duncan's multiple range test. Percent seed germination values were transformed by arcsine, before analysis of variance. Although both Expts. I and II were repeated only one set data is presented in each case, since there were no discrepancies between the Experimental results.

RESULTS AND DISCUSSION

Expt. I. Inhibition of weed and crop seed germination by aqueous extracts Both shoot and rhizome extracts of torpedograss caused significant reductions in the % germination of seeds of at least two crop species and two weed species, after seven days of exposure. From the variety of species tested (Tables 1 and 2) brinjal and chilli were particularly sensitive to both shoot and rhizome extracts. Mustard (*Brassica juncea* H.K.F. and Th.) was sensitive only to rhizome extracts (Table 2). Among the weeds, *Tridax*, *Chrysopogon aciculatus* Trin. and *Achyranthes aspera* L. showed sensitivity to both shoot and rhizome extracts, with significant reductions in their seed germination. However, the germination of seeds of crop species okra (*Hibiscus esculentus* L.), tomato (*Lycopersicon esculentum* Mill.), mung-bean (*Phaseolus aureus* Roxb.), winged-bean (*Psophocarpus tetragonolobus* (L.) DC.), bitter-gourd (*Mormodica charantia* L.), radish (*Raphanus sativus* L.) and cabbage (*Brassica oleracea* L. var., *capitata* L.) and weed species, *Euphorbia hirta* L., *Amaranthus viridis* L. and *Hyptis capitata* Jacq. remained largely unaffected by torpedograss extracts (Tables 1 and 2).

Table 1. Effect of different concentrations of shoot extracts of torpedograss, on the germination of a variety of crop and weed species, at room temperature (30°C) and under continuous light after 7 days.

Plant species	Germination			
	Water	Extract concentration (mg/ml)		
		125	250	500
		%		
Crop species				
Okra	95 a[1]	90 a	93 a	90 a
Tomato	93 a	85 a	93 a	93 a
Mung bean	97 a	99 a	97 a	92 a
Winged bean	80 a	85 a	80 a	80 a
Bitter-gourd	91 a	86 a	100 a	99 a
Mustard	43 a	28 a	31 a	27 a
Radish	85 a	85 a	80 a	75 a
Cabbage	60 a	55 a	65 a	63 a
Brinjal[3]	79 a	68 a	53 ab	17 b
Chillie[3]	75 a	52 ab	40 a	37 b
Weed species				
Euphorbia hirta	55 a	48 a	50 a	53 a
Amaranthus viridis	45 a	53 a	46 a	45 a
Hyptis capitata	88 a	75 a	46 a	79 a
Chrysopogon aciculatus[3]	57 a	45 b	39 b	15 c
Achyranthes aspera[2]	29 a	31 a	20 b	12 b
Tridax procumbens[3]	97 a	56 b	21 b	5 c

[1] Mean values along rows, followed by the same letter are not significantly different at 5% level according to the Duncan's Multiple Range Test.

[2,3] Indicate species showing high to moderate sensitivity, respectively to the extracts.

Table 2. Effect of different concentrations of rhizome extracts of torpedgorass, on the seed germination of a variety of crop and weed species at room temperature (30°C) and under continuous light, 7 days.

Plant species	Germination			
	Water (Control)	Extract concentration (mg/ml) 125	250	500
		%		
Crop species				
Okra	95 a[1]	92 a	95 a	93 a
Tomato	73 a	87 a	88 a	92 a
Mung bean	97 a	92 a	96 a	95 a
Winged bean	80 a	83 a	70 a	75 a
Bitter-gourd	91 a	93 a	93 a	93 a
Mustard[2]	43 a	30 b	13 bc	7 c
Radish	85 a	75 a	80 a	85 a
Cabbage	60 a	60 a	65 a	60 a
Brinjal[3]	79 a	57 a	15 b	11 b
Chillie[3]	75 a	35 b	20 bc	9 c
Weed species				
Euphorbia hirta	55 a	60 a	55 a	58 a
Amaranthus viridis	45 a	45 a	50 a	42 a
Hyptis capitata	88 a	79 a	78 a	81 a
Chrysopogon aciculatus[3]	57 a	43 b	47 ab	16 c
Achyranthes aspera[2]	29 a	23 a	27 a	8 b
Tridax procumbens[3]	92 a	63 b	8 c	1 c

[1] Mean values along rows, followed by the same letter are not significantly different at 5% level according to the Duncan's Multiple Range Test.

[2,3] Indicate species showing high to moderate sensitivity, respectively to the extracts.

Expt. II. Influence of shoot and rhizome extracts on seedling growth of selected species Both the shoot and rhizome extracts caused significant inhibition of the seedling growth of brinjal and *Tridax*, While only the rhizome extract was inhibitory to chillie (Fig. 1). In general radicle elongation was more sensitive to the inhibitory action of the extracts, compared with effects on shoot elongation. The overall results showed that rhizome extracts were more inhibitory than shoot extracts, to the growth of seedling of sensitive species.

The extract dilutions used in these studies were in the range of a higher concentration than dilutions used in similar studies in the literature (1, 6, 13, 20). However, the results are generally in good agreement with those of a number of other researchers reporting inhibition of seed germination and seedling growth in a variety of plants by water extracts of potentially allelopathic plants (4, 7, 8, 9). It appears that the inhibitory nature of the aqueous shoot or rhizome extracts of torpedograss in the present studies could be at least partly due to substances present in the extracts.

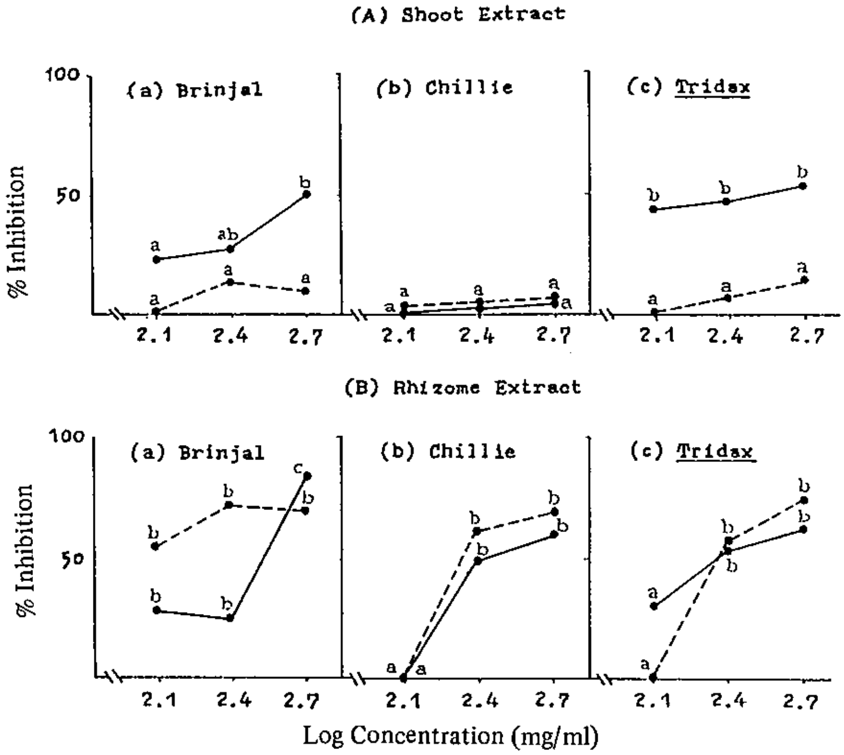

Fig. 1. Inhibition of radicle (•———•) and shoot (•- - - - -•) elongation in seedlings of three sensitive species, by torpedograss shoot or rhizome extracts. After 28 days of growth under continuous light and 30°C. Mean values followed by same letter are not significantly different at 5% level.

Expt. III. Influence of soil-incorporated and decaying shoot or rhizome residues on seed germination and seedling growth of sensitive species Both the fresh weight of seedlings and seed germination data of *Tridax* and chilli (Figs. 2–5) clearly showed that these were significantly affected by the concentration of shoot or rhizome residues previously incorporated into the soil. This effect of residue concentration on the seed germination and growth of *Tridax* and chilli was dependent on the time the residues were allowed to decay in the soil. Soil effects between heavy and light soils were not significant, although on a number of instances, more inhibition was noticeable in the heavier soil.

Fresh weight of control plants (where no residues were incorporated into soil) was significantly higher than of plants grown in soil in which 3, 6 of 10% of shoot residues or 2, 4 or 10% of rhizomes had decayed for one month. Growth of both *Tridax* and chilli in soils with 1% residues which had decayed for one month was not significantly different from the controls.

Generally, plant growth decreased as % residues in the soil increased, after the residues had decayed for one month (Figs. 2 and 3). For any residue concentration, plant growth tended to be unaffected as decay time increased up to 2, 3, or 4 months. Comparing the inhibitory activity brought about by decaying shoot residues and rhizome residues, the results showed a significantly more pronounced inhibition due to rhizome residues than with shoot residues. *Chrysopogon* and brinjal, the other two test species also responded in much the same way as *Tridax* and chilli, but inhibition of their growth by the decaying residues was somewhat less than those of the more sensitive species (data not presented).

Seed germination data also confirmed that *Tridax* and chilli were more sensitive to incorporated, decaying torpedograss residues than other test species. Both shoot and rhizome residues at all

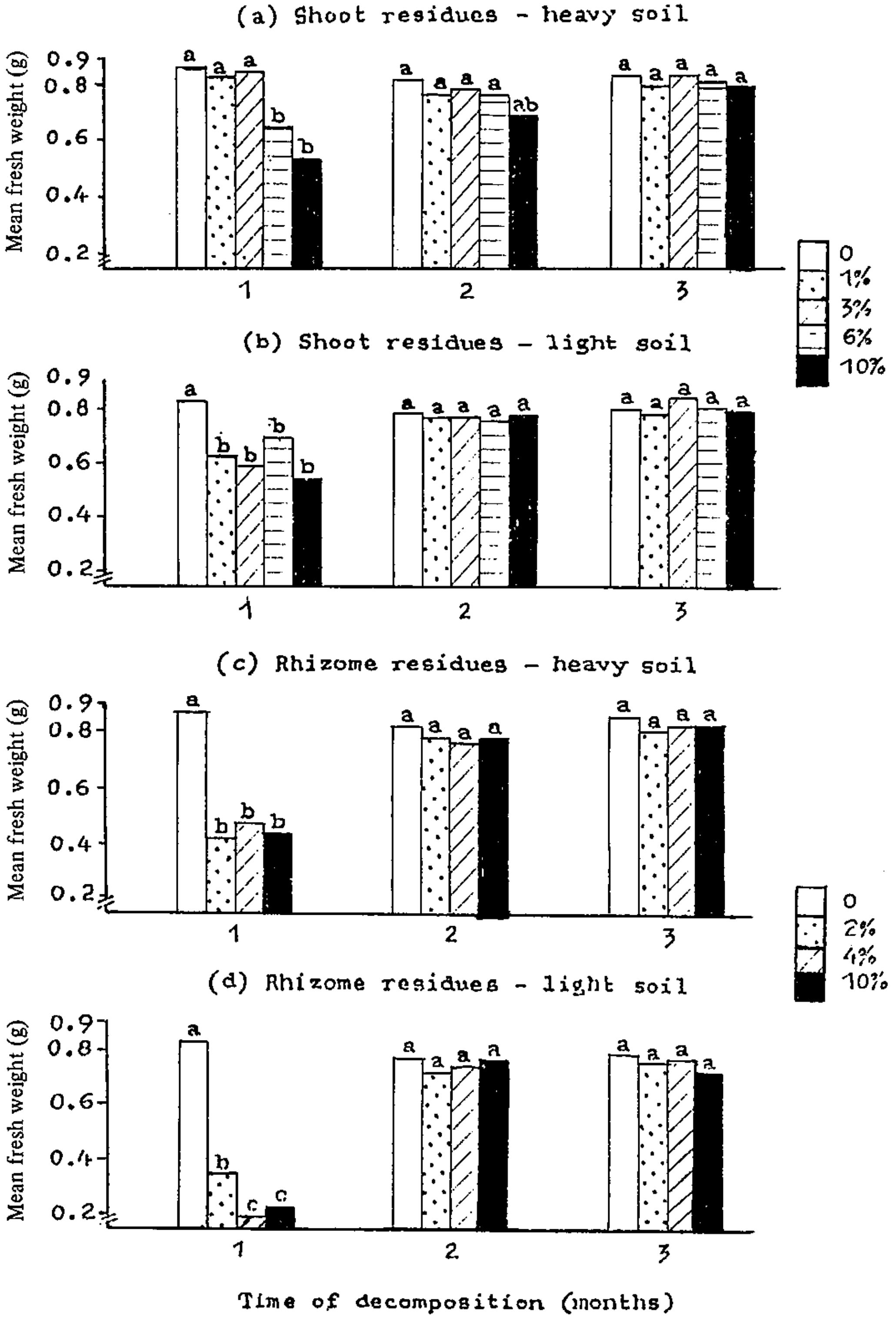

Fig. 2. Fresh weight of *Tridax* seedlings (28 days after planting) as affected by varied amounts of torpedograss shoot or rhizome residues which had decayed in soil for 1, 2 or 3 months.

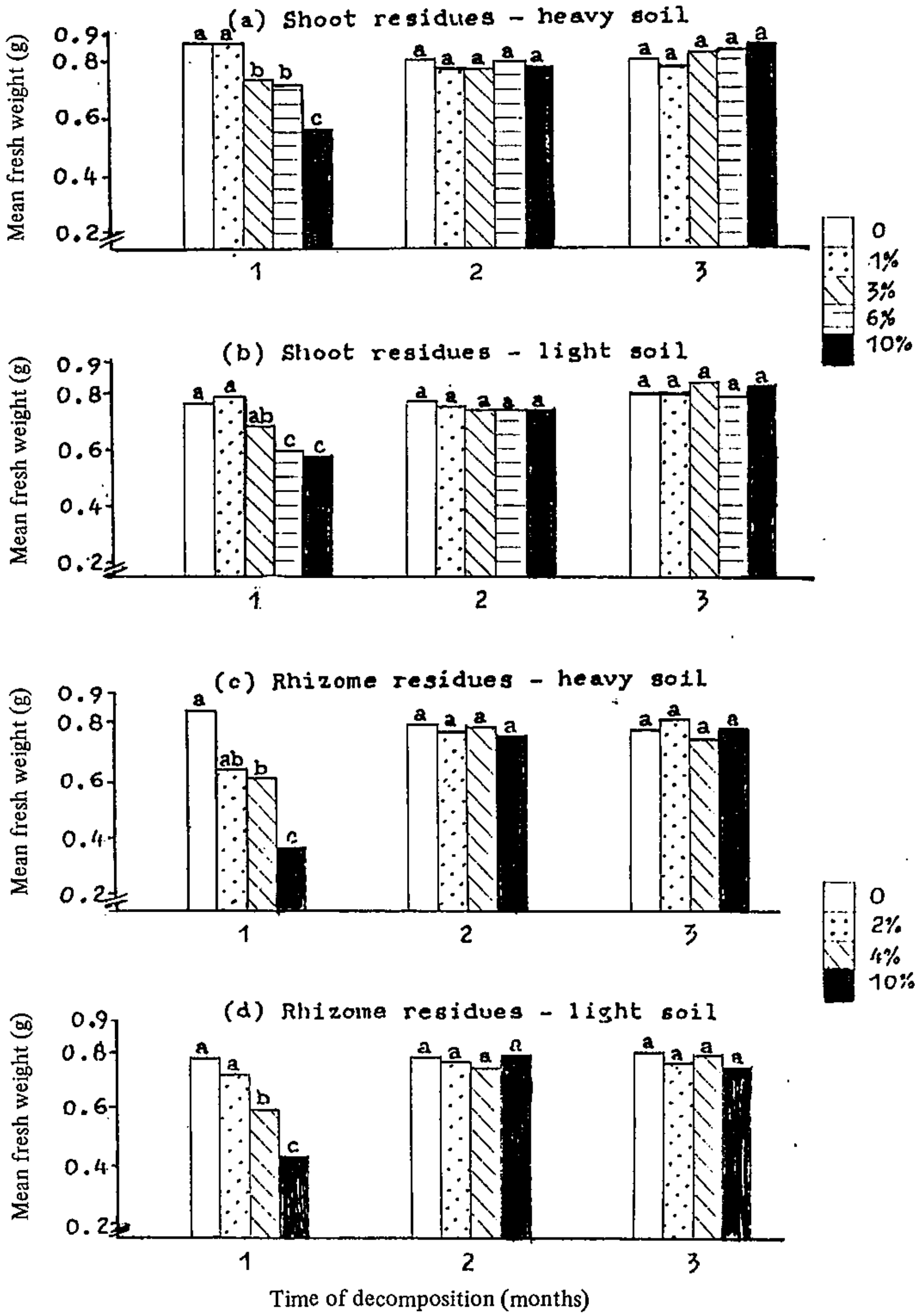

Fig. 3. Fresh weight of chilli seedlings (28 days after planting) as affected by varied amounts of torpedograss shoot or rhizome residues which had decayed in soil for 1, 2 or 3 months.

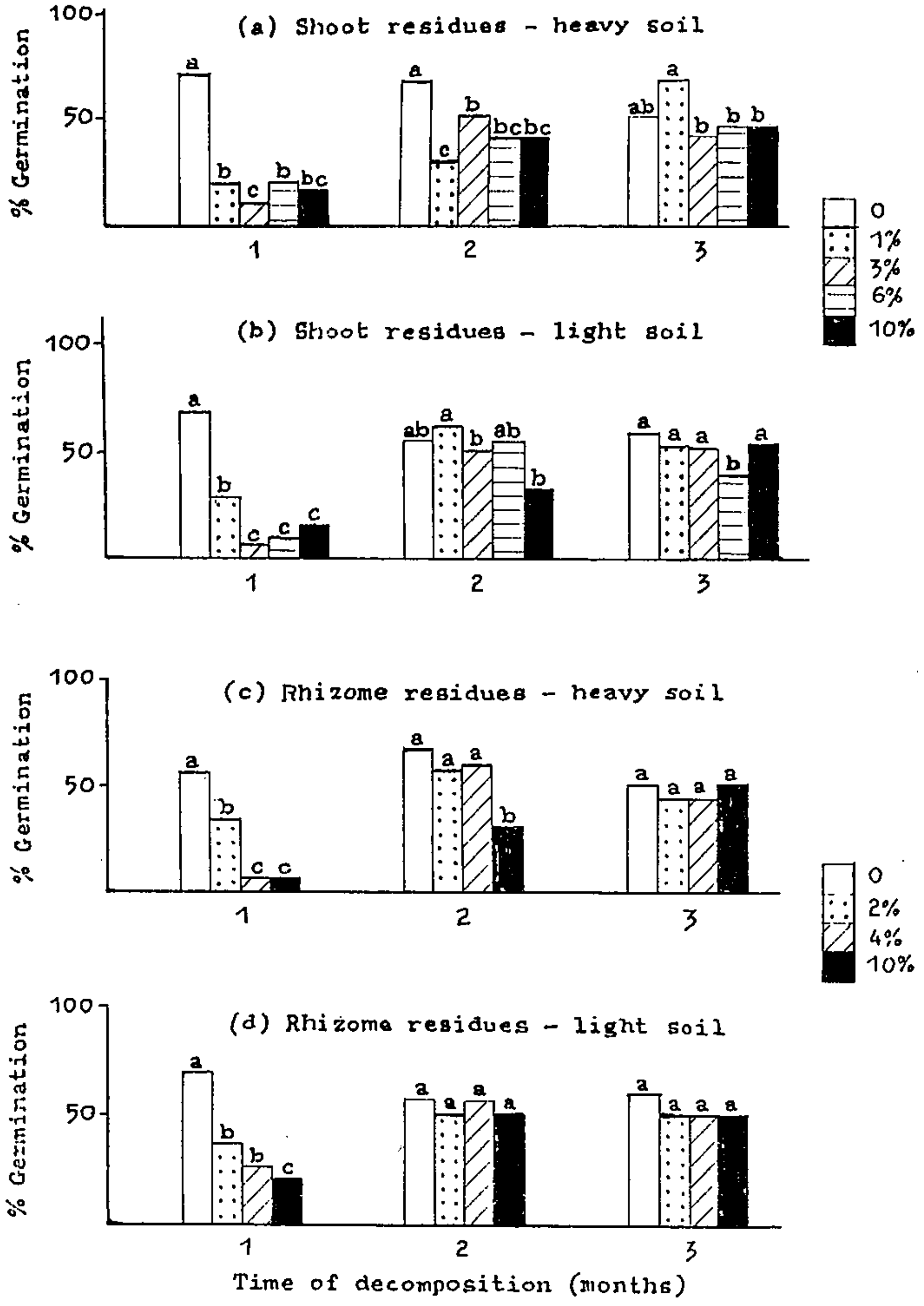

Fig. 4. Percent germination of *Tridax* seeds (7 days after planting) as affected by varied amounts of torpedograss shoot or rhizome residues which had decayed in soil for 1, 2 or 3 months.

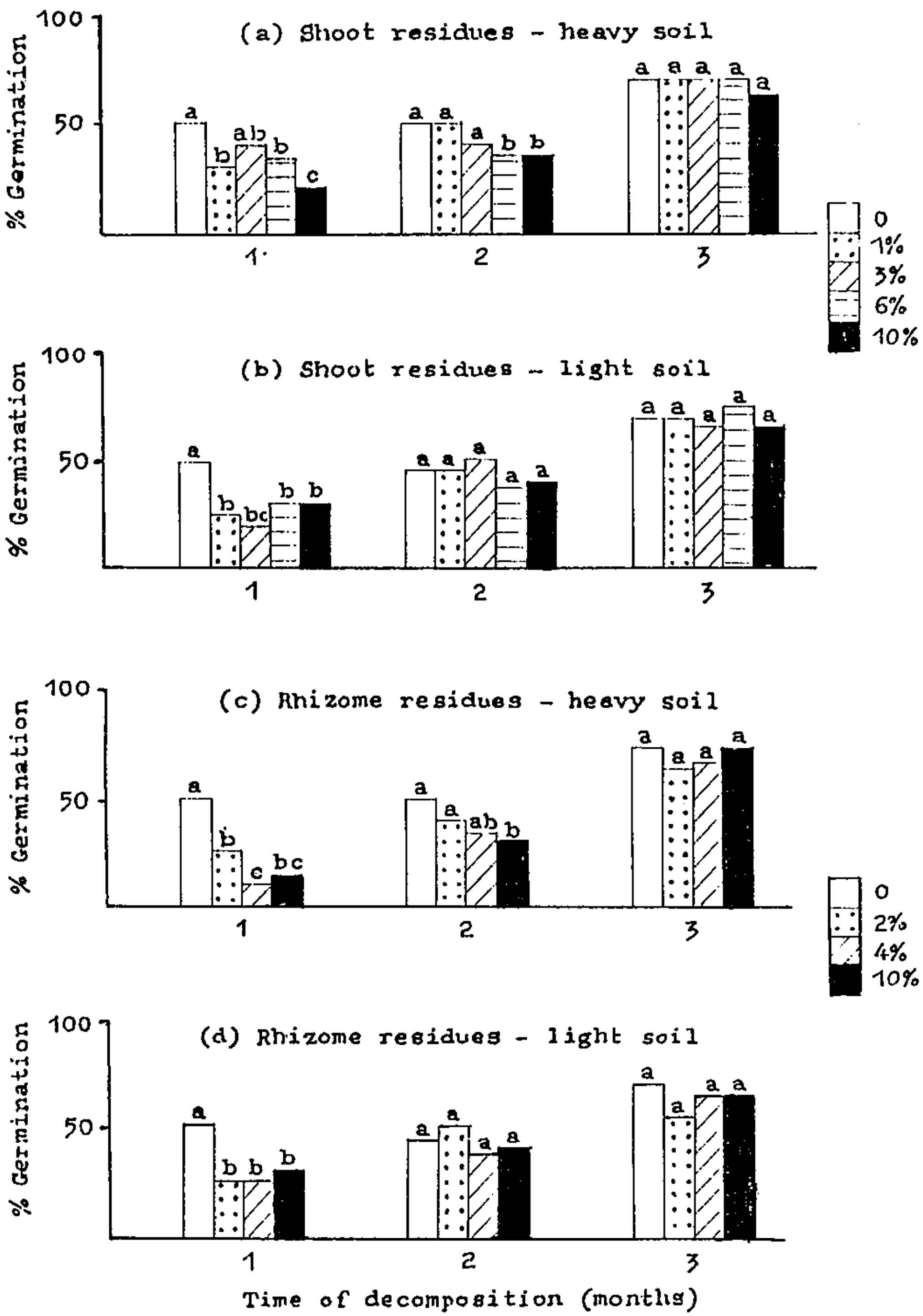

Fig. 5. Percent germination of chilli seeds (7days after planting) as affected by varied amounts of torpedograss shoot or rhizome residues which had decayed in soil for 1, 2 or 3 months.

concentration in % germination of *Tridax* (Fig. 4) and chilli (Fig. 5) after the residues had decayed for one month. The effect was much variable and also less pronounced after two months of residue decay. For each residue concentration, % seed germination tended to increase as decay time increased from 1 to 2, 3 or 4 months, with both these test species. *Chrysopogon* seed germination was similary affected by torpedograss redisues decaying in soil for up to one month (data not presented). No effects were however noticeable at 2, 3 or 4 month decay times. Brinjal seed germination was unaffected by the residues in both types of soils and at all concentrations (data not presented).

The lower seedling growth and seed germination in soils that had the higher shoot or rhizome residue concentrations, and the fact that residue fragments were not present in the soils after 1, 2, 3 or 4 months, when the soils were used for testing, indicate that the sensitive species were affected by substances left over in the soil from the decay of residues and/or microbial activity. These results clearly indicate that the decay products of torpedograss shoot or rhizome residues have a harmful effect on the seed germination and seedling growth of particularly *Tridax* and chilli. The observed increase in the plant growth and seed germination with decay time is in good agreement with other reports (4, 8) and indicate that, under field conditions torpedograss residue which decayed for more than one month may be of little or no practical significance as allelopathic agents against the tested crop and weed species.

GENERAL CONCLUSIONS

The study clearly demonstrates that torpedograss is also strongly allelopathic towards certain crops and weed species, in much the same way as other well-known perennial grass weeds. Allelochemicals found in both the shoot and rhizome systems are water extractable as shown by the bio-activity in the aqueous extracts. The same growth inhibitory substances may be responsible for the growth inhibition observed in residue studies. Although the presence of growth inhibitors in water extract does not necessarily mean that they are of any practical significance, the fact that inhibitory allelochemicals are released during the decay of shoot or rhizome residues in soil, point to the importance of such substances in nature. Further studies are currently in progress to investigate whether inhibitory substances are exuded by living torpedograss rhizomes, and to isolate and characterize the allelochemicals in torpedograss shoot and rhizomes.

LITERATURE CITED

1. Abdul-Wahab, A.S. and E.L. Rice. 1967. Plant inhibition by johnsongrass and its possible significance in old-field succession. Bull. Torrey Bot. Club 94: s486-497.
2. Altieri, M.A. and J.D. Doll. 1978. The potential of allelopathy as a tool for weed management in crops. PANS 24:495-502.
3. Barnes, J.P. and A.R. Putnam. 1983. Rye residues contribute weed suppression in no-tillage cropping systems. J. Chem. Ecol. 9: 1045-1057.
4. Friedmen, T. and M. Horowitz. 1970. Phytotoxicity of subterranean residues of three perennial weeds. Weed Res. 10: 382-385.
5. Gabor, W.E. and C. Veatch. 1981. Isolation of a phytotoxin from quackgrass (*Agropyron repens*) rhizome. Weed Sci. 29: 155-159.

6. Guenzi, W.D. and T.M. McCalla. 1966. Phenolic acids in oats, wheat, sorghum and corn residues and their phytotoxicity. Agron. J. 58: 303-304.
7. Horowitz, M. and T. Friedman. 1971. Biological activity of subterranean residues of *Cynodon dactylon* L., *Sorghum halepense* L. and *Cyperus rotundus* L. Weed Res. 11: 88-93.
8. Leather, G. R. 1983. Sunflowers (*Helianthus annus*) are allelopathic to weeds. Weed Sci. 31: 37-42.
9. Lynch. J.M. and D. J. Penn. 1980. Damage to cereals caused by decaying weed residues. J. Sci. Food Agric. 31: 321-324.
10. McCalla, T. M. and F. A. Haskins. 1964. Phytotoxic substances from soil micro-organisms and crop residues. Bacteriol. Rev. 28: 181-207.
11. Molisch, H. 1937. Der Einfluss einer Pflanze auf die andere-allelopathie. Fischer (Jena) Jena, G.O.R.
12. Muller, C. 1969. Allelopathy as a factor in ecological process. Vegetatio 18: 348-357.
13. Nielson, K.F., T.F. Cuddy and E.B. Woods. 1960. The influence of the extract of some crops and soil residues on germination and growth. Can J. Plant Sci. 40: 188-197.
14. Ohman, J. and T. Kommendahl. 1960. Relative toxicity of extracts from vegetative organs of quackgrass (*Agropyron repens*) to alfalfa. Weeds 8: 666-670.
15. Putnam, A.R. 1985. Weed allelopathy. *In* S.O. Duke (ed.) Weed Physiology, Vol. 1: Reproduction and ecophysiology. CRC Press, Inc., Florida, USA. 131-155.
16. Putnam, A. R., J. De Frank and J. P. Barnes. 1983. Exploitation of allelopathy for weed control in annual and perennial cropping systems. J. Chem. Ecol. 9: 1002-1010.
17. Putnam, A. R. and W. B. Duke. 1978. Allelopathy in agroecosystems. Ann. Rev. Phytopathology 16: 431-451.
18. Rice, E. L. 1984. Allelopathy. Academic Press, New York, USA.
19. Rovira, A. D. 1969. Plant root exudates. Bot. Rev. 35: 35-51.
20. Toai, T. V. and D. L. Linscott. 1979. Phytotoxic effect of decaying quackgrass (*Agropyron repens*) residues. Weed Sci. 27: 595-598.
21. Tukey, H. B., Jr. 1969. Implications of allelopathy in agricultural plant science. Bot. Rev. 35: 1-16.
22. Weston, L. A. and A. R. Putnam. 1984. Inhibition of growth, nodulation and nigrogen fixation of legumes by quackgrass (*Agropyron repens*). Crop Sci. 25: 561-565.

PRESENT STATUS OF HERBICIDE USE IN INDONESIA

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ABSTRACT

At present, there are 40 common names and 75 different trade names of herbicides registered in Indonesia with single or mixed formulation. Only registered herbicides that have clearance from the Minister of Agriculture could be distributed, stored, and used in Indonesia. The Pesticide Committee assists the Minister of Agriculture on pesticide policies. Herbicides are mostly used in estate crops such as rubber, oil palm, tea, and sugarcane, but only a small quantity is used for food crops and vegetables. The areal expansion of estate crops outside Java markedly increases the use of herbicides due to the large acreage of plantations and limited labor force available. The major problems of herbicide application in Indonesia are Iack of skilled farmers, shortage of water as herbicide carrier, and high rainfall occuring after herbicide application.

INTRODUCTION

The total cultivated area in Indonesia amounted to 63.5 million ha in 1982 or about one-third of the total land area. The cultivated area consisted of 21.3 million ha planted with woody plants, 13.2 million ha under shifting cultivation, 8.3 million ha of plantations, 7.9 million ha of wet land, and the rest were homeyard and others (1). The breakdown of total harvested area of food crops and projected area of estate crops in Indonesia are shown in Tables 1 and 2.

In Java, where the average farm is less than 0.5 ha, conversion of agricultural lands into nonagricultural areas for industrial, transportation, and housing sites is rapidly increasing. The farm size in Java has

Table 1. Total harvested area of food crops in Indonesia in 1984.[1]

Commodities	Total harvested area (1000 ha)
Rice	9,764
Corn	3,025
Cassava	1,339
Soybean	838
Peanut	523
Sweet potato	279

[1] Source: Central Bureau of Statistics (1)

Table 2. Projected area of estate crops in Indonesia in 1987[2].

Commodities	Total area (1000 ha)	Remarks
Coconut	3,778	mainly smallholders
Rubber	2,380	mainly smallholders
Oil palm	1,242	mainly estates
Coffee	787	mainly smallholders
Clove	699	mainly smallholders
Sugarcane	469	estates-smallholders
Tobacco	239	mainly smallholders
Tea	121	mainly estates
Cocoa	87	mainly estates

2 Source: Directorate General of Estates (1984)

even become smaller; as a result agricultural extensification has been done outside Java.

Five-year plan on replanting and expansion of estate crops as shown in Table 3 indicates that total replanting and expansion area on all of estate crops is about 440 000 ha per year and most of them done outside Java. Due to the limited labor force available and the large size of plantations outside Java, the application of herbicide to weed control is preferred especially during land preparation and unproductive growth period of estate crops.

Table 3. Target on replanting and expansion of estate crops during 1984–1988[1].

Commodities	Area (1000 ha)
Coconut	346
Rubber	648
Oil palm	910
Coffee	5
Clove	25
Sugarcane	115
Cocoa	40
Others	113
Total	2,202

1 Source: Directorate General of Estates (2).

HERBICIDE USAGE

Insecticide is the most widely used pesticide in Indonesia, whereas herbicide accounted for only

29% of the total pesticides used in 1974 (6). However, it is assumed that the market share of herbicide is increasing gradually thereafter. In Malaysia, herbicide accounts for 80% of the pesticide market share (4). Eventhough there is no exact figure about the amount of herbicide used for specific weeds, alang-alang (*Imperata cylindrica*) is still the major weed in Indonesia controlled by herbicides.

Herbicides are used mostly for estate crops, especially in the Government and private estates. The large quantity of herbicides used in estate crops is attributed to the large acreage of the plantations and the limited labor force available. As many as 35 herbicide trade names are registered for rubber, followed by tea (20 herbicides), oil palm (19), and sugarcane (17). Although coconut covers the largest area among the estate crops (Table 2), only 4 herbicides are registered for this crop (Table 4). The use of these herbicides is suspected to be low due to the fact that coconut is mainly planted by smallholders who do not use herbicides for controlling weeds.

Table 4. Number of herbicides registered for specific crops in Indonesia in 1987[1].

Crop	No. of registered herbicide (trade name)
Plantation crops	
Rubber	35
Tea	20
Oil palm	19
Sugarcane	17
Cotton	6
Coconut	4
Cocoa	4
Coffee	3
Food crops	
Rice	32
Soybean	13
Peanut	9
Corn	6
Vegetables	4
Fruits	0

[1] Source: Directorate of Food Crop Protection (3).

For food crops in Indonesia, herbicides are used mostly in rice and soybean (Table 4). The size of food crop farm is so small, that the farmer is able to control the weeds by hand or by using a simple rotary weeder. Although there are 32 herbicides registered for rice, the amount of herbicide used is relatively small.

TYPES OF HERBICIDE

According to the latest figure released by the Indonesian Pesticide Committee in 1987, there are 40 types (common names) of herbicides registered for market in Indonesia (Table 5). These herbicides are registered under 75 trade names. Most of the herbicides in the same common name have only one or two trade names are 2,4-D (10 trade names), dalapon (4), diuron (3), paraquat (3), and MCPA (3).

The number of herbicides submitted to the Pesticide Committee for registration has increased in the last decade. As illustration, in 1976 only 24 herbicide trade names were registered (6) while in 1987 there are 75 trade names (Table 5). A few herbicides, however, have been taken out of the list due to undesirable findings of the compounds or not being re-registered due to failure in marketing.

Attempts to broaden or improve the weed control spectrum by mixing two or three compounds as a cocktail has been done by several agrichem companies. The mixture might consist of pre and postemergence herbicides as well as grass and broadlef weed herbicides.

HERBICIDE MANAGEMENT

On 16 April 1969, the Minister of Agriculture formed the Pesticide Committee to assist him in formulating and implementing policies on pesticides. The other tasks assigned to the Committee are to issue pesticide use permit and to make recommendations concerning the manufacturing, formulation, import, distribution, and storage of pesticides in accordance with existing provisions stipulated by the Minister of Agriculture (5).

Distribution, storage, and use of pesticides is regulated by the Government Decree No. 7/1973. For implementation of the decree, several decrees of the Minister of Agriculture have been issued such as No. 280/1973 on the procedure of application for pesticide registration, No. 429/1973 on the requirements for pesticide labelling and packaging, and No. 944/1984 on the limitation of pesticide registration.

Application of pesticide registration should be made by a manufacturer or formulator or its representative in Indonesia having permanent residence in Indonesia. Registration of all pesticides applies to the formulation, and not to the active ingredient. Applicants are required to provide technical data and information concerning the formulation.

Registration may be granted as an experimental, a provisional, or a permanent clearance. An experimental clearance for 1 year period is granted if the information on safety aspects and efficacy are not known. Under this clearance the formulation is not allowed to be distributed in the market. A provisional clearance is given to a pesticide formulation that is relatively safe and effective for special purposes. Additional data are still required for further considerations. Under this clearance the formulation can be distributed in a limited quantity for 1 year. A permanent clearance is granted for a pesticide formulation that is safe for human and environment, and effective for special pruposes and applications. The duration of a permanent clearance is 5 years. Under this clearance the formulation can be distributed, stored, and used in Indonesia in an unlimited quantity.

Data derived from field experiments are required for herbicide registration. Depending on the target weeds and the treated crops, at least two experiments are required to be carried out at two different locations. The experiments may be done by the Research Institutes, Universities, or other Research Agencies. In Indonesia there are 27 institutions involved in weed science or weed research and extension

Table 5. Classification of herbicides registered in Indonesia in 1987[1].

Chemical group	Common name	No. of registered trade name
Aliphatics	dalapon	4
	glyphosate	2
Amides	alachlor	1
	butachlor	1
	metolachlor	1
	pretalachlor	2
	propanil	1
Benzoics	dicamba	1
Bipyridiliums	paraquat	3
Carbamates	asulam	1
Diphenyl ethers	oxyfluorfen	1
Phenoxys	2,4-D	10
	MCPA	3
Triazines	ametryn	2
	atrazine	2
	cyanazine	1
	metribuzine	1
	terbumeton	1
Ureas	benzsulfuron	2
	chlorbromuron	1
	diuron	3
	linuron	1
	methabenzthiazuron	1
Unclassified	bentazon	1
	bialafos	1
	chlomethoxynil	2
	fluazifop-butyl	1
	glufosinate	1
	haloxyfop-methyl	1
	imazapyr	1
	norflurazon	1
	oxadiazon	2
	sethoxydim	1
	triclopyr	1
Mixture of 2 compounds	–	15
Mixture of 3 compounds	–	1
Total	40	75

[1] Source: Directorate of Food Crop Protection (3).

activities with about 70 full-time weed scientists (7).

The highly toxic pesticides such as paraquat are not approved to be used by general public. Those pesticides require special skill and equipments, and are therefore approved only for restricted use by authorized users who have been well-trained.

All active ingredients of herbicide available at present are imported from other countries and then formulated in Indonesia. There is an attempt to manufacture the active ingredients of herbicides, especially the popular and expensive herbicides.

Only Indonesian companies are authorized to distribute herbicides in Indonesia. Retailers who are the last chain of herbicide distribution before reaching farmers have an important role not only as suppliers but also as sources of information on the use of herbicide for the farmers. Most of the retailers have only a limited knowledge on the use of herbicides. As a consequence, the herbicide is sometimes improperly handled or the farmers are misinformed. Problem of adulteration of herbicides may also occur.

HERBICIDE APPLICATION

The areal expansion of estate crops outside Java significantly increases the use of herbicides due to the large size of the estates and the limited labor force available. The new plantation site is usually in an isolated area, therefore, the quantity as well as the quality of water often becomes a serious problem for herbicide application. Attempts to reduce the volume of water as carrier or diluent have been made by using ULV (ultra low volume), CDA (controlled droplet application), or special equipments.

Unlike insecticides, in Indonesia herbicides have never been applied by aircraft. Herbicide spraying is mostly done by knapsack sprayers. The possibility of using aircraft is quite evident for herbicide application in controlling weeds that infest a large area. For that, changing herbicide formulation to a suitable one for aerial application is necessary. It should be noted that aerial application can increase the risk of incidence of negative side effects (8).

In the humid tropical area such as Indonesia, the efficacy of foliar applied herbicides is often hampered by rainfall coming shortly after the application. Rainfall washes-away the herbicide solution from weed foliage, therefore the herbicide will be ineffective. The use of an adjuvant to enhance herbicide penetration into the leaf or the use of sticker to maintain the herbicide on the leaf surface may reduce this problem.

LETERATURE CITED

1. Central Bureau of Statistics. 1986. The statistical year book of Indonesia 1985. Centr. Bureau of Stat., Jakarta. 637p. (In Indonesian).
2. Directorate General of Estates. 1984. The fourth of the Five Year Development Plan, estate subsector, 1984/1985-1988/1989. Department of Agriculture. 172p. (In Indonesian).
3. Directorate of Food Crop Protection. 1987. Pesticides for agriculture and forestry. Dir. of Food Crop Protec., Jakarta. 206p. (In Indonesian).
4. Mohamad, R. and S. M. Ali. 1986. The status of herbicide in Malaysia. Proc. of the Symp. in Weed Sci., Bogor, Indonesia, 10-12 April 1984. BIOTROP Spec. Publ. No. 24, p. 69-75.

5. Oka, I. N. and M. Soekardi. 1982. Pesticide management in Indonesia. Ind. Agric. Res. Dev. J. 4(2): 36-42.
6. Soerjani, M. 1978. Preventing yield losses by controlling weeds properly. Menara Perkebunan 46(4): 175-186. (In Indonesian).
7. Soerjani, M., M. Sundaru and C. Anwar. 1986. The present status of weed problems and their control in Indonesia. Proc. of the Symp. in Weed Sci., Bogor, Indonesia, 10-12 April 1984. BIOTROP Spec. Publ. No. 24, p. 7-23.
8. Wardojo, S. 1984. Aspects on aerial application of pesticides. Menara Perkebunan 52(1):2-6. (In Indonesian).

IDENTIFICATION OF PLANT GROWTH INHIBITING SUBSTANCES CONTAINED IN *PERILLA FRUTESCENS* (L.) BRITT. AND *P. CRISPA* TANAKA BY GAS CHROMATOGRAPHY–MASS SPECTROMETRY

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ABSTRACT

Two crops which belong to Labiatae, *Perilla frutescens* and *P. crispa* show a strong allelopathy. To characterize allelochemics contained in these plants, the isolation and the identification were carried out. Methanolic extracts from both plants showed a strong inhibitory effect in the growth of rice (cv. Tanginbozu) seedlings. They were purified by charcoal-celite column chromatography and TLC. The purified substances were identified as perillaketone for *P. frutescens* and perillaldehyde for *P. crispa* by UV and GC-MS analyses. These substances seem to be closely related to allelopathy.

INTRODUCTION

Two crops, *Perilla frutescens* (L.) Britt. and *P. crispa* Tanaka which belong to family Labiatae have been known to show strong allelopathy. In the old days when shifting cultivation was widely practiced in Japan, farmers were employing the cropping of *P. frutescens* in a series of crop rotation system to expect its phytotoxic ability for inhibiting weed emergence and growth (2,3). *P. crispa* plants often escape from cultivated fields and form pure community with its allelopathic effects (Harada, unpublished).

This paper deals with an identification of plant growth inhibiting substances contained in *P. frutescens* and *P. crispa* to clarify allelopathy in these plants.

MATERIALS AND METHODS

Materials Two month-old plants of *P. frutescens* and *P. crispa* grown in the field of Hokuriku Nat'l. Agr. Exp. Station, Joetsu City, Niigata Prefecture from May to June 1983 were sampled and kept at −80°C until use.

Bioassay for plant growth inhibiting activity Frozen plant material as homogenized with five times the amount (w/w) of cold methanol by a universal homogenizer (Nipponseiki, type HC) twice. Filtered methanol extract was concentrated in vacuo. Aqueous residue was partitioned with an equal volume of n-hexane five times. From original methanol extract, n-hexane phase and aqueous residue, an equivalent amount of 0.1, 1 and 5 g fresh material respectively was taken and poured into a glass vial (28mmϕ x 118mmH) containing 1.5 g of cillulose powder (Toyo, type D) and dried out in a vacuum chamber. Then, 6 ml of distilled water per vial was added and uniformly germinated rice (*Oryza sativa* L. cv. Tan-ginbozu) seeds were placed in groups of six. The vials were covered with vinyl film and placed in a growth chamber with a temperature of 30°C and a light intensity of 3000 lux at plant level. Distilled water was added at 1 ml per vial 3 days later and the length of the second leaf sheath and the longest root were measured after another 7 days. Each treatment was duplicated.

Charcoal-celite column chromatography Concentrated methanol extract (equivalent to 50 g fresh material) was poured on top of the column (14 mm ϕ x 300 mm L) packed with the mixture of 5 g charcoal (Wako, activated charcoal powder) and 10 g celite (Johns-Manville, No. 545). Step elution with water/acetone mixture (v/v) was employed from 40/60 to 0/100 at 10% difference. Every 100 ml eluate was collected and concentrated in vacuo for the use of bioassay or further analysis.

Thin-layer chromatography (TLC) Biologically active fractions of charcoal-celite column chromatography (water/acetone 20/80 and 10/90, v/v) was developed on a silica gel TLC plate (Whatman, LK6) by using n-hexane/ether mixture (5/1, v/v) as a developing solvent. Dark-spotted area under UV-light was scraped off and eluted with methanol for the use of bioassay, UV (by Shimadzu spectrophotometer, UV-300) and GC-MS (by Shimadzu gaschromatograph-mass spectrometer, LKB-9000) analyses.

RESULTS AND DISCUSSION

Effects of the original methanolic extract, n-hexane and aqueous phase of *P. frutescens* and *P. crispa* plants on the growth of rice seedlings are shown in Fig. 1. Methanolic extracts of both plants inhibited the root growth, and the shoot growth at higher concentration. The growth inhibitors were partially partitioned into n-hexane phase.

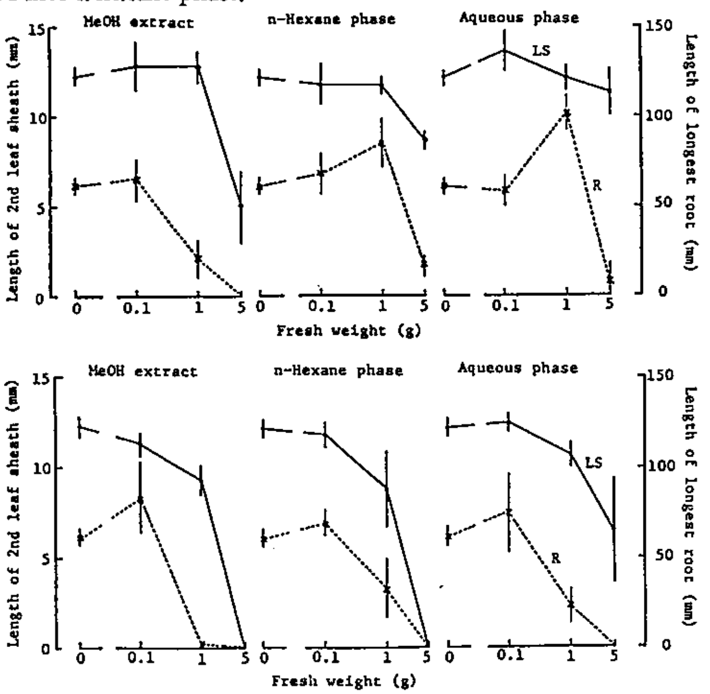


Fig. 1. Effects of the methanolic extract, n-hexane or aqueous phase from 0.1, 1 and 5 g fresh weight of *Perilla frutescens* (upper) and *P. crispa* (lower) on the growth of rice seedling cv. Tan-ginbozu.

Methanolic extracts were purified by charcoal-celite column chromatography with water/acetone step elution system. As a result (Table 1), growth inhibiting activity was mainly shown in the third and the fourth eluates (water/acetone, 20/80 and 10/90, v/v) in both plants.

Table 1. Separation of plant growth inhibiting substances contained in *Perilla frutescens and P. crispa* by charcoal-celite column chromatography.

Eluate Water: Acetone (v/v)		Growth inhibition[1]	
		P. frutescens	*P. crispa*
40	60	–	–
30	70	±	±
20	80	+++	+++
10	90	++	++
0	100	±	±

[1] Bioassay: rice seedling cv. Tan-ginbozu

The biologically active eluates were combined, concentrated in vacuo, and further purified by TLC with n-hexane/ether (5/1. v/v) solvent system. As a result (Fig. 2), five zones at Rf 0.13, 0.20, 0.28, 0.48 and 0,80 in *P. frutescens* and four zones at Rf 0.15, 0.30, 0.45 and 0.80 in *P. crispa* were detected under UV light. Among them, only a substance which appeared at Rf 0.48 in *P. frutescens* and at Rf 0.45 in *P. crispa* showed a strong growth inhibiting activity and a deep yellow color with aldehyde reagent (0.5%, 2,4-dinitrophenylhydrazine in 2N HCl) spray. From the results, plant growth inhibiting substances contained in both plants resembled to each other and were considered to be aldehyde or ketone.

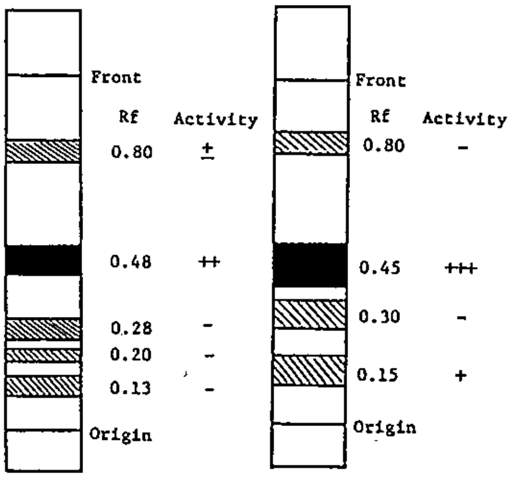


Fig. 2. Thin-layer chromatograms of the active fraction from charcoal-celite column chromatography.
Perilla frutescens (left) and *P. crispa* (right). Silica-gel TLC plate ... Whatman LK 6,5 x 20cm. Developing solvent ... n-Hexane:Ether 5:1 (v/v)

Biologically active zones were scraped off from TLC plates, eluted with methanol, then UV and GC-MS analyses were carried out. UV-absorption spectra (Fig. 3) clearly showed that the active substance in *P. frutescens* was different from the one in *P. crispa*. As shown in Fig. 4, fragment peaks of MS: m/e 166 M^+, 151, 137, 123, 110, 95, 81, 67, 55, 43, 39 in *P. frutescens* and 150 M^+, 135, 122, 107, 93, 91, 79, 77, 68, 67, 53, 41, 39 in *P. crispa* were obtained, respectively. From the results, plant growth inhibiting substances were identified as perilla ketone for the former and perillaldehyde for the latter. These substances were already known as components of essential oils in these plants (1).

Although enough samples were not available, preliminary experiments revealed that 100 ppm perilla ketone inhibited about 100, 70% and perillaldehyde inhibited about 70, 46% in the root and shoot growth of rice seedlings, respectively. These substances showing strong plant growth inhibition seem to be closely related to allelopathy of *P. frutescens* and *P. crispa*, further study, however, is essential to clarify the phenomenon.

ACKNOWLEDGEMENT

The author wishes to express his sincere gratitude to Mr. Akira Yamamoto, Shinetsu Chemical Ind. Co., Ltd., Japan for GC-MS analysis.

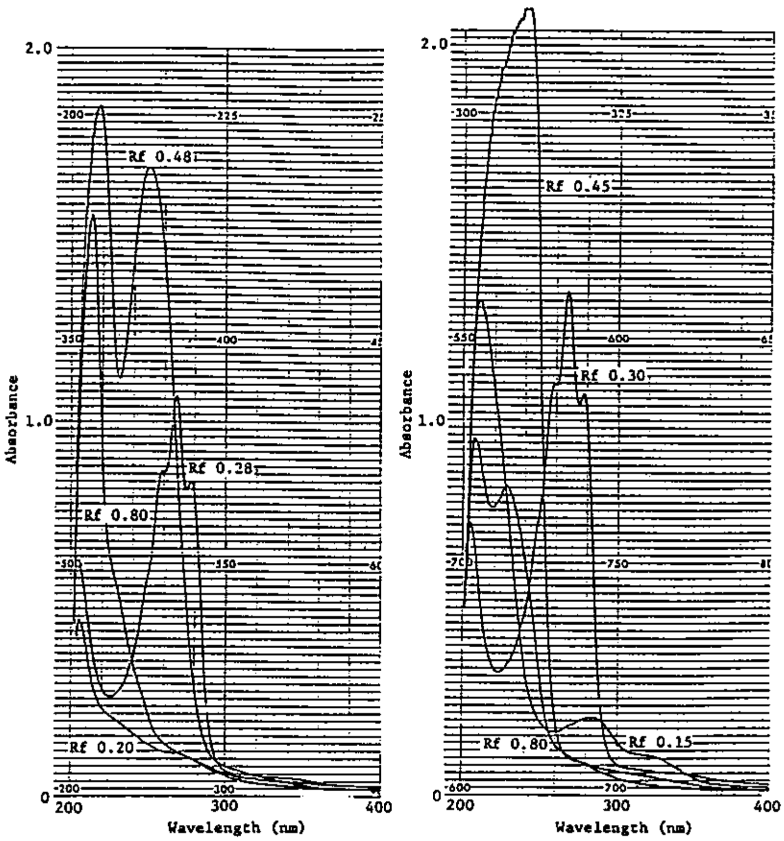
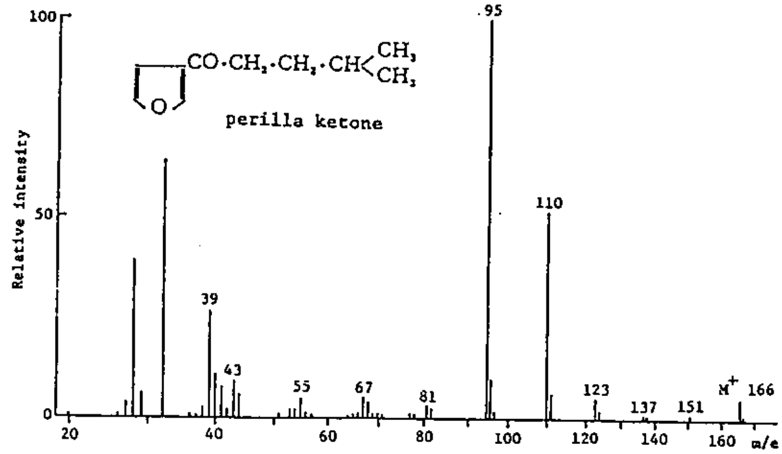


Fig. 3. UV-absorption spectra of methanol solution of the substances isolated from *Perilla frutescens* (left) and *P. crispa* (right).



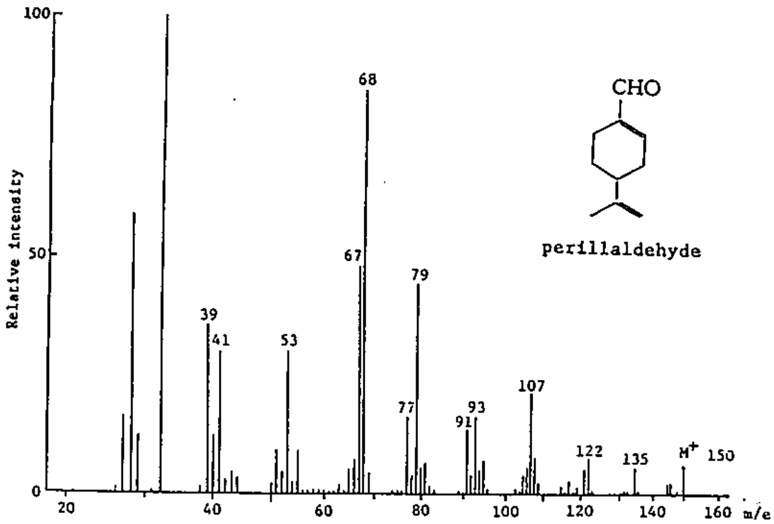


Fig. 4. Mass spectrograms of plant growth inhibiting substances isolated from *Perilla frutescens* (upper) and *P. crispa* (lower).

LITERATURE CITED

1. Okuda, O. 1967. Hanbook for perfume chemistry, Hirodawa Pub. Co., Tokyo, 503pp.
2. Sugawara, S. 1980. Weed control in the slash-and-burn method of agriculture. Weed Res. (Japan) 25: 300-303.
3. Sugawara, S. 1982. Studies on the shifts in weed vegetation in the maturation process of farms. 12. The effective control of weeds by planting *Perilla frutescens.* Weed Res. (Japan) 27: 184-190.

ALLELOPATHIC POTENTIAL OF *DIGITARIA ADSCENDENS*: INHIBITORY EFFECTS OF PREVIOUSLY GROWN SOIL ON CROP GROWTH AND WEED EMERGENCE

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ABSTRACT

Two soils previously grown with *Digitaria adscendens* Henr. and soybean were compared for effects on winter weed emergence and on growth of subsequent crops. In *Digitaria* plot the number of weed seedlings emerged in the following winter was only about one-third of that in the soybean plot. Surface soils were then potted in May and growth responses of several crops were tested: Stem length and leaf chlorophyl content of cucumber as well as fresh weight increase and nodulation of soybean were less in *Digitaria* soil. Since these results appeared to have implicated allelopathy, further experiments were carried out using weed-free soil as a check in place of soybean soil: Soil previously grown with *D. adscendens* showed selective inhibitory effects on crop growth, cucumber being most susceptible. Inhibition of seed germination also varied among species.

INTRODUCTION

Digitaria adscendens is one of the most troublesome weeds distributed through temperate to tropical zones, and dominated in many kind of habitats. Such wide distribution is attributable not only to its high adaptability to the various environments but also to its strategic capacity for suppressing surrounding species, in which allelopathy must take an important part.

Allelopathic potential of *D. adscendens* has already been proven in the previous paper (2). The purposes of this study, therefore, were 1) to confirm the inhibitory effect of field soil in which this weed has grown previously and 2) to determine whether the allelopathic influences affect on the growth of succeeding crops.

MATERIALS AND METHODS

Experiment–1. Effect on winter weed emergence The experiment was conducted twice, from 1983 to 1984 and from 1984 to 1985, in the Experiment Farm of Kyoto University. Weed emergence was compared between three treatments where *D. adscendens*, soybean and their mixture were planted in the previous year. Two blocks (2.4 m x 3.0 m each) were randomly assigned per treatment in the eastern and western halves of the experimental area. The weed and soybean were sown in late June and grown until the end of October. Thereafter the aerial parts were removed and the soil was kept undisturbed until the measurement in the next spring. In mid-April weed seedlings emerged were counted for 1 m^2 per block.

Experiment–2. Effects on succeeding crops (I) The experiment was carried out in the greenhouse in

1984. Effects of the soil prepared in Experiment–1 were determined using cucumber, soybean and corn as test plants. Soil of 100 cm x 50 cm and 0–5 cm deep was collected per block just after the weed counting and placed in 1/10,000 acre Wagner pots. Five pots per block were used for one crop species. Three seeds were sown per pot for each crop on May 18 and seedlings were thinned to one in a week after emergence. Fertilizers N, P and K at 10 g/m^2 each were applied on May 23, and pots were irrigated every day to keep optimum soil moisture. The plants were allowed to grow for 4 to 5 weeks depending on the growth rate of crop species. Then they were harvested and plant length, leaf number, fresh weight and several other characters were measured.

Experiment–3. Effects on growth of succeeding crops (2) In this experiment weed free soil was used as the control. Soil was prepared in 1986. *D. adscendens* were grown in 2 blocks of 1 m x 1 m for a season and other 2 blocks were kept free from weeds. In November 10 cm of surface soil was gathered, air-dried and stored at 5°C.

On May 22, 1987 the soil was potted and corn, wheat, cucumber, tomato, Japanese radish, lettuce and soybean were seeded. Seedlings were thinned to one plant per pot and allowed to grow for 5 to 6 weeks. Eight pots per treament were used for one crop. Other procedures and measurements were practiced in the same manner as in Experiment–2.

RESULTS AND DISCUSSION

Effect on weed emergence Total number of weed seedlings in April was least in *Digitaria* treatment, followed by that in *Digitaria* + soybean treatment (Table 1). The same trend was obtained both in 1984 and 1985. Seedling numbers of the dominant species; *Erigeron* spp., *Ceratium glomeratum, Cardamine flexuosa, Capsela brusa-pastoria* and *Veronica persica,* were generally reduced in order of soybean, *Digitaria* + soybean and *Digitaria.* Growth amount of *D. adscendens* in the previous year in *Digitaria* + soybean plot was approximately 40% of that in *Digitaria* plot, while that of soybean in the mixture was about 80% of single planting. Therefore, the amount of weed emergence was thought to be more proportional to the growth of *Digitaria* plants than that of soybean in the previous year. On the other hand, weed seedlings which were too small to be identified at counting were conversely most abundant in *Digitaria* plot.

These results suggest that *D. adscendens* roots must release some substances which inhibit weed germination during the winter time but are decomposed as the temperature rises in spring. Parenti and Rice (3) reported on allelopathic potential of *D. sanguinalis,* species closely related to *D. adscendens,* that root exudates of this species had strong inhibitory effects on other herbaceous species and it might play an important role in old field succession. The ability of *D. adscendens* to release substances whcih suppress the emergence of other herbs within its stands seems quite profitable for the gemination of its own seeds, by providing full light and critical alternate temperature on surface soils (5).

Effects on crop growth Growth of soybean planted in soils in which *D. adscendens* had grown previously was significantly reduced in fresh weight and number of root nodules formed (Table 2). Plant height was also affected by the treatments. In cucumber top and root growth did not differ significantly between the treatments, but some qualitative differences were observed: Plants in *Digitaria* treatment produced less number of male flowers, lower content of chlorophyll in leaves and showed more rapid fruit growth than two other treatments (Table 3). Values in *Digitaria* + soybean treatment

Table 1. Winter weed emergence in the fields where *Digitaria adscendens*, soybean and their mixture have grown previously[1].

Weed species	Number of seedlings / m²					
	1983–1984			1984–1985		
	D[2]	D+G[2]	G[2]	D	D+G	G
Erigeron spp.	4	12	2	138	240	475
Mazus pumilas	0	0	0	54	4	5
Veronica arvensis	16	1	1	2	0	8
V. persica	0	39	53	8	1	11
V. peragrina	0	1	0	3	14	17
Lamium amplexicaule	0	2	6	0	0	1
Trigionotis peduncularis	0	0	0	14	4	5
Astragalus sinicus	1	2	4	3	0	1
Cardamine flexuosa	4	16	8	35	35	70
Capsella bursa-pastoris	2	28	21	5	24	57
Cerastium glomeratum	69	350	806	82	193	200
Sagina japonica	0	0	5	6	3	4
Stellaria alsine	17	44	77	9	23	3
Other dicotyledons	2	5	5	0	0	2
Unidentified dicotyledons	53	28	29	10	15	1
Alopecurus aequalis	0	1	6	0	1	0
Poa annua	0	1	1	0	0	2
Total	168	530	1,046	369	557	862

[1] Data are indicated as means of 2 (eastern and western) blocks.

[2] D, G and D+G indicate *Digitaria*, soybean and their mixture, respectively.

Table 2. Growth of soybean plants planted in soils in which *Digitaria adscendens*, soybean and their mixture have grown previously.

Treatments	Fresh weight (g)		No. of nodes	Plant height (cm)	No. of nodules
	Leaf + stem	Root			
Digitaria	10.56a[1]	2.40a	8.9a	28.9a	47.4a
Digitaria + soybean	11.28ab	2.42a	9.0a	31.2b	110.2b
Soybean	12.01b	3.05b	9.2a	30.7ab	131.2b

[1] Numbers in a column followed by the same letter are not significantly different at the 5 % level by t-test.

Table 3. Growth of cucumber plants planted in soils in which *Digitaria adscendens*, soybean and their mixture have grown previously.

Treatments	Fresh weight (g)			No. of leaves	Plant height (cm)	No. of flowers		Chlorophyl Content(mg/l)
	Leaf+stem	Root	Fruit			♂	♀	
Digitaria	29.63a[1]	7.00a	15.48a	7.4a	27.8a	7.6a	2.6a	12.25a
Digitaria + soybean	28.13a	6.63a	1058a	7.3a	27.0a	7.6a	2.7a	14.86ab
Soybean	26.54a	6.48a	2.02b	7.9a	28.1a	11.3b	2.7a	17.86b

[1] Numbers in a column followed by the same letter are not significantly different at the 5% level by t-test.

were usually intermediate, both for soybean and cucumber. No significant effect was observed in corn growth.

Comparison of soil previously in contact with *Digitaria*, with weed free soil demonstrated more reliable results of inhibition by this weed (Table 4). Fresh weight of wheat and tomato was significantly reduced both in top and root, while only top weight decreased in corn, cucumer and soybean. Radish and lettuce were not affected. As the aerial parts of this weed, either extracted with water or incorpotated in soil, were known to inhibit root growth only(1), active substances contained in the top and the root might be different.

Table 4. Effects of field soil in which *Digitaria adscendens* has previously grown on the growth of several crops.

Test species	Part	Mean fresh weight (g)		
		Control	Test	
Corn	Top	8.22	6.82[2]	(83)[3]
	Root	3.74	3.52	(94)
Wheat	Top	2.72	2.05[2]	(75)
	Root	2.26	1.47[2]	(65)
Cucumber	Top	9.16	7.80[2]	(85)
	Root	1.50	1.71	(114)
Tomato	Top	7.67	5.76[2]	(75)
	Root	1.41	1.11[2]	(79)
Radish	Top	3.20	3.04	(95)
	Root	3.45	3.32	(96)
Lettuce	Top	2.55	2.75	(108)
	Root	1.06	1.36	(130)
Soybean	Top	6.00	5.21[1]	(87)
	Root	1.19	1.20	(101)

[1,2] Means followed by 1 and 2 are significantly diferent from control at the 5 and 1 % levels, respectively.

[3] Figures in parenthesis indicate percent of the control.

In cucumber in Experiment–3 there was not any qualitative change as found in Experiment-2. This may be due to the difference of inhibitor's concentration in soil between these two experiments. Plant height and fresh weight values were scattered in *Digitaria* treatment in Experiment–2 (Fig. 1): Some were lower but others were higher than those in soybean treatment. Many inhibitors have been known to show promotive effects at very low concentrations, and this is probably the same case. It is noticeable that the soil in contact with this weed has hormone-like activities as found in cucumber.

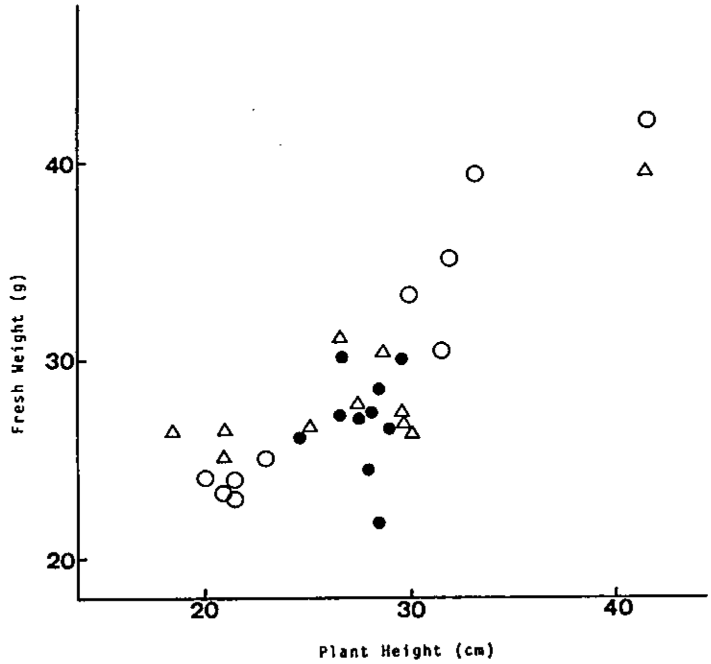

Fig. 1. Distribution pattern of fresh weight and plant height of cucumber plants planted in soils in which *Digitaria adscendens* (○), soybean (●) and their mixture (△) have grown previously.

LITERATURE CITED

1. Ito, M., Y. Matsushita, Y. Umeki and K. Ueki. 1981. Determination of physiological effects of grass mulch in orchard: Biosaay of leachate from weed residues (Japanese, English summary) Weed Sci. (Japan) 26: 221-227.
2. Ito, M. K. Kamada and K. Ueki. 1986. Determination of allelopathic potential of young and mature *Digitaria adscendens* on crop growth. Weed Sci. (Japan) 31: 116-123.
3. Parenti, R. L. and E. L. Rice. 1969. Inhibitional effects of *Digitaria sanguinalis* and possible role in old field succession. Bull. Torrey Bot. Club 96: 70-78.
4. Rice, E. L. 1974. Allelopathy. Academic Press, New York pp35-173.
5. Tsuyuzaki, H. and K. Nakagawa. 1987. Effects of burial condition on dormancy, germination and mortarity of *Digitaria adscendens* Henr. Weed Sci. (Japan) 32: In press.

THREE SUBMERGED AQUATIC WEEDS OF THE FAMILY HYDROCHARITACEAE IN JAPAN

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ABSTRACT

Around 1960, *Elodea nuttallii* (Planch.) St. John was noticed growing wild in Lake Biwa in Japan, and around 1970, *Egeria densa* Planch. was also first observed in the same place. Since then, their eventual spread and rapid colonization of diverse aquatic habitats has made it one of the most troublesome aquatic weeds, while *Hydrilla verticillata* (L.f.) Royle, one member of the same family, has long been established in Japan and is well known here as a native submerged aquatic weed. *Egeria* very closely resembles *Hydrilla* and sometimes it's not able to distinguish between the two weeds. The habitats where *Egeria* is allowed to grow vigorously require such waters as those which are more stagnant and more enriched than those of *Hydrilla*. The morphological variation of three species was estimated by comparing the morphology of various plants, collected from different parts of Japan, after cultivation under similar conditions. It appeared that large differences occur within the species of *Hydrilla*. In Japan, *Hydrilla* is dioecious and both the male and female plants have been found. Also both diploid (2n = 16) and triploid (2n = 24) of *Hydrilla* have been observed. *Elodea* can overwinter making a dense mat of vegetation just above the bottom. *Egeria* has a period of quiescence in the winter, and rootcrowns and stems containing double nodes are verified as the over-wintering and propagative structures. In the case of *Hydrilla,* in order to survive conditions unfavourable for growth, it produces two types of reproductive propagules, axillary turions and subterranean turions. Furthermore viable seed productions have been observed in Japan.

INTRODUCTION

One member of the family Hydrocharitaceae, *Hydrilla verticillata* (L.f.) Royle, is a native submerged aquatic weed which has long been established in Japan, and is now widespread throughout Japan, Around 1960, a new adventive species of the same family, *Elodea nuttallii* (Planch.) St. John was noticed growing wild in Lake Biwa, Japan (4), and around 1970, another adventive species, *Egeria densa* Planch. was also first observed in the same place (11). Since then, eventual spread of the introduced *Egeria* and *Elodea,* and their rapid colonization of diverse aquatic habitats has made it one of the most troublesome aquatic weeds. Extensive growth results in the slowing of water movement, and the impeding of water traffic and water-based works. At present, mechanical removal is the most popular control method, but this control provides only temporary relief and so expensive.

The purpose of this study is to provide basic information on habitats, morphology and propagation of these three submerged aquatic weeds for establishing an appropriate methods of weed management.

MATERIALS AND METHODS

Field observations were carried out from 1985 to 1987 in 102 aquatic habitats located in Okayama, Kagawa, Hyogo, Shiga, Tottori and Shimane prefectures, in the western part of Japan, including ponds, lakes, rivers, irrigations and drainage ditches. At each site, a vegetation community with dominant and predominant species was surveyed. The pH (DKK HP-22, pH meter), conductivity (KENIS CM-55, EC meter) and dissolved oxygen (DKK HDO-22, DO meter) were also measured at the actual sites. Furthermore surface water was sampled for chemical analysis such as NO_3-N,NO_2-N,NH_4-N,PO_4-P,$SO_4{}^{2-}$, Cl^-, Ca^{2+}, Mg, Na and K. Based on these investigations, the habitats of *Hydrilla, Egeria* and *Elodea* were given in this report.

Next thirty-eight strains of *Hydrilla* and 17 strains of both *Egeria* and *Elodea* were collected during summer of 1985 from different habitats of the western part of Japan including 2 strains of *Hydrilla* from Thailand.

In the phytotron under 14-h photoperiod at 15–25°C, a ramet of each collection was grown in a Wagner pot (1/5000 a) which was filled with tap water, and contained a layer of clay with a fixed rate of nutrients at the bottom. After 5 months of culture, each 10 shoot tips per one strain which had developed in the pots were examined for morphological parameters. Ten internodia of an actively growing stem apex, excepting 3 cm of shoot tip, were used. The data which were registered included: the number of leaves in each whorl, the number of nodes per 10 cm, the length and width of each leaf and the number of teeth along the margin of a chosen leaf in each whorl. The original material had been also examined for the same morphological parameters.

Chromosome numbers of *Hydrilla* were determined in metaphases from root-tips. Meristems were pre-treated with 0.002 molar aqueous solution of hydroxyquinoline and fixed in acetic alcohol (1:3). After maceration in 0.1 N hydrochloric acid for 5 minutes at 60°C squashes were prepared and stained with aceto-orcein solution.

RESULTS AND DISCUSSION

Habitats Three species showed the preference for neutral to alkaline waters, however, *Hydrilla* was present in water with wider pH range compared with *Egeria* and *Elodea.* The habitats where *Egeria* was allowed to grow vigorously require such waters as those which were more stagnant and more enriched than those of *Hydrilla* and *Elodea* (Fig. 1). According to Cook (1), *Hydrilla* is found in acidic oligotrophic to eutrophic waters and even tolerates strongly alkaline water. On the other hand, *Egeria* is reported that it seems to be somewhat commoner in acid and humus-rich waters, but also grows in calcareous eutrophic waters (2). In Japan, a similar result was observed by Kadono in 1982 (5) who reported it to be commonest in calcium-rich waters with high alkalinity (pH 6.4-9.2) and releatively high conductivity (0.07-0.49 mS/cm). In the case of *Elodea,* it is reported its greater tolerance of nutrient enrichment (10).

Morphology Comparison of morphology of *Hydrilla, Egeria* and *Elodea* after growing the plants under the same conditions for 5 months was shown in Table 1. Sometimes *Egeria* very closely resembles *Hydrilla* and it's not able to distinguish between the two weeds. According to Table 1, however, it was found that leaf characters, leaves in whorls, teeth along the leaf margin and internode were the means of

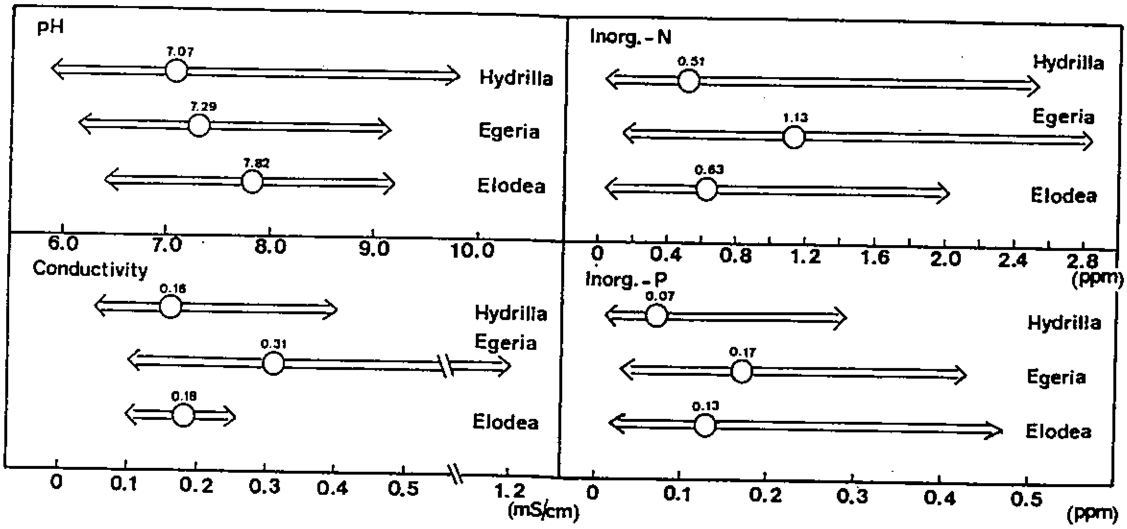

Fig. 1. Water quality in habitats of *Hydrilla, Egeria* and *Elodea.*

identification and included in most keys to three species though the range of these characters was often overlap. Namely *Egeria* tends to have wider and larger leaves than other two species, and nodes close together. *Elodea* has usually recurved leaves with inconspicuous teeth on the margins, but a lot of number of teeth was recorded in Table 1.

Table 1. Comparison of morphology of *Hydrilla, Egeria* and *Elodea* after growing the plants under the same conditions for 5 months.

		Hydrilla	*Egeria*	*Elodea*
Leaf form (Length/Width)	Mean ±S.D. Range	7.04 ± 1.17 5.10 – 11.13	4.34 ± 0.63 3.17 – 5.18	6.78 ± 0.99 3.69 – 8.14
Leaf surfaces (Length x Width)	Mean ±S.D. Range	25.48 ± 8.53 7.48 – 42.40	49.03 ± 6.37 33.74 – 56.90	12.61 ± 1.27 10.21 – 15.53
Number of leaves in a whorl	Mean ±S.D. Range	5.60 ± 0.70 4.10 – 6.80	3.67 ± 0.43 3.00 – 4.55	2.89 ± 0.13 2.67 – 3.00
Number of teeth along the leaf margin/cm	Mean ±S.D. Range	14.72 ± 2.24 8.41 – 20.59	20.49 ± 2.50 15.42 – 23.90	35.17 ± 1.67 30.40 – 37.47
Number of nodes/ 10 cm	Mean ±S.D. Range	13.58 ± 3.03 8.43 – 22.86	40.99 ± 7.24 29.53 – 63.30	25.74 ± 3.32 20.85 – 33.14
Number of strains		38	17	17

Cook (1) reported that *Hydrilla* was highly plastic and readily modified by changes in the environment, however, even after 5 months of culture under the same conditions, morphological variations such as leaf length, leaf width and number of leaves in a whorl within the strains of *Hydrilla* were observed significantly different (Figs. 2 and 3). These figures showed that there was no obvious distinction between the sexes in morphological parameters. When we had just collected *Hydrilla* plants from various sites, the most obvious differences of original materials were in general appearance, which were mainly due to the size of the leaves and the thickness of the stems. Certain plants were relatively slender and delicate, while other plants were relatively robust. From our unpublished data, it was found that in general the leaf size became smaller and the differences of general appearance have disappeared gradually when the plants were cultivated under the same conditions. However, some plants showed significant differences in their morphology except the number of teeth along the leaf margin which was readily modified by changes in the environment. A similar result was observed by Verkleij in 1983 (12).

In contrast to Hydrilla, the characters of *Egeria* and *Elodea* were not so variable within the strains, for example, in *Egeria* the leaves were mostly in whorls of 4, while in *Elodea* they were mostly in whorls of 3 (Fig. 3). Fig. 3 showed also internode was the better character for distinction among three species.

All thirty-six strains of *Hydrilla* in Japan were dioecious and both male and female plants have been found, while 2 strains from Thailand were monoecious. Also both diploid (2n = 16) and triploid (2n = 24) of *Hydrilla* have been observed (Table 2 and Fig. 4). In the case of our collected Japanese materials it would seem that triploids dominate. However, there was no obvious distinction between the chromosome numbers in morphological parameters after 5 months of culture under the same conditions. A list of chromosome counts throughout the world is presented in the papers of Cook (1) and Verkleij

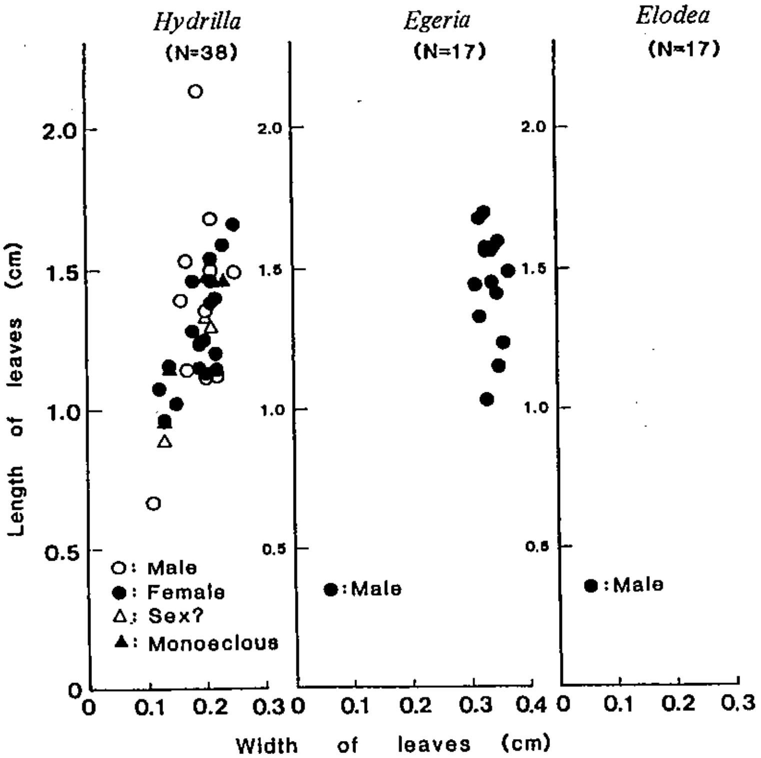

Fig. 2. Variation in leaf form of *Hydrilla, Egeria* and *Elodea* after 5 months of culture under the same conditions.

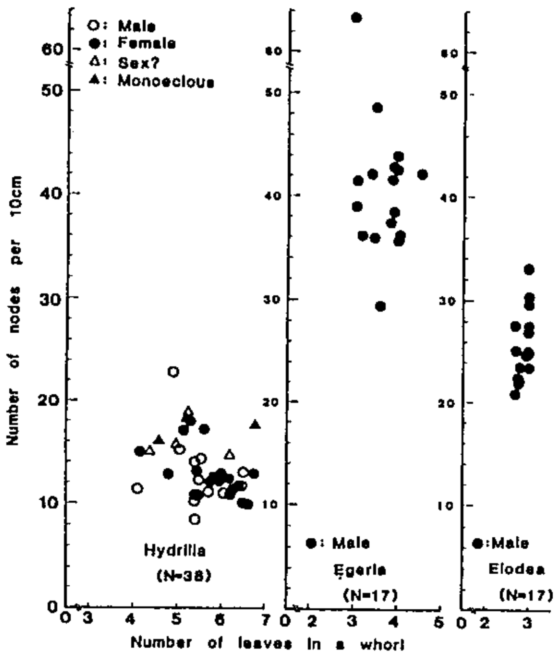

Fig. 3. Variation in morphological parameter of *Hydrilla, Egeria* and *Elodea* after 5 months of culture under the same conditions.

(12). According to them, the number of chromosomes which has been observed in *Hydrilla* strains is either 16 or 24, and the diploids are widely distributed. A tetraploid (2n = 32) has been found only in Alabama, U.S.A. In Japan both diploid and triploid plants were already found in 1928 by Sinoto and Kiyohara (9).

On the other hand, in both *Egeria* and *Elodea,* male plants have found only in Japan.

Propagation Reproductive methods of three species are as follows: *Hydrilla* ; stem fragments, axillary turions that form in the leaf axils, subterranean turions that develop in the mud. *Egeria* and *Elodea* ; stem fragments.

As mentioned before, in both *Egeria* and *Elodea,* female plants are missing so that they are not able to produce viable seeds. Consequently they propagates only by stem fragments.

Elodea can overwinter making a dense mat of vegetation just above the bottom. More detailed information can be obtained by referring to the papers by Kunii (7,8). Also *Egeria* has a period of quiescence in the winter, and rootcrowns and stems containing double nodes are observed as the over-wintering and propagative structures in Japan as shown in South Carolina, U.S.A. (3).

In the case of *Hydrilla,* it produces 2 types of reproductive propagules, axillary turions and subterranean turions as well as stem fragments. Two types of turions usually produce new plants in the spring. From our observation, It was found that the shape of both 2 types of turions from Thailand strains differed from those of our collected Japanese materials. The differences in their appearance have led to suggest the presence of intraspecific variation between the tropical material and the temperate one. Besides it was found by Kadono (6) that subterranean turions from some *Hydrilla* plants grown in Kyushu area, in the south part of Japan, were similar to those of tropical plants. Furthermore viable

Table 2. Sex and number of chromosomes of *Hydrilla*.

Strain number	Sex	Number of chromosomes	Habitat
N–2 (Okayama)	Male	2n = 24	Drainage
N–14 (Okayama)	Male	16	Pond
N–16 (Okayama)	Female	24	Drainage
N–19 (Okayama)	Female	16	River
N–20 (Okayama)	Female	24	River
N–21 (Okayama)	Male	24	River
N–21 (Okayama)	Female	24	River
N–22 (Okayama)	Male	16	River
N–22 (Okayama)	Female	16	River
N–23 (Okayama)	Male	24	River
N–25 (Okayama)	Male	16	River
N–25 (Okayama)	Female	16	River
K–2 (Kagawa)	Female	24	River
K–3 (Kagawa)	Female	16	River
K–5 (Kagawa)	Female	24	Pond
K–6 (Kagawa)	Female	24	Drainage
K–7 (Kagawa)	Female	24	Drainage
B–1 (Biwa lake)	Female	24	Lake
B–3 (Biwa lake)	Male	24	Lake
B–5 (Shiga)	Female	24	Pond
T–1 (Tottori)	Male	24	Pond
M–1 (Shimane)	Female	24	Pond
M–2 (Shimane)	Female	24	Pond
M–4 (Shimane)	Male	24	Pond
M–6 (Shimane)	Female	24	Drainage
M–8 (Shimane)	Female	24	Drainage
Thai–1 (Bangkok)	Monoecious	16	Drainage
Thai–2 (Bangkok)	Monoecious	16	River
Hy–2 (Hyogo)	Female	16	Pond

seed productions have been observed in Japan.

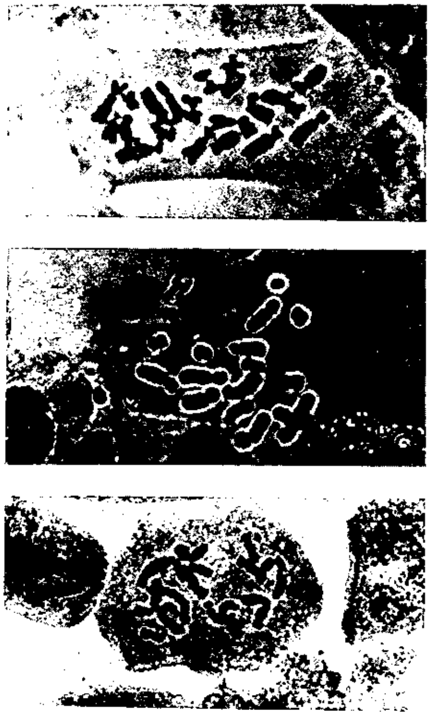

Fig. 4. Somatic chromosomes of *Hydrilla.*
top: dioecious (2n = 24)
center: (2n = 16)
bottom: monoecious (2n =16)

CONCLUSION

Hydrilla is long established and has reached all waters to which it is suited, but it's rarely reported to be a serious weed in Japan. In contrast to *Hydrilla, Egeria* and *Elodea* are newly established and they have been expanding its range in Japan. They produce dense mats of vegetation and often dominate the water where they grow. The success of *Egeria* and *Elodea* in Japan is a function of their ability to overwinter and reproduce vegetatively in the following spring so quickly by means of specialized structures. Also these naturalized plants are suited to more enriched waters though *Hydrilla* appears to have a wider range of adaptability, and the invasion of *Egeria* and *Elodea* is dependent of the result of man's activity. At present, it is observed ,that there is an overlapping area where three species grow together. We must know urgently whether the invasion of these species into water bodies which has resulted in the displacement of *Hydrilla* or not.

On the other hand, it's reported that many water bodies are threatened by *Hydrilla* throughout the tropical regions. From our study that significant differences in their morphology occur within the strains of *Hydrilla,* we suggest Japanese materials differ so widely from alien materials. Now we are conducting studies comparing the physiology and the ecology of various strains, and also isoenzyme patterns of various strains have been determined electrophoretically.

LETERATURE CITED

1. Cook, C.D.K. and R. Lüönd. 1982. A revision of the genus *Hydrilla* (Hydrocharitaceae). Aquatic Bot. 13:485-504.
2. Cook, C.D.K. and K. Urmi-könig. 1984. A revision of genus *Egeria* (Hydrocharitaceae). Aquatic Bot. 19: 73-96.
3. Getsinger, K.D. and C.R. Dillon. 1984. Quiescence, growth and senescence of *Egeria densa* in Lake Marion. Aquatic Bot. 20:329-338.
4. Ikusima, I. and H. Kabaya. 1965. A new introduced aquatic plant, *Elodea occidentalis* (Pursh) St. John in Lake Biwa, Japan. J. Japan. Bot. 40: 57-64.
5. Kakono, Y. 1982. Occurrence of aquatic macrophytes in relation to pH, alkalinity, Ca, Cl and conductivity. Jap. J. Ecol. 32:39-44.
6. Kadono, Y. 1987. Intraspecific variation of *Ottelia alismoides* and *Hydrilla verticillata.* Plants of Fukuoka (in press).
7. Kunii. H. 1981. The critical water temperature for the active growth of *Elodea nuttallii.* Jap. J. Ecol. 32: 111-112.
8. Kunii, H. 1982. Characteristics of the winter growth of detached *Elodea nuttallii* in Japan. Aquatic Bot. 11: 57-66.
9. Sinoto, Y. and K. Kiyohara. 1928. A preliminary note on the chromosomes of *Hydrilla verticillata.* Bot. Mag., Tokyo 42:82-85.
10. Stuckey, R. 1971. Changes of vascular aquatic flowering plants during 70 years in Put-in-Bay Harbour, Lake Erie, Ohio,Ohio. J. Sci. 71:321-342.
11. Tanimizu,K. and T. Miura. 1976. Studies on the submerged plant community in Lake Biwa. Physiol. Ecol. Japan 17:283-290.
12. Verkleij. J.A.C. 1983. A comparative study of the morphology and isoenzyme patterns of *Hydrilla verticillata.* Aquatic Bot. 17:43-59.

ACTIVITY OF MON 7200 MIXTURE WITH SULFONYL UREA HERBICIDES IN TRANSPLANT RICE

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ABSTRACT

Mixture of MON 7200 with sulfonyl urea herbicides covers a weakness of sulfonyl urea herbicides on *Echinochloa crus-galli*. No antagonism between MON 7200 and sulfonyl urea herbicides was observed and these mixtures gave very wide weed spectrum at extremely low rates. These mixtures gave excellent control of major annual and perennial weed species up to *E. crus-galli* 2.0 leaf-stage application timing. The mixtures showed good rice safety even at 0 day after transplanting application. Temperature and soil types did not affect the activity of the mixtures. The mixtures maintained high activity on *E. crus-galli* until 70 days after transplanting.

INTRODUCTION

Currently several rice herbicides have been developed to provide wide range weed control through the rice cultivation period with one application. Sulfonyl urea herbicides give excellent control of many problem weeds in paddy fields at extremely low rate. This chemistry, however, shows only fair control of barnyardgrass which is the most important weed in paddy rice. MON 7200, which was discovered by Monsanto Co., has very high unit activity and good longevity on barnyardgrass. It was expected that the mixture of MON 7200 and sulfonyl urea herbicides could be the highest active one shot rice herbicide giving excellent control of all problem weeds including barnyardgrass. This paper describes the activity of this mixture.

MATERIALS AND METHODS

The mixtures of MON 7200 with two sulfonyl urea herbicide, bensulfuron methyl (DPX-F5384) and pyrazosulfuron-ethyl (NC–311) were evaluated.

Field test method Rice seedlings of 2.5 leaf-stage were transplanted by machine or hand. Puddling was coducted at 3 to 4 days before transplanting. Weed seeds and propagules were planted at 1 to 2 days before transplanting if necessary. Paddy water depth was held at 3 cm throughout the test period. Chemicals were applied to soil surface. Plots were randomized complete block design with three replications. Plot size was 4 m^2 (2m x 2m). Visual assessment was made at each observation.

Pot test method The tests were conducted in the growth chamber lighted 350 μE 14 hours a day. Temperature was set 27°C in day time and 20°C in night time. Rice seedlings of 2.5 leaf-stage were transplanted by hand after puddling. Weed seeds and propagules were planted before transplanting. Water was flooded at 3 cm deep throughout test period. Chemicals were applied to soil surface with three replications at each dose. Pot size was 0.24 m^2 . For the test to determine rice safety different transplanting depth, rice seedlings were transplanted at 1 cm deep or just placed on soil surface. Flooded water was kept at 1, 3 or 6 cm deep for water depth test. Visual assessment was made at each observation.

RESULTS

Herbicidal activity The mixture of MON 7200 at 120 g ai/ha with bensulfuron methyl at 25 g ai/ha showed excellent efficacy on many problem weeds in rice paddy such as, barnyardgrass, *Monochoria vaginalis, Scirpus juncoides, and Cyperus serotinus* for pre to early post-emergence application. This mixture could control other problem perennial weeds such as, *Sagittaria pygmaea* and *Sagittaria trifolia* at 120/50 g ai/ha and gave marginal control of *Eleocharis kuroguwai* at 120/75 g ai/ha (Table 1). Neither antagonism nor synergism were observed between the two chemicals (Fig. 1). MON 7200 with pyrazosulfuron-ethyl at 120/21 g ai/ha had almost equal weed spectrum to that of MON 7200/ bensulfuron methyl at 120/51 g ai/ha (Table 2). Application window of these two mixtures was summarized in Fig. 2. MON 7200/bensulfuron methyl gave excellent control of barnyardgrass up to 2.0 leaf-stage. The same trend was obtained with MON 7200/pyrazosulfuron-ethyl. The mixture of MON 7200/bensulfuron methyl provided about 70 days control of barnyardgrass, while longevity of mefenacet/bensulfuron methyl at 1,200/75 g ai/ha was about 40 days (Fig. 3). The mixture of MON 7200/bensulfuron methyl gave consistent control of barnyardgrass from soil pH 4.9 to 7.4, while the activity of bensulfuron methyl on barnyardgrass was very much affected by soil pH (Fig. 4). The weed efficacy of MON 7200/bensulfuron methyl and MON 7200/pyrazosulfuron-ethyl was not affected by different soil type, organic matter content, temperature and water depth conditions.

Table 1. Weed spectrum of MON 7200/Bensulfuron methyl

	Rate (g ai/ha)[1]		
Weeds	MON 7200	Bensulfuron methyl	MON 7200/ bensulfuron methyl
Annual			
Echinochloa crus-galli	120	>75	120/25
Monochoria vaginalis	120	25	60/25
Perennial			
Scirpus juncoides	>120	25	60/25
Cyperus serotinus	>120	25	60/25
Sagittaria pygmaea	>120	50	60/50
Sagittaria trifolia	>120	50	60/50
Eleocharia kuroguwai	>120	>75	>60/75

1 The rates which gave ⩾ 95% control of *E. crus-galli*
⩾ 90% control of the other weeds species.

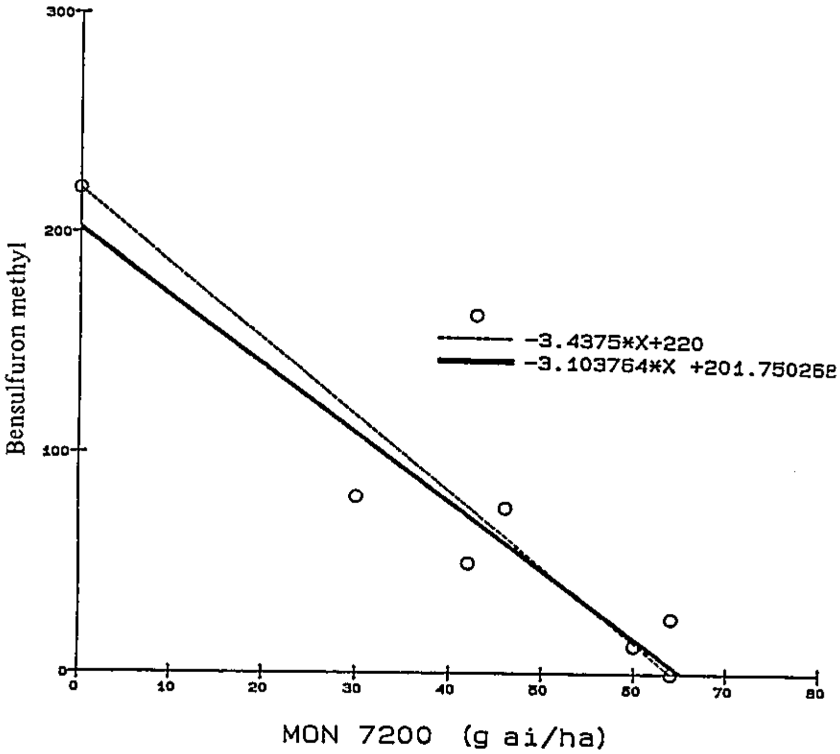

Fig. 1. Isobole of MON 7200/Bensulfuron methyl to give 90% control of barnyardgrass.

Table 2. Herbicidal activity of MON 7200/Sulfonyl urea

Chemicals	Rate (g ai/ha)	% Control			
		E. c.	*M. v.*	*S. j.*	*C. s.*
MON 7200/ bensulfuron methyl	120/51	99	100	98	93
MON 7200/ pyrazosulfuron-ethyl	120/21	98	99	97	94

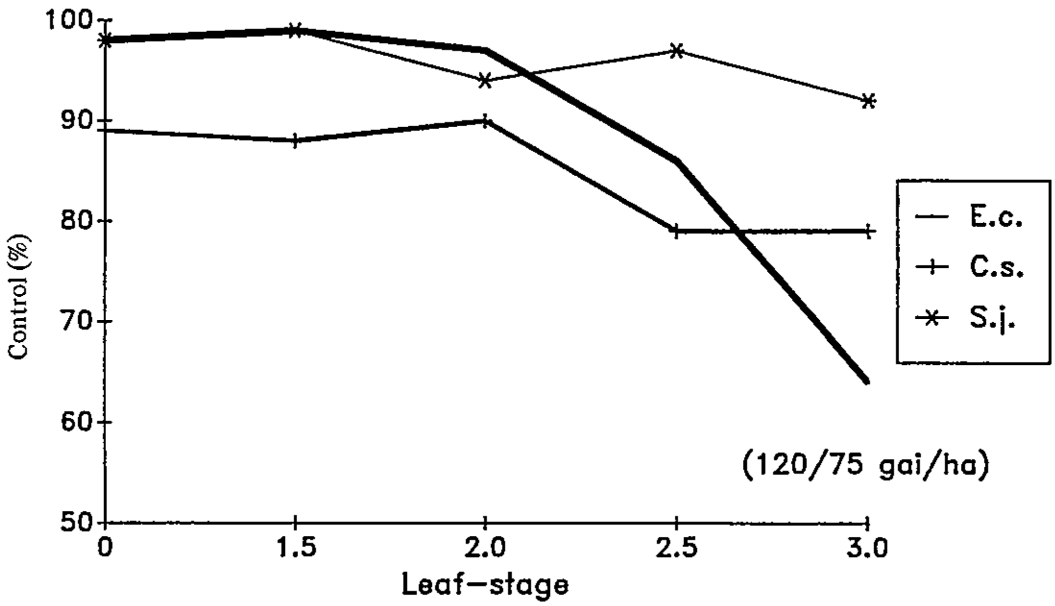

Fig. 2. Application window of MON 7200/Bensulfuron methyl mixture

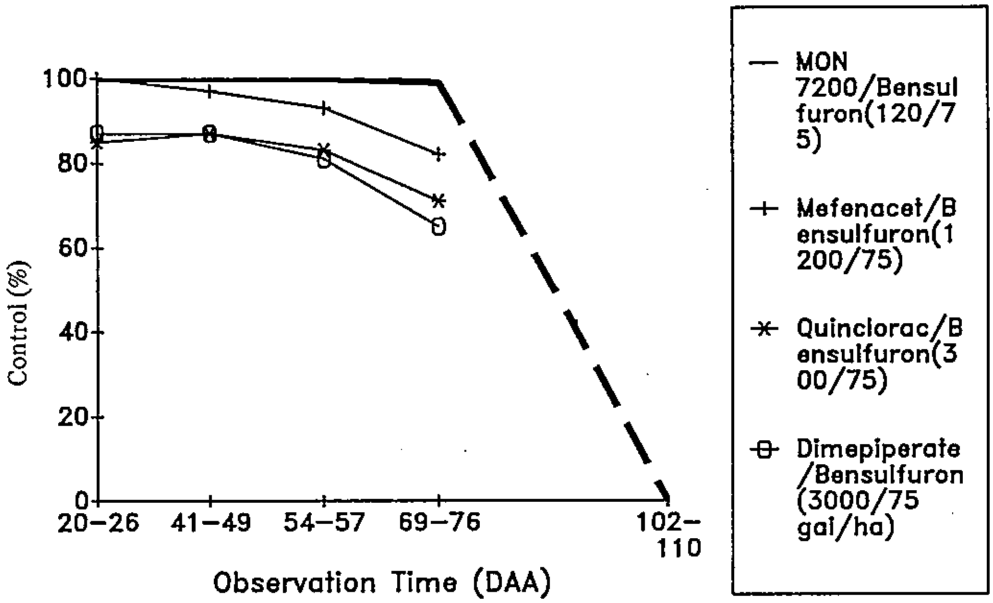

Fig. 3. Longevity of MON 7200/Bensulfuron methyl mixture on barnyardgrass.

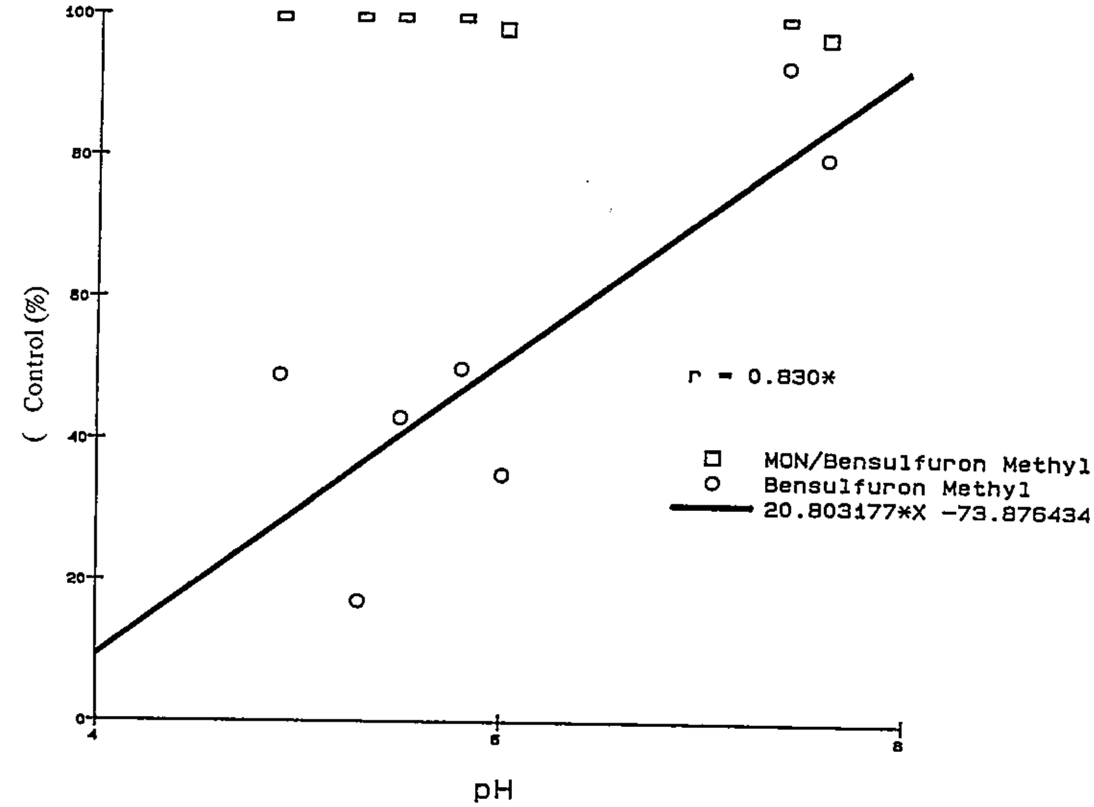

Fig. 4. Activity of MON 7200/Bensulfuron methyl on barnyardgrass in different soil pH.

Rice safety MON 7200/bensulfuron methyl at 120/75 g ai/ha and MON 7200/pyrazosulfuron-ethyl at 120/21 g ai/ha showed very good rice safety. These mixtures did not give any severe rice injury even at 0 DAT (days after transplanting) application. The rice safety of these mixtures was not affected by soil type, organic matter content, temperature and water depth conditions. Transplanting depth test showed that MON 7200/bensulfuron methyl and MON 7200/pyrazosulfuron-ethyl caused severe rice injury when basal stem of a rice seedling was exposed to flooded water, however, rice safety of these mixtures was very much increased when basal stem was covered with soil even at 1 cm transplanting depth (Fig. 5). This result indicated that it was important to avoid floating rice at transplanting time for using these mixtures safely.

DISCUSSION

The mixture of MON 7200/bensulfuron methyl and MON 7200/pyrazosulfuron-ethyl provide excellent control of almost all problem annual and perennial weeds from pre-emergence to 2.0 leaf-stage barnyardgrass applications with good rice safety. Both MON 7200 and sulfonyl urea herbicides have

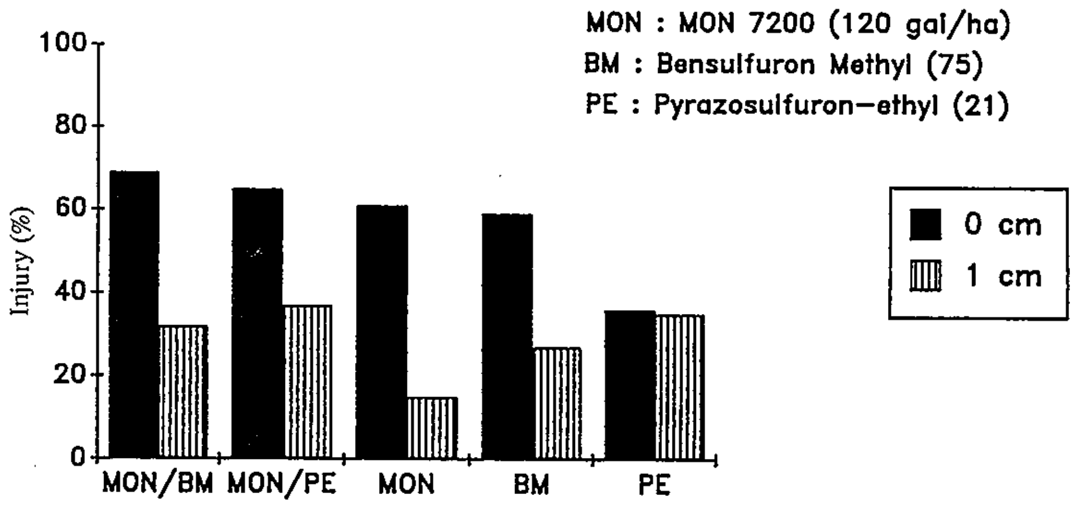

Fig. 5. Rice safety of MON 7200/Sulfonyl urea mixtures with different transplanting depth.

extremely high unit activity and the recommended rates are 120/25-75 g ai/ha for MON 7200/ bensulfuron methyl and 120/21 g ai/ha for MON 7200/pyrazosulfuron-ethyl. The most important property of these mixtures is their longevity on barnyardgrass (70 days) indicating that these mixtures were effective especially in cool climate areas where barnyardgrass germinated slowly as well as warm areas. It was concluded that the mixtures have high potential to be the highest unit active one shot herbicides in transplant rice in Asia.

A FIELD TECHNIQUE FOR EVALUATING "RAINFASTNESS" OF HERBICIDES

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INTRODUCTION

The evaluation of rainfall effects on foliar herbicide applications has been studied for years. Rainfall simulators are accurate but difficult to use when tested in remote locations or when the objective of the experiment is to screen a large number of formulations and/or timings from application to rainfall (critical rainfree periods).

During 1986, Monsanto Australia Limited conducted a series of field trials to determine if different formulations of glyphosate or addition of various additives to glyphosate could improve the ability of glyphosate to tolerate rainfall soon after treatment.

A simple, repeatable testing method was developed to rapidly evaluate glyphosate formulations and additive candidates to measure the critical rainfree period between application and rainfall.

MATERIALS AND METHODS

In developing a critical rainfree period evaluation technique the following criteria for the method must be met for maximum usefulness. The technique needs to be simple, reliable, repeatable, allow for treatment replication, and to be operated by a single field officer if necessary.

A simulated heavy rainfall of 10 mm can be obtained by diverting a 10L volume of water over a $1m^2$ area. The volume of water is evently applied within the $1m^2$ quadrat by a 10L watering can.

The simulated rainfall is normally delivered over a five minute period which provides an extreme rainfall event. This method simulates a worst case situation but was considered acceptable for evaluation of a commercial critical rainfree period when commercial standards are used in the trials.

A design for a simple trial is shown in Fig. 1. This involves four treatments and four timings of simulated rainfall. The operator marks the trial in a normal manner and randomly places four pegs in each treatment to locate the rainfall quadrants. Plots are then sprayed, the application time recorded, and time for application of simulated rainfall noted on the worksheet.

A commercial glyphosate formulation Roundup (Registered trademark of Monsanto Company, USA.) (360 g/L glyphosate) was applied at the commercial rate for the species present. It was evaluated against a commercial formulation and rate of fluazifop, Roundup® plus ammonium sulphate, and MON 8794, an experimental glyphosate formulation. All treatments were applied in a 100L/ha spray solution.

a) TRIAL DESIGN OF SINGLE REPLICATE

A	B	B	C	D	A	B	C
C	D	A	D	B	C	D	A
TRT 1		TRT 2		TRT 3		TRT 4	

b) RECORDING FORM SHOWING HERBICIDE TREATMENTS AND CRITICAL RAINFREE PERIODS

Treatment	1	2	3	4
Time sprayed				
1 hour due (A)				
Completed				
2 hour due (B)				
Completed				
4 hour due (C)				
Completed				
6 hour due (D)				
Completed				

Fig. 1. A single replication of a trial design and recording form for field evaluation of simulated rainfall following herbicide applications.

RESULTS AND DISCUSSION

The four chemical treatments were tested over 6 critical rainfree periods in 10 locations. Treatments are listed in Table 1 and results are displayed in Fig. 2. Results presented are means across all trial locations.

The significant reduction in efficacy of glyphosate herbicides which is caused by rainfall soon after application is illustrated in Fig. 2. The addition of ammonium sulphate to Roundup improved weed control efficacy when rainfall occurred two to three hours after application.

MON 8794 showed enhanced performance compared to both Roundup and Roundup/ammonium sulphate treatments under the same rainfall regimes. The results would support the labelled rainfall free periods claimed for fluazifop and Roundup.

CONCLUSION

The test procedure outlined provided a repeatable field evaluation technique to evaluate the critical

Table 1. Critical rainfree period determination for Glyphosate over 10 field locations in Australia.

Treatment	Rate	% weed control by interval to rainfall (Critical Rainfree Period)					
		0.5 hr	1.0 hr	2.0 hr	3.0 hr	4.0 hr	No. Rain
Roundup	N [1]	20	26	35	34	65	82
Roundup + Ammonium sulphate	N	20	28	44	48	60	86
MON 8794	N	50	56	68	82	81	96
Fluazifop	N	–	72	54	60	65	71

[1] Where N is the commercial herbicide rate necessary for control of the weed species present.

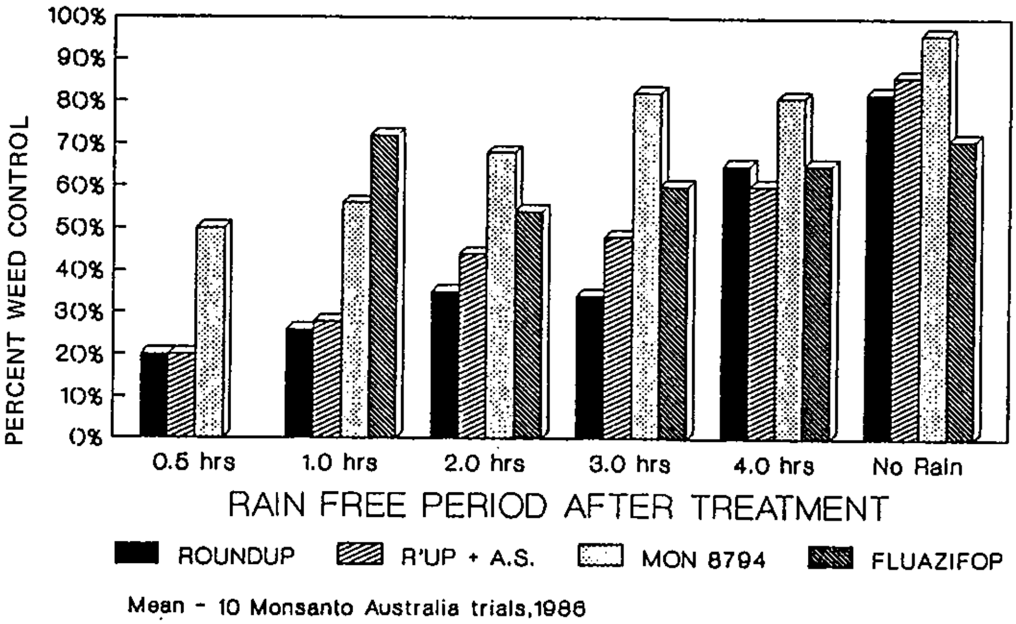

Fig. 2. Critical rainfree period for Glyphosate formulations.

rainfree periods of glyphosate herbicides and should be extendable to other herbicides.

The evaluation technique requires a simple watering container and a supply of water in addition to normal plot application equipment. Limitations exist if test species are tall growing herbaceous plants or trees and brush. However for low growing herbaceous species the results correlate closely with product labels. The inclusion of a commercial standard will show large relative differences between treatments which can be studied in greater detail if desired.

FATE OF THE HERBICIDE NAPROANILIDE IN A RICE PADDY MODEL ECOSYSTEM

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PURPOSE

Using ^{14}C-naproanilide to study the fate of the herbidide in rice paddy model ecosystem.

MATERIALS AND METHODS

1. ^{14}C-Naproanilide was uniformly labelled at the naphthalene ring with specific activity 1.65 mCi/mmole.
2. Authentic compounds included 2- (2-naphthoxy) -propionic acid, methyl-2-(2-naphthoxy) propionate, 2-naphthol, 2,3-naphthalenediol, 2,6-naphthanlenediol, 2,7-naphthalenediol, 1-naphthylamine and 2-hydroxy-1,4-naphthoquinone.
3. Model ecosystem was first developed by R.L.Metcalf (1971). It was modified by Hsu (1979) by substituting the biota existed in paddy field in Taiwan (Fig. 1).

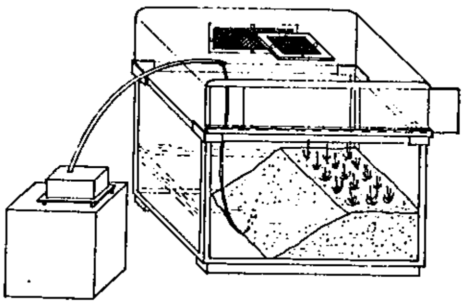
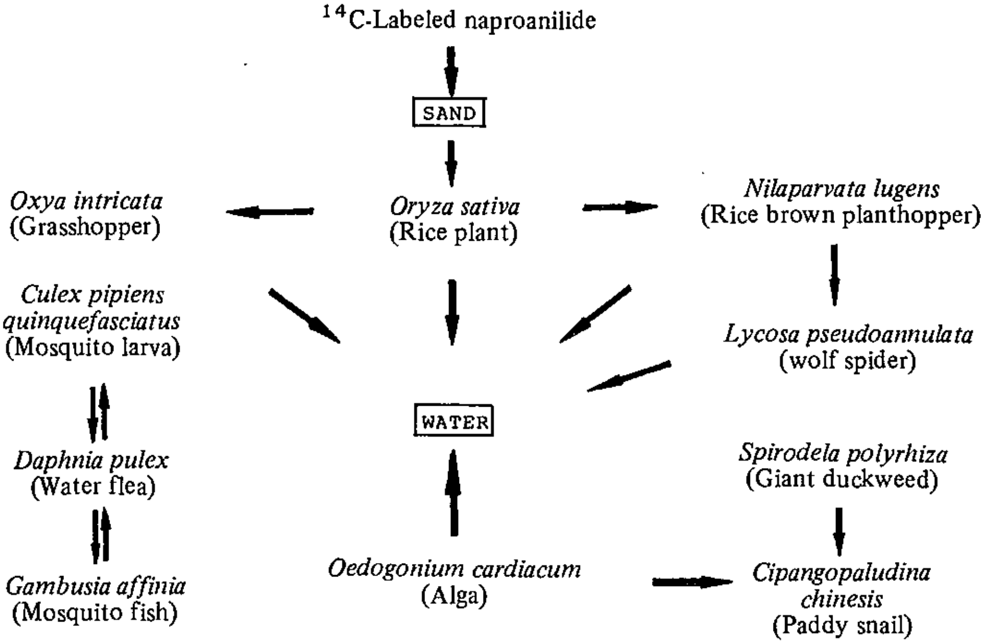


Fig. 1. The rice paddy model ecosystem.

4. The biota involved in this system were rice plant, rice brown plant-hopper, wolf spider, grasshopper, duckweed, alga, water flea, mosquito larva, paddy snail and mosquito fish (Fig. 2).
5. The metabolites were identified by thin layer chromatography and cochromatography. They were quantified by liquid scintillation counter.

RESULTS

1. Nine metabolites, 2-(2-naphthoxy) -propionic acid (I), methyl-2-(2-naphthoxy) propionate (II), 2-naphthol (III), 2,3-naphthalenediol (IV), 2,6-napthalenediol (V), 2,7-naphthalenediol (VI), 2-



Eig. 2. Food web of the organisms in the rice paddy model ecosystem.

hydroxy-1,4-naphthoquinone (VII) and two unknown compounds (VIII, IX) were identified (Fig. 3).

2. In a 30 days experiment, 78.10, 7.80 and 1.40 % of the total radioactivity were found in sand, water and the biota, respectively.
3. Less accumulation of naproanilide in the aquatic organisms was observed from their low ecological magnification (EM) values. These values were 36.50 for alga, 26.70 for duckweed, 5.50 for water flea, 18.00 for mosquito larva, 96.50 for paddy snail and 147.00 for mosquito fish (Table I).
4. The higher biodegradability indices (BI) indicated faster degradation of naproanilide in the organisms than that of other persistent pesticides. Their values were 0.96 for rice plant, 0.48 for rice brown planthopper, 1.04 for wolf spider, 2.48 for grasshopper, 3.29 for alga, 4.84 for giant duckweed, 0.85 for water flea, 0.49 for mosquito larva, 1.73 for paddy snail and 0.56 for mosquito fish.

CONCLUSIONS

The low ecological magnification values and high biodegradability indices suggested that naproanilide seemed to be easily degradable in the organisms and not easily accumulated in the food chain. From above evidence, the use of naproanilide in paddy field was found to be pretty safe.

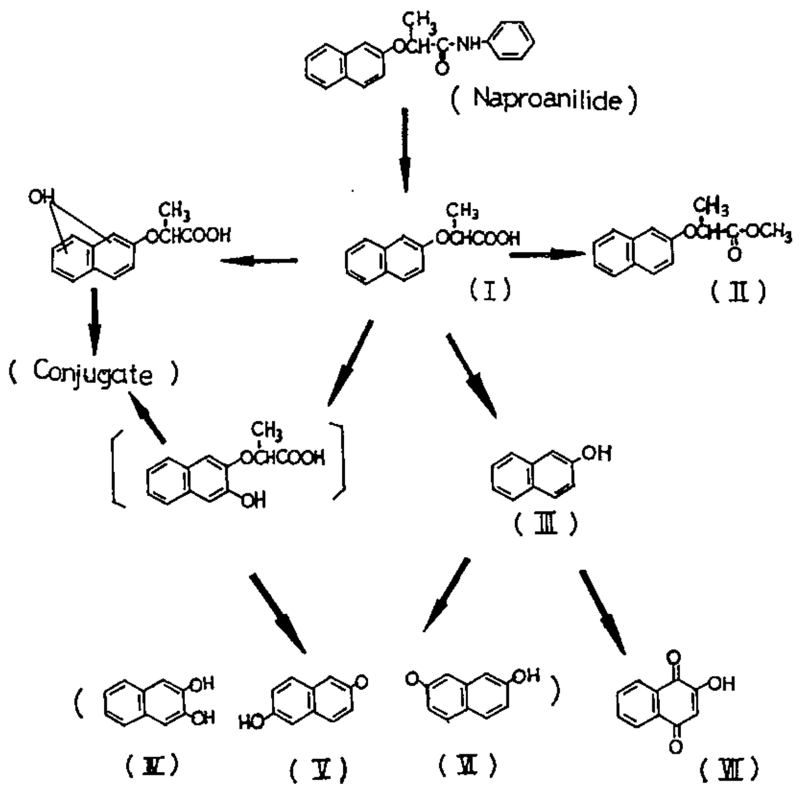


Fig. 3. Proposed metabolic pathway of naproanilide in model ecosystem.

Table. 1. The distribution of radioactivity in the components of the model ecosystem.

Components	Total activity	percentage of application	Ecological magnification	Biodegradability indices
Rice plant	16,523	0.260	......	0.96
Rice brown planthopper	185	0.003	......	0.48
Wolf spider	500	0.008	......	1.04
Grasshopper	924	0.014	......	2.48
Alga	28,587	0.447	36.50	3.29
Giant duckweed	11,224	0.175	26.70	4.84
Water flea	78	0.001	5.50	0.85
Mosquito larva	199	0.003	18.00	0.49
Paddy snail	17,338	0.271	96.50	1.73
Mosquito fish	19,433	0.304	147.00	0.56
Water	500,000	7.800	1.00	....
Sand	5,000,000	78.100	......	....

BEHAVIOR OF ISOURON IN SUGARCANE SOILS IN TAIWAN

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PURPOSE

1. To study the movement and adsorption of isouron [3-(5-*tert*-butyl-3-isoxazolyl)-1,1-dimethylurea] in the three sugarcane soils.
2. To observe the influence of soil properties on the degradation of isouron.
3. To identify the degradation pathway of the herbicide in soil.

METHODS

1. Movement of surface-applied isouron is soils

It was performed with 45cm x 4cm ID glass columns packed with 30cm height of soil in laboratory. The surface-applied isouron and ^{14}C-isouron was leached by water at various rate. The radioactivity in leachate was determined. In the outdoor test, it was carried out with cement tanks (100cm x 90cm ID) containing Touliow sandy loam.

2. Adsorption of isouron in soils

Every 4g of soil was placed in flask, then 20ml of 0.05N $CaCl_2$ solution containing 1,2,5,10,20 and 30 ppm of isouron and 1 μ Ci/1 ^{14}C-isouron was added. The flasks were shaked for 16 hr at 25°C before assay.

3. The influence of soil conditions on the degradation of isouron

Proper amounts of soil containing 4 ppm of isouron and 1 μ Ci/kg ^{14}C-isouron were treated with water to make to 60% field capacity and incubated at 10,10,30 and 40°C, respectively. The influence of soil moisture content was estimated at 20°C. Residues of isouron in soils were analyzed at designed intervals.

4. Identification of degradation products

A proper amount of Touliow sandy loam containing 500 ppm isouron was placed in flasks for 20 weeks. The degradation products were extracted and separated by TLC, then identified by autoradiography and mass spectrometry.

RESULTS AND DISCUSSION

1. Isouron was easily leached out from the soil in the laboratory studies (Fig. 1). The rate of leaching influenced the degree of movement of isouron in Touliow sandy loam (Fig. 2). At outdoor experiments, most of the herbicide was remained in the upper 30cm after receiving 347mm of rainfall during 112 days (Fig. 3).

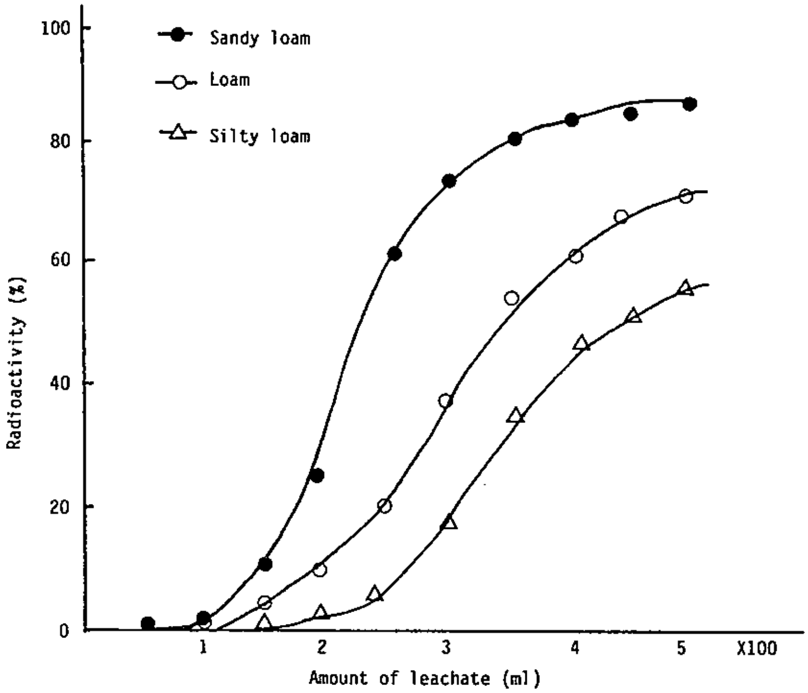

Fig. 1. Cumulative ^{14}C in leachate from soils leached with 500ml (398mm) of water at 8mm/hr.

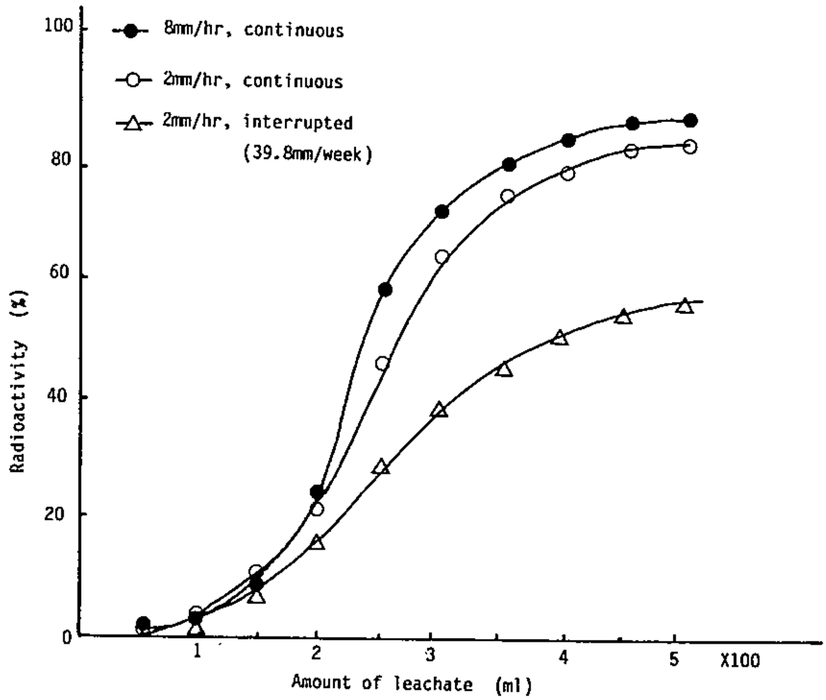

Fig. 2. Cumulative ^{14}C in leachate from Touliow sandy loam leached with 500ml (398mm) of water.

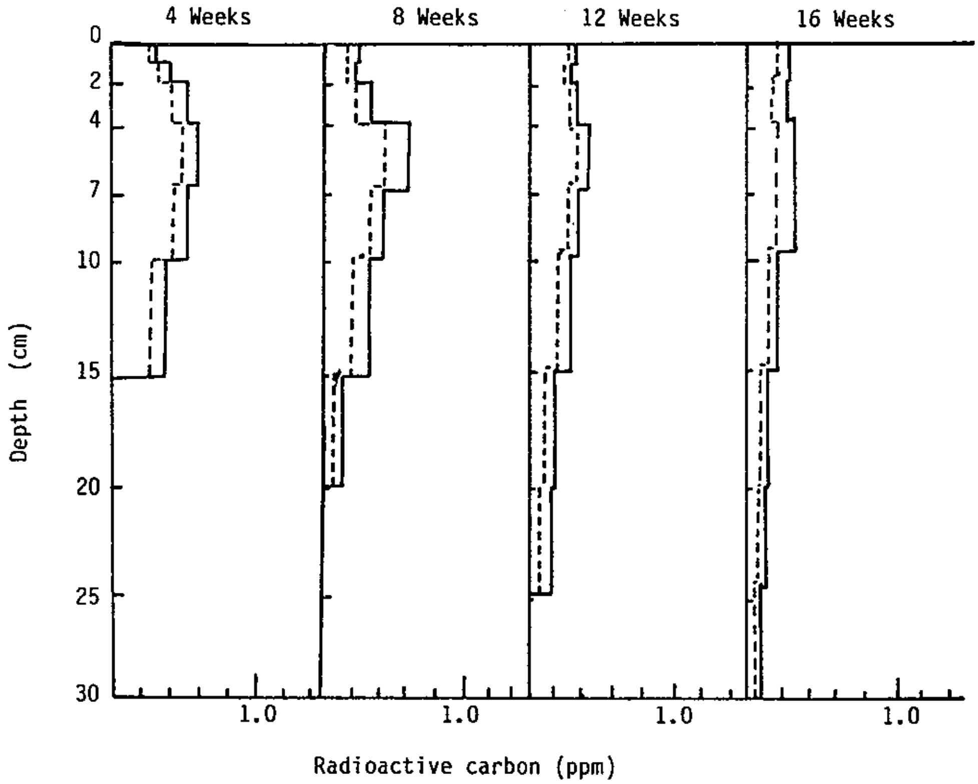

Fig. 3. Movement of isouron in Touliow sandy loam at cement tanks.
total ^{14}C, ... unchanged isouron.

2. The adsorption of isouron by soil might be expressed by Freundlich and Langmuir equations. The K values of Freundlich equation and the maximum adsorption in Langmuir equation were showed in Tables 1 and 2, respectively.

Table 1. Freundlich adsorption isotherm constants for isouron adsorbed by the soils.

Soil	Freundlich constants		Coefficient
	K	l/n	
Sandy loam	0.58	0.926	0.998
Loam	1.09	0.897	0.999
Silty loam	2.91	0.854	0.998

Table 2. Langmuir absorption isotherm constants for isouron adsorbed by the soils.

Soil	$(x/m)_{max}$ (μ g/g)	Constant K	Coefficient
Sandy loam	48.85	0.0119	0.893
Loam	72.15	0.0144	0.891
Silty loam	94.43	0.0305	0.971

3. Degradation of isouron fitted first order kinetic, with half-lives (H) of 42 to 203 days at various conditions in the laboratory experiments (Table 3). Close correlations between the degradation rate and the soil moisture (M) and temperature were observed. The effect of moisture content could be assessed by an empirical equation, $H = AM^{-B}$ or logH = logA-BlogM, where A and B were constants depending on kind of soil and its moisture content.

Table 3. The half-lives of isouron at different conditions from laboratory experiments[1].

Temp. (°C)	Moisture (% of F. C.)	Half-life (days) Touliow sandy loam	Taichung loam	Annei silty loam
10	60	200	203	148
20	60	84	79	67
30	60	70	68	58
40	60	61	56	42
20	20	125	129	140
20	40	97	92	90
20	90	73	75	59
30	60	200[2]	208[2]	148[2]

[1] Initial concentration : 4ppm

[2] Autoclaved.

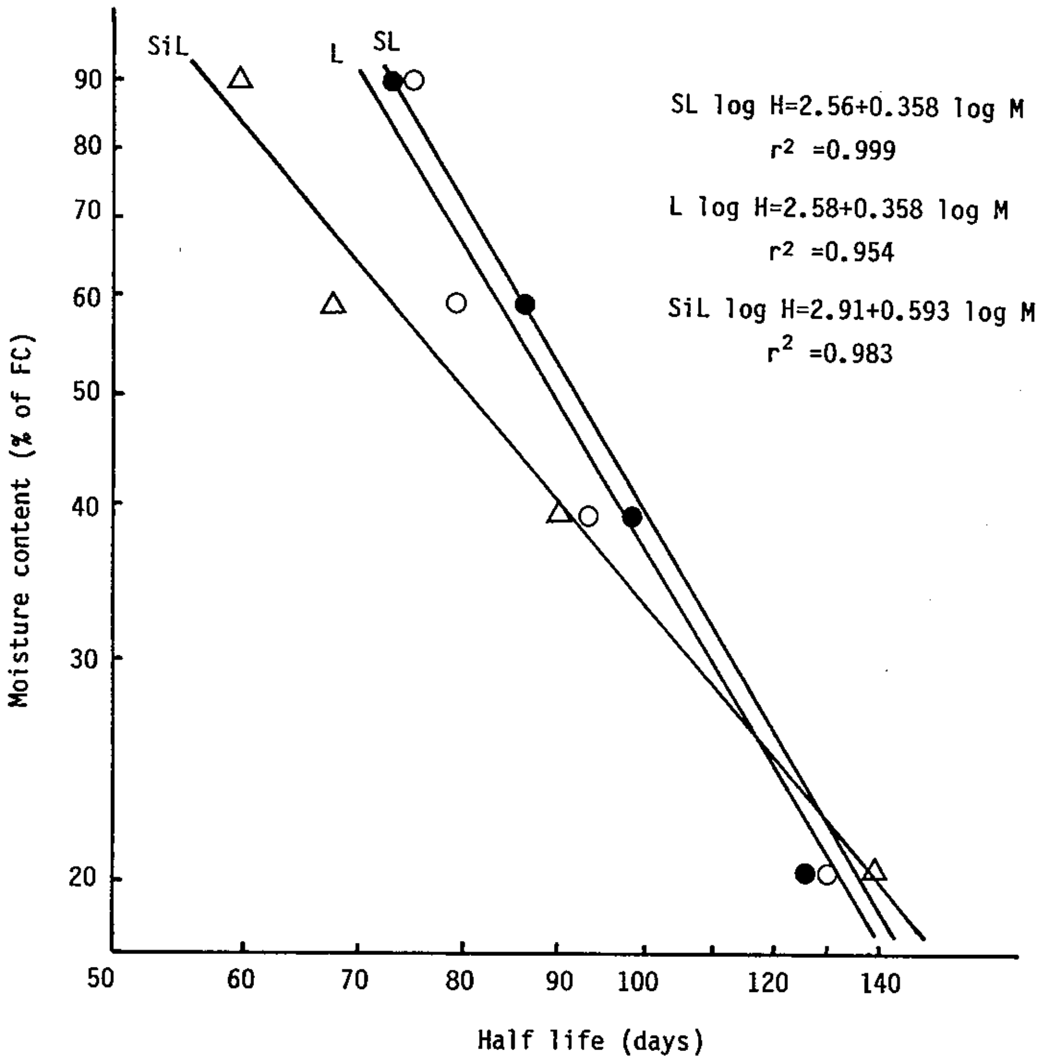

Fig. 4. Relation between moisture content of soils (M) and half-life (H) of isouron.

4. *N*-Demethylation and hydroxylation of *tert*-butyl group were the principal pathways involved in the degradation of isouron in the soils. Besides one unknown metabolite (VIII), 6 degradation products, namely 3-(5-*tert*-butyl-3-isoxazolyl)-1-methylurea (II), 3-[5-(1,1-dimethyl-2-hydroxyethyl)-3-isoxazolyl]-1,1-dimethylurea (III), 3-(5-*tert*-butyl-3-isoxazolyl) urea (IV), 3-[5-(1,1-dimethyl-2-hydroxyethyl)-3-isoxazolyl]-1-methylurea (V), 3-[5-(1,1-dimethyl-2-hydroxyethyl)-3-isoxazolyl] urea (VI), and 3-amino-5-*tert*-butyl-isoxazole (VII) were identified by autoradiography and mass spectrometry.

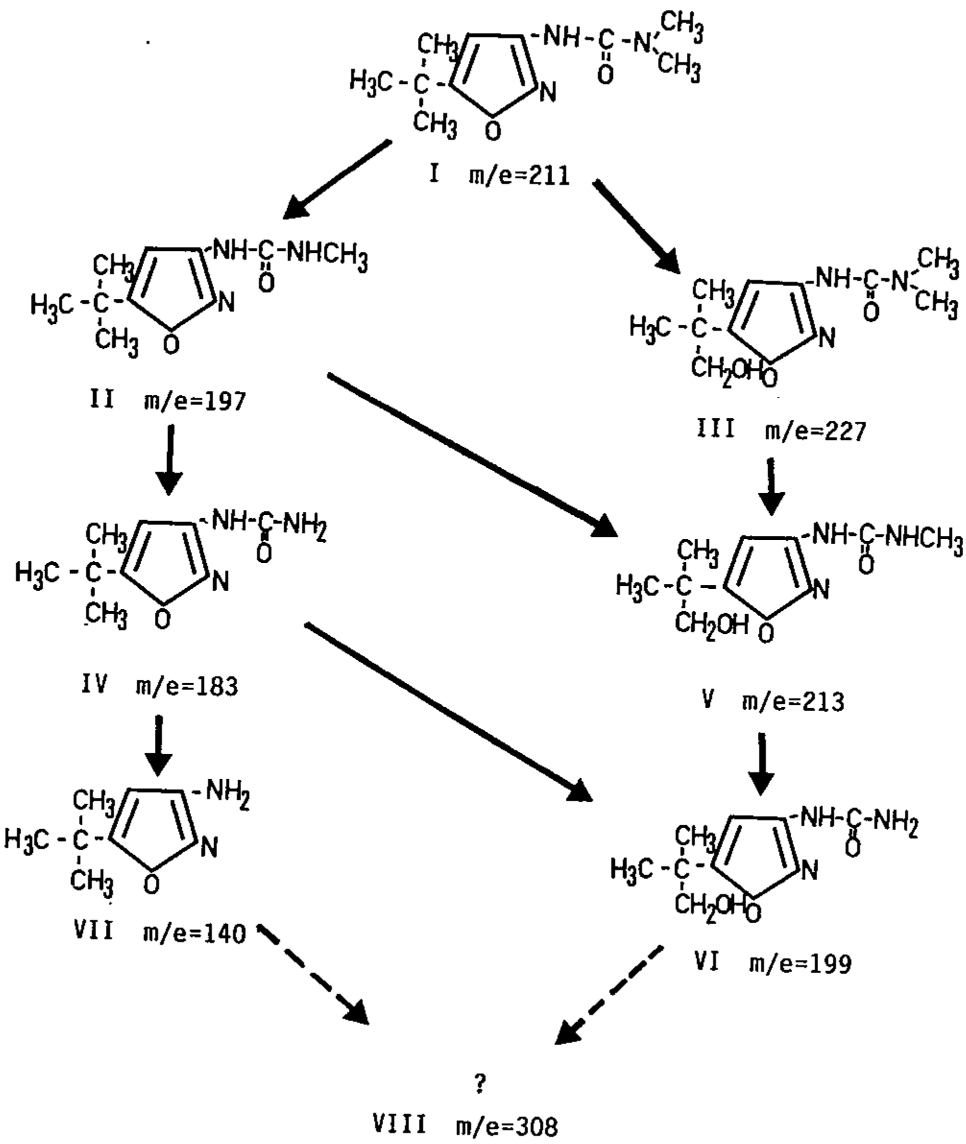

Fig. 5. Degradation pathways of isouron in Touliow sandy loam.

REVIEW OF PULSE™, AN ORGANO-SILICONE SURFACTANT, FOR IMPROVED PERFORMANCE OF GLYPHOSATE ON SOME NEW ZEALAND WEED SPECIES

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ABSTRACT

Pulse™, an organo-silicone surfactant, is marketed in New Zealand as an additive to glyphosate spray solutions. When added at 0.1 to 0.25% v/v, Pulse will: improve the control of gorse (*Ulex europaeus* L), a hard to control exotic brushweed; act as a substitute for diesel and emulsifying surfactants as additives to glyphosate for the control of bracken (*Pteridum aquilinum*); overcome temporary seasonal tolerance of perennial ryegrass (*Lolium perenne* L) to glyphosate; reduce the critical rainfall period required for glyphosate in some situations.

INTRODUCTION

Glyphosate, formulated as the isopropylamine salt with 360 g ae/l, is used in New Zealand to control a variety of weed species. Recommended use rates vary from 0.36 kg ae ha^{-1} for annual species to 7.2 kg ae ha^{-1} for hardy perennials. Spray volumes of 15 to 2000 1 ha may be used to apply the herbicide.

The ratio of surfactant to glyphosate in the formulation is fixed and in some situations added surfactant may improve the activity of the treatment. One surfactant, a polyalkyleneoxide modified dimethylpolysiloxane (Pulse™) is used in New Zealand to improve glyphosate activity in several situations.

Pulse™ is a trademark of Monsanto Co. USA. Pulse contains 100% Silwet M which is a registered trademark of Union Carbide Corp. USA.

Roundup® is a registered trademark of Monsanto Co. USA.

Triton® is a registered trademark of Rohm and Haas, Philadelphia, USA.

Improved control of gorse (*Ulex europaeus* L.) Gorse is a major scrub weed to farmers and foresters in New Zealand (6) which was traditionally controlled with 2,4,5-T alone or in combination with other herbicides. Recent expansion of horticulture in New Zealand has created many "hormone sensitive areas" restricting the use of the phenoxyacetic acid herbicides because of the potential for drift during the summer application period.

In ten field trials, using high volume application, Lane and Park (7) showed that gorse was controlled by glyphosate when 0.25% Pulse was added to the spray mix. These trials showed large increases in control compared to glyphosate alone and to the commercial standard of 2,4,5-T plus picloram (Table 1).

In concurrent studies under controlled environment conditions using C^{14}-glyphosate, Zabkiewicz et

Table 1. Effect of glyphosate and the addition of Pulse on the control of gorse in ten field trials (7).

Treatment	Kg ai l^{-2}	Mean Control (%) 12 MAT[1]	24 MAT[1]
2,4,5-T + picloram	0.1 + 0.025	94	79
glyphosate	0.36	54	64
glyphosate + Pulse ™	0.36 + 0.25	97	90
glyphosate	0.54	82	80

[1] months after treatment.

al, (11) demonstrated that glyphosate uptake into gorse could be increased from 7% to 70% by adding Pulse (0.5% v/v) to the spray mix. They showed that Pulse improves foliar wetting by lowering the droplet contact angle on gorse foliar wax and subsequent field trials by Balneaves (1, 2) confirmed that the herbicidal effectiveness of glyphosate spray mixtures was enhanced by the addition of Pulse.

Substitute for other additives for control of bracken ***(Pteridium aquilinum)*** Using similar techniques to measure droplet contact angles, Gaskin et al (5) showed that the potential wetting of bracken foliage was increased by adding Pulse to glyphosate spray solutions. Much larger contact angles (i.e. reduced wetting) were measured for solutions containing the standard additive treatment proposed by Preest (8) of diesel oil and emulsifying agent, and for Triton ® X-45 alone (Fig. 1).

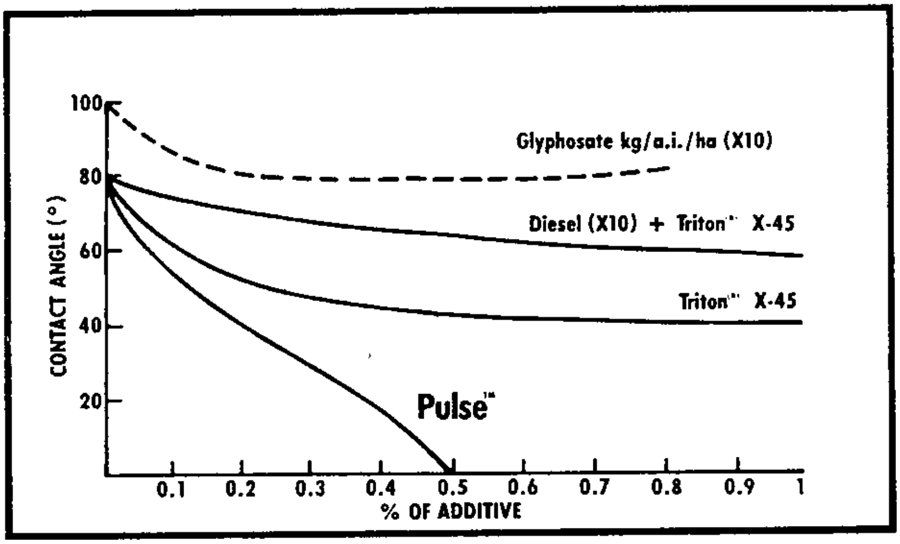


Fig. 1. Contact angles of Roundup® formulations (at 7 litres/300 litres of water) with three additives. (Data courtesy of Gaskin et al, 1985).

Field trials at two sites in successive years showed that the control of bracken using Roundup and Pulse was equal to or better than control using the standard additive of diesel oil and emulsifier (5). Similarly, Ray et al (9) demonstrated in aerially applied field trials that glyphosate and Pulse solutions provided better bracken control than mixtures containing diesel oil and Triton® X-45 when applied at high application volumes (200 l ha^{-1}). The herbicidal effectiveness of the glyphosate and Pulse mixture was no better than the diesel standard when the mixture was applied in 20 l ha^{-1} of water.

Overcome seasonal tolerance of perennial ryegrass to Glyphosate Glyphosate is frequently used in New Zealand to remove perennial ryegrass (*Lolium perenne* L.) dominant pastures prior to sowing spring cereals. Temporary tolerance to glyphosate associated with the onset of vigorous spring growth occasionally occurs and treatment with 0.72-1.08 kg ai ha^{-1} of glyphosate does not adequately control subsequent tiller growth (3). At other times of the year, rates as low as 0.54 kg ai ha^{-1} may be effective.

In field experiments conducted on 3 year old perennial ryegrass pasture, Bishop and Field (3, 4) showed that the efficacy of the herbicide was effected by the rate of glyphosate and the date of spring application. The most consistently effective treatment during spring was 0.72 kg ai ha^{-1} plus 0.5% Pulse™ (Fig. 2).

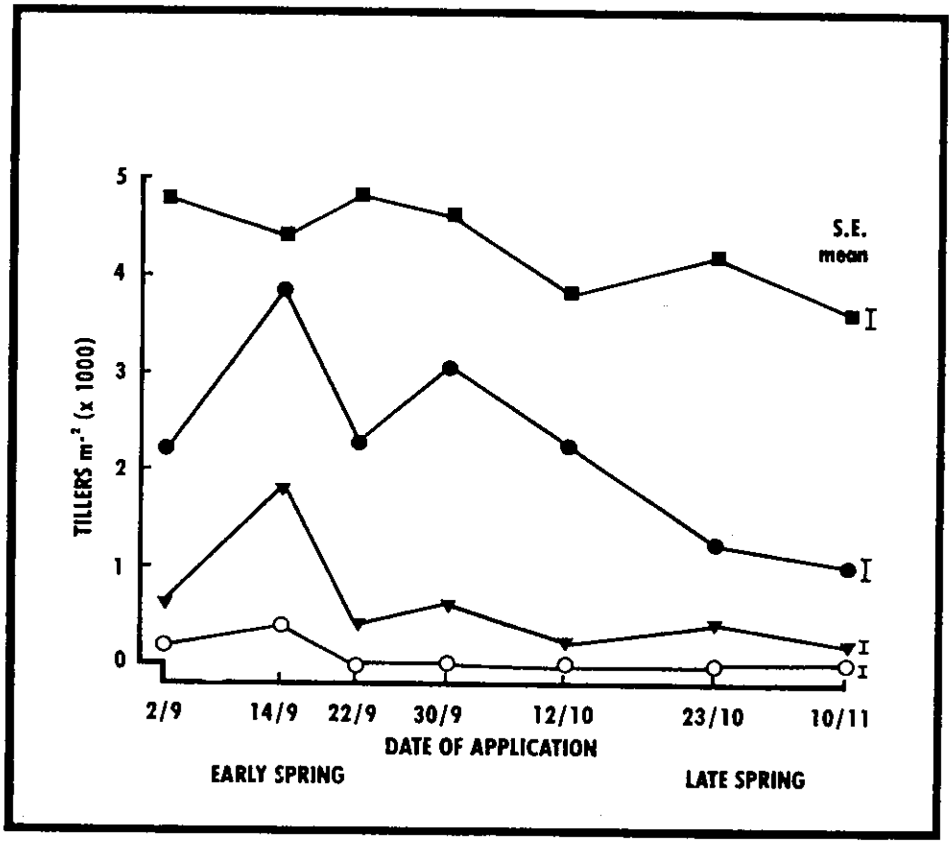


Fig. 2. Pattern of tiller regrowth of perennial ryegrass following application of glyphosate at 0 (■): 0.72 + 0.5% Pulse™ (○) and 1.05 (▼) kg ha^{-1}. (Data from Bishop and Field, 1983)

Bishop and Field (4) suggested that the mechanism of action of Pulse™ was associated with rapid foliar penetration and incorporation into leaf tissues. Using C^{14} - glyphosate they showed that the addition of 0.1% v/v Pulse stimulated uptake of 26 percent of the applied glyphosate by the upper leaf surface within 3 hours. In contrast, in the absence of Pulse, only 1.3 percent of the applied glyphosate was absorbed by the upper leaf surface after 3 hours. They demonstrated with sodium fluorescein that Pulse promotes rapid stomatal infiltration of glyphosate solutions. The increased uptake led to increased performance during this semi-tolerant period.

Reduced critical rainfall period for Glyphosate A rainfree period of six hours is recommended after the application of most glyphosate formulations to ensure adequate foliar uptake of the herbicide for good performance.

Bishop and Field (4) demonstrated that the rapidity of perennial ryegrass foliar uptake of glyphosate was enhanced by Pulse and they predicted that the use of Pulse could reduce the required critical rainfree period after application. Foliar uptake, however, can be affected by the dose of herbicide, environmental conditions and the physiological condition of the target species so field trials were conducted to determine the minimum duration of the rainfree period when Pulse was added to the spray mix (Fig. 3).

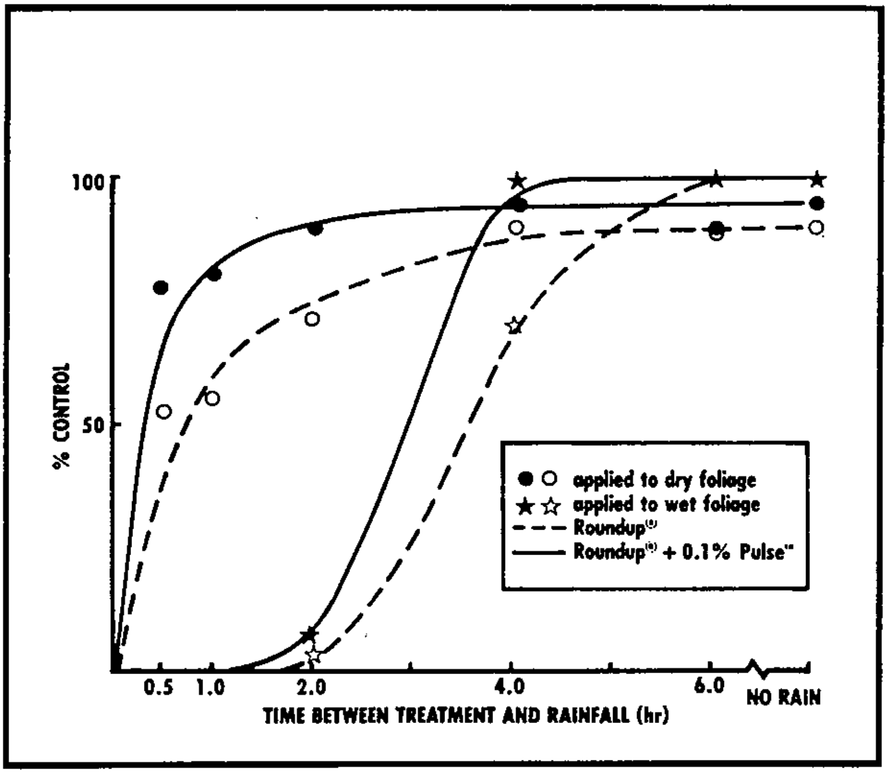


Fig. 3. The effect of Pulse™ on the critical rainfall period of glyphosate applied at threshold rates to wet and dry perennial ryegrass foliage. (Monsanto New Zealand Ltd. trail results.)

These results indicate that the addition of Pulse™ does reduce the critical rainfree period for glyphosate under field conditions. A rainfree period of two hours is feasible for perennial ryegrass when the mixture is applied to dry foliage. However, when applied to rain affected or dew covered foliage a longer rainfree period is necessary possible because some of the mixture is lost from the plant or perhaps rapid foliar uptake only occurs as droplets of the mixture dry on the surface of the leaf.

CONCLUSIONS

The introduction of Pulse as an additive to glyphosate has altered the use of this herbicide in New Zealand in several ways. It has increased the range of weed species controlled by glyphosate and has substituted for other additives such as diesel oil that may be dangerous or expensive to use.

On perennial ryegrass, New Zealand's major pasture species, the addition of Pulse to the spray mixture overcomes spring tolerance to glyphosate and a reduction in the recommended rainfree period between application and the onset of rain is feasible for this species.

At concentrations as low as 0.1%, Pulse promotes very low surface tension in aqueous solutions. When mixed with glyphosate, Pulse produces better leaf wetting than any other additive currently available and in some species this facilitates rapid foliar uptake, probably by stomatal infiltration of the solution.

LITERATURE CITED

1. Balneaves, J. M. 1985. The effect of added surfactant on the performance of scrubweed herbicides. Proc. 38th N. Z. Weed and Pest Control Conf. 98-101.
2. Balneaves, J. M. 1986. Seasonal effect of glyphosate and Silwet M applied to mature gorse. Proc. 39th N. Z. Weed and Pest Control Conf. 74-76.
3. Bishop, N. G. and R. J. Field. Improved performance of glyphosate in the full season control of perennial ryegrass. Aspects of Applied Biology. 4:363-370.
4. Bishop, N. G. and R. J. Field. 1987. Controlling perennial ryegrass with glyphosate in spring. Proc. 40th N. Z. Weed and Pest Control Conf. 191-198.
5. Gaskin, R. E., N. A. Davenhill and J. A. Zabkiewicz. 1985. Preliminary screening of bracken (*P. aquilinum*) herbicide formulations of asulam and glyphosate plus surfactants. In Proc. "Bracken 85" Conf. Leeds, U. K.
6. Hill, R. L. and R. A. Sandrey. 1986. The costs and benefits of gorse. Proc. 39th N. Z. Weed and Pest Control Conf. 70-73.
7. Lane, P. M. S. and O. L. Park. 1984. Gorse control with glyphosate. Proc. 37th N. Z. Weed and Pest Control Conf. 194-196.
8. Preest, D. S. 1975. Effect of additives on bracken control by asulam and glyphosate. Proc. 28th N. Z. Weed and Pest Control Conf. 49-52.
9. Ray, J. W. A. L. Vanner and B. Richardson. 1986. Effect of application volume and spray additive concentration on the control of bracken. Proc. 39th N. Z. Weed and Pest Conf. 89-91.
10. Rolston, M. P. and J. R. Sedcole. 1983. Improved grass control by glyphosate using ammonium sulphate or surfactant. Proc. 36th N. Z. Weed and Pest Conf. 176-179.

11. Zabkinewicz, J. A., R. E. Gaskin and J. M. Balneaves. 1985. Effect of additives on foliar wetting and uptake of glyphosate into gorse (*Ulex europaeus*). BCPA Monograph No. 28, Symp. Appli. and Bio. Univ. Reading, U. K. 127-134.

TITLES OF THE POSTERS DID NOT PUBLISHED IN THE PROCEEDINGS

THE INFLUENCE OF THE WEED CONTROL ON GROWTH, QUALITY AND QUANTITY OF THE SATSUMA MANDARIN (PO-1)
K. Suzuki, K. Hirose and K. Kawase

HERBICIDAL PERFORMANCE OF BAS 514..H AND COMBINATION IN RICE IN MALAYSIA (PO-2)
L. S. Ho and J. C. van de Weerd

FIELD PERFORMANCE OF QUINCLORAC AND ITS COMBINATION ON RICE PADDY FIELDS IN TAIWAN (PO-3)
H. H. G. Wu and E. Hennlich

EFFECT OF SPRAYING METHOD ON THE EFFICIENCY OF FOLIAR APPLIED HERBICIDES (PO-5)
M. Konnai, R. Ochiai, N. Ichizen and T. Takematsu

MON 7200 AS A NEW PRE-EMERGENT HERBICIDE IN TRANSPLANTED RICE (PO-7)
P. M. Halos, S. Campiranon and V. Srinivasan

CONTROL OF *IMPERATA CYLINDRICA* USING MON 8793 HERBICIDE (PO-8)
A. Arif, S. Campiranon, S. T. Chew and R. P. Schnelder

THE OCCURENCE OF *SALVINIA MOLESTA* IN THE PHILIPPINES (PO-9)
P. P. Pablico, L. E. Estorninos Jr., E. M. Castin and K. Moody

SELECTIVITY AND WEED CONTROL OF BAS 521 09 H IN DIRECT SEEDED RICE OF TAIWAN (PO-10)
F. S. Soung and U. Busse

BUTACHLOR UPTAKE AND EFFECTS ON PLANT GROWTH AND PHYSIOLOGICAL ACTION (PO-11)
S. S. Chang

METABOLISM OF BIALAPHOS IN RATS (PO-12)
A. Suzuki, K. Nishide, M. Takaichi, M. Shimura,
T. Watanabe and I. Yamamoto

WEED CONTROL IN TRANSPLANTED RICE WITH BUTACHLOR MIXTURES IN TAIWAN (PO-13)
L. Q. Wu

NEW GLYPHOSATE MIXTURES FOR GENERAL WEED CONTROL IN JAPAN (PO-15)

CLOSING ADDRESS

Chairman of The Organizing Committee

Yuh-Lin Chen

Honoured Guests, Ladies and Gentlemen:

At the end of this Conference, I must confess I have rather mixed feelings. Relief and happiness that it has proceeded for the most part according to plan, and a certain sadness that it is over, after all the efforts that the Organizing Committee has expended. It seems that friends both old and new are leaving almost as soon as they got here, and there is never enough time to meet as many people as I would like. I am pleased to inform you that a total of 307 overseas participants have registered and 155 from our local participants. Therefore a total of 19 countries including Taiwan, R.O.C. attended.

I wish to say that what makes it worthwhile is the realization through this Conference, new knowledge has been acquired, and further progress has been made towards solving the common problems in weed science. And on that point, it should be said that actually the work of the Organizing Committee has only just begun. For with the Conference now over we will be working hard to ensure that the information furnished by distinguished guests from all over the world, is collated and made available to all who can put it to practical and beneficial use.

I am indebted to all the speakers who honoured us with their attendance and the dissemination of their knowledge, and I was personally uplifted by the tremendously high standard of the contributions, and the amount of time and effort that obviously went into preparing them.

While you were here I also hope that you had time to enjoy yourself, and see a little of our nation, and its attractions, and I sincerely hope that we will have recourse to meet each other again in a professional or private capacity. As one of your hosts, I may say that it has been a pleasure to be with you over the last week, and that I personally welcome all of you to visit us again, and may be spend more time in getting to know our country. It has been a delightful experience for myself and I hope for you all too. I wish you all a pleasant journey home.

Thank you.

ERRATA IN THE PROCEEDINGS 1

Insertion

Seven figures in the paper entitled "BEHAVIOR OF QUINCLORAC IN SOILS, RESULTS OF BIOASSAYS (CO-44) by S. Kashibuchi, H. Rosebrock and J. Beck published in the Proceedings 1 have been omitted. Hereby the seven figures are inserted here to make it complete.

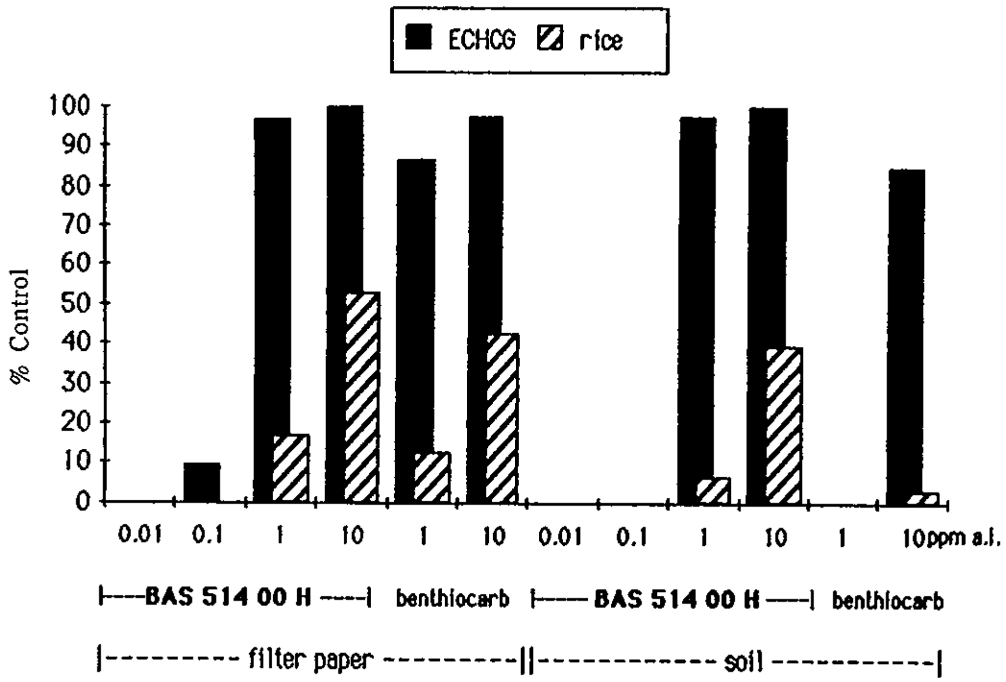


Fig. 1. Activity of BAS 514 00 H and benthiocarb on the germination and initial growth of *Echinochloa crus-galli* and rice in petri dish tests using filter paper or soil.

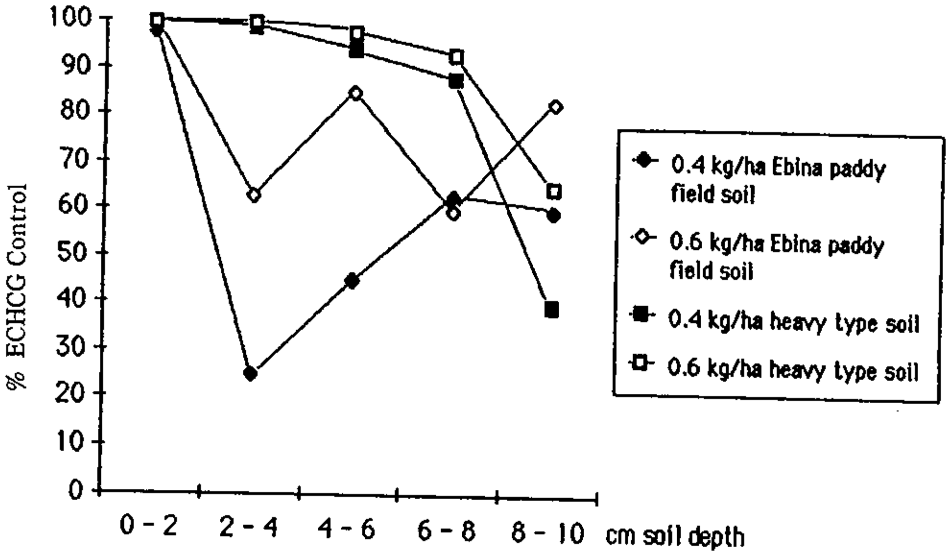
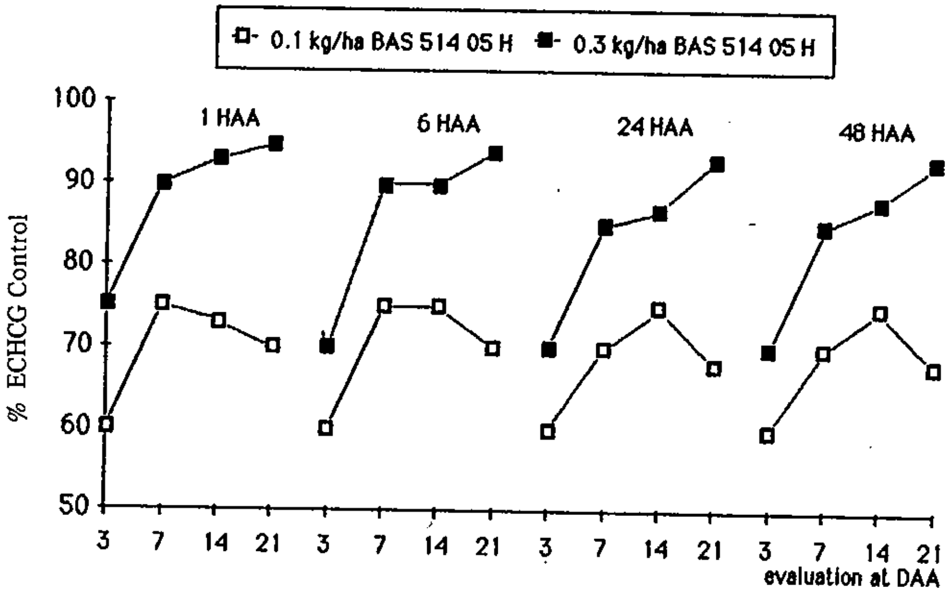
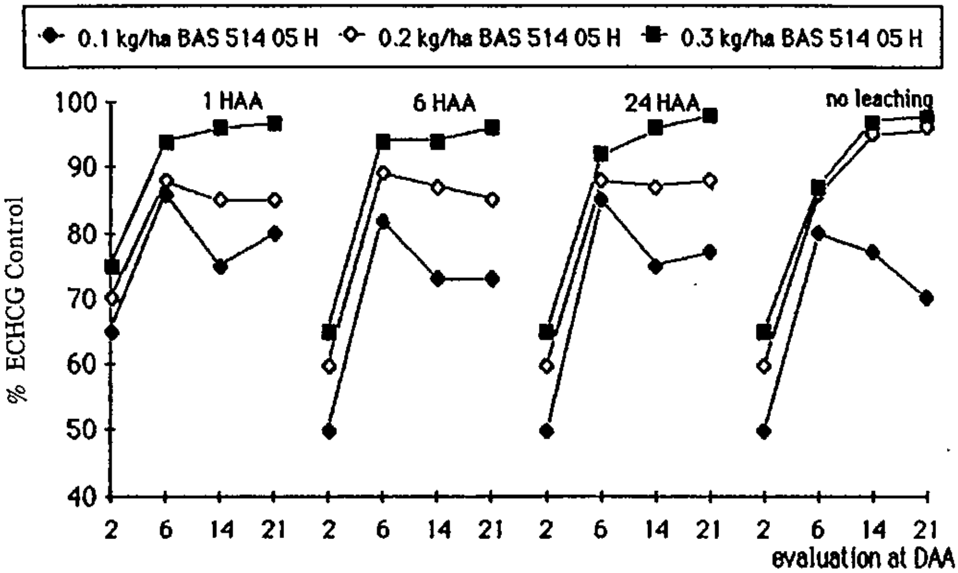


Fig. 2. Vertical movement of BAS 514 05 H in 2 types of soil expressed by the activity against *Echinochloa crus-galli.*



DAA: days after application
HAA: hours after application

Fig. 3. Influence of leaching on the efficacy of BAS 514 05 H against *Echinochloa crus-galli* (start of leaching at 1, 6, 24 and 48 hours after application).



DAA: days after application
HAA: hours after application

Fig. 4. Influence of leaching on the efficacy of BAS 514 05 H against *Echinochloa crus-galli*. (Leaching of 3 cm/day for 3 days, starting at 1, 6 and 24 hours after application)

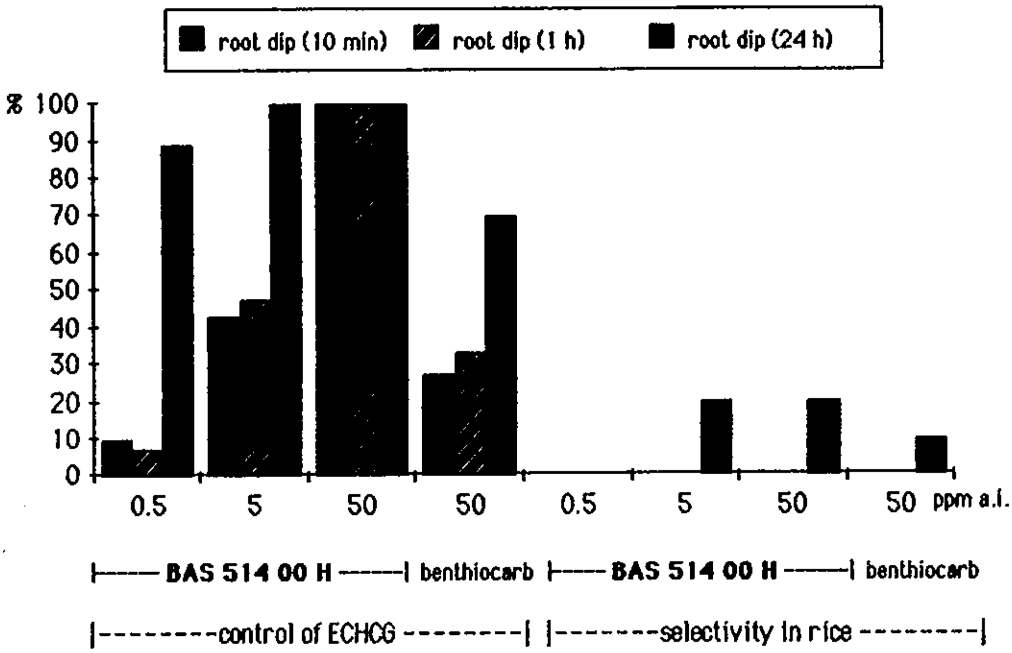


Fig. 5. Efficacy on *Echinochloa crus-galli* and selectivity in rice by BAS 514 00 H and benthiocarb after root dip treatment for 10 minutes, 1 or 24 hours.

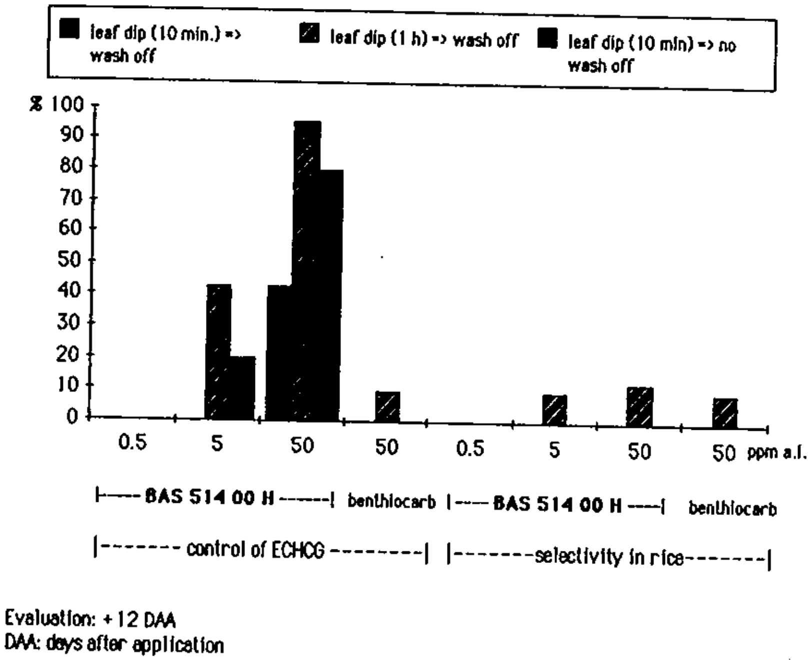


Fig. 6. Efficacy on *Echinochloa crus-galli* and selectivity in rice by BAS 514 00 H and benthiocarb after a leaf dip treatment for 10 minutes or 1 hour.

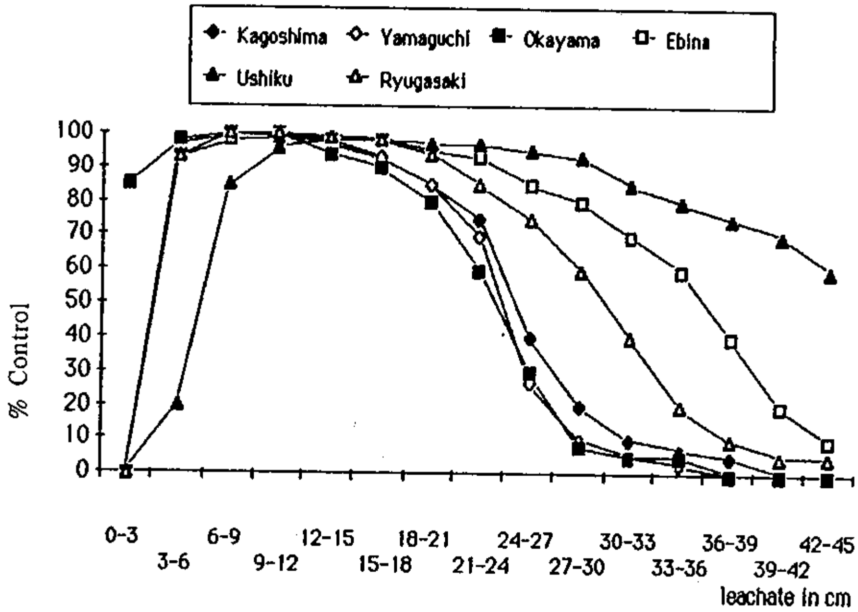


Fig. 7. Wash-out of BAS 514 06 H through 10 cm soil: effect of leachate on *Echinochloa crus-galli*

Errata

Correction on the Proceedings 1

Page	Line	Erratum	Correction
14	39	$/ (W_2 - W_1) (\log_e L_2 - \log_e L_1)]$	$/ [(W_2 - W_1) (\log_e L_2 - \log_e L_1)]$
45	5	ASEAN-OLANTI	ASEAN-PLANTI
45	13	*Cyperu*	*Cyperus*
47	10	*lavagdulifolia*	*lavandulifolia*
47	19	*Oralis*	*Oxalis*
47	24	*pilose*	*pilosa*
47	31	*Chromolasena*	*Chromolaena*
48	18	*Oralis*	*Oxalis*
50	10	H: *Digitaria adcendens*	H: *Digitaria ciliaris*
50	11	I: *Digitaria sanguinalis*	I: *Digitaria nuda*
52	24	*Molugo stricat*	*Molugo strict*
52	33	*corrchorifolia*	*corchorifolia*
53	15	*Elentheranthera rederalis*	*Eleutheranthera ruderalis*
53	21	*Emila sanchifolia*	*Emilia sanchifolia*
59	Fig. 2	(y axis) Conductivity (/cm)	Conductivity ($\delta\mu$ mho/cm)
60	3	s/μs	Σs/μs
60	20	μv/cm	μ mho/cm
73	3	J. I. Aclderon	J. I. Calderon
73	5	CIBA-GEIGY Ltd.	CIBA-GEIGY (Phils) Inc.
73	6	CIBA-GEIGY Ltd.-- Developments	CIBA-GEIGY Services Ltd. ------- Development
73	7	CIBA-GEIGY Ltd.	CIBA-GEIGY
73	9	CIBA-GEIGY Ltd.	CIBA-GEIGY (SDN) BHD.
73	28	in IRRI	an IRRI
74	8	SETOFF has	SETOFF (Registered tradename of CIBA-GEIGY Ltd. Basle, Switzerland) has
77	29	49	47
77	36	saturated (1-3 cm) at	saturated at
79	8	Conf. 119-130	Conf. 117-128
117	4	Quandranti, J. Rufence	Quadranti, J. Rufener
117	10	has not veen	has not been
118	2	Talbe 2 -- pypsico	Table 2 -- physico
118	7	test	tests
118	21	seedling	seedlings

Correction on the Proceedings 1

Page	Line	Erratum	Correction
119	12	pypsico-chemical	physico-chemical
119	21	10^{-3}mmHg	10^{-13}mmHg
119	24	5000 mg/kg	>5000 mg/kg
119	25	2000 mg/kg	>2000 mg/kg
119	26	5000 mg/m³	>5000 mg/m³
120	1	Setoff R	Setoff®
120	14	Setoff R	Setoff®
120	18	Application	Application timing
120	23, 27	X soil type	$\overline{X}$ soil type
120	30	35% sand.	36% sand,
120	31	45% silt	34% silt
121	1	Setoff	Setoff®
123	2	Talbe 3	Table 3
123	17	as weed	as well
123	30	Setoff R	Setoff®
125	24	agter	after
126	1	Setoff R	Setoff®
127	4	in (1)	in (2)
127	27	Setoff R	Setoff®
127	30	CIBA-CEIGY'S	CIBA-GEIGY'S
127	33	Calderon, J. I., ...	Calderon, J. I., C. J. Hare, E. V. Palis, H. Burhan, A. Bhandhufalek, and W. C. Chong. 1987.
127	34	Setoff R 75	Setoff®. 73
127	35-36	75-81.	73-79.
128	9	23, 23-25	23: 23-35
128	13	Entomolgical	Entomological
129	27	-amylase	α-amylase
134	22	to 10^3M	to 10^{-3}M
153	1	BENZSULFURON ON	BENSULFURON METHYL ON
153	9 etc.	B (or b) enzsulfuron	B (or b) ensulfuron methyl
153	35	§ 2-	{ 2-
154	1	benzenesulfonamide.	benzenesulfonamide }.
154	4 etc.	B (or b) enzsulfuron	B (or b) ensulfuron methyl
154	17	$\mu E.m^2.S^{-1}$	$\mu E.m^{-2}.S^{-1}$

Correction on the Proceedings 1

Page	Line	Erratum	Correction
154	28	then W_1	where W_1
154	32	*S. pygmea*	*S. pygmaea*
155	1 etc.	benzsulfuron	bensulfuron methyl
156	2, 12	benzsulfuron	bensulfuron methyl
157	2 etc.	B (or b) enzsulfuron	B (or b) ensulfuron methyl
157	37	Blackman, 1919 cited	(Blackman, 1919 as cited
157	38	plants	plant
158	2 etc.	benzsulfuron	bensulfuron methyl
158	7	Fig. 2.	Fig. 1.
158	8	Fig. 3.	Fig. 2.
159	Fig. 1, 2	B (or b) enzsulfuron	B (or b) ensulfuron methyl
160	10	benzsulfuron	bensulfuron methyl
160	Fig. 3	Sagittaria pygmaea	*Sagittaria pygmaea*
161	3	Benzsulfuron	Bensulfuron methyl
161	6	continues	continue
179	3	Sumanarak	Suwananak
200	15	of Weeds-kg/Plot	. . . of Vegetable Yield-kg/Plot
247	16	3MAP	3WAP
247	29	(1, and Sudjadi and Satari, 1986).	(1).
248	11	spitters	Spitters
249	14	of, and	of β, Ω and
250	Fig. 1	(y axis)	(g/pot)
250	Fig. 3	(y axis)	(g/pot)
250	Fig. 5	(y axis)	10^{-2} (g/pot)
250	Fig. 6	(y axis)	(qt/ha)
251	1	of, and	of β, Ω and
251	3	Species	Species β Ω
251	13	8^{ab}	8^{a}
251	15	(p 0.05)	($p \leqslant 0.05$)
251	21	8.9^{efl} 6.7^{ed}	8.9^{ef} 6.7^{d}
251	23	8.6^{af}	8.6^{f}
251	24	(p 0.05)	($p < 0.05$)
253	5	18.3 30.0 69.3	18.3^{a} 30.0^{a} 89.3^{c}
	6	30.0 86.0 88.3	30.0^{a} 86.0^{cd} 88.3^{cd}
	7	99.3 84.3 48.3	99.3^{b} 84.3^{cd} 48.3^{b}

Correction on the Proceedings 1

Page	Line	Erratum	Correction
	8	81.7 60.0 31.0	81.7[cd] 60.0[b] 31.0[a]
	9	Blank	Numbers followed by different letter indicate statistical difference ($p \leqslant 0.05$)
253	12	21.1[bl]	21.1[b]
253	17	(p. 0.05)	($p \leqslant 0.05$)
253	21	Control (weedy check)	Control
253	23	manual 6WAP	manual weeding at 6WAP
253	25	(p 0.05)	($p \leqslant 0.05$)
254	4	49.7[al]	49.7[a]
254	5	2x	2x (at 3-6 WAP)
254	7	manual 6WAP	manual weeding at 6WAP
254	9	(p 0.05)	($p \leqslant 0.05$)
254	19	manual 6WAP	manual weeding at 6WAP
254	22	in column . . . (p 0.05)	in a column . . . ($p \leqslant 0.05$)
255	7	*Boreria alate*	*Borreria alata* (Aubl.) DC.
255	9	*Eleutheranthea*	*Eleutheranthera*
255	12	*ruderalle*	*ruderalle* (Jacq.) Cass.
255	13	*oudica*	*oudica* L.
255	14	*permum*	*ruditospermum*
255	19	*Trida*	*Tridax*
255	20	*valerianifolia*	*valerianifolia* (Wolf) DC.
255	21	*reoens*	*repens* L.
255	22	*benghalis*	*benghalensis*
255	25	*paniculata*	*paniculata* L.
255	36	λ_1 =	A_1 =
255	37	λ_2 =	A_2 =
255	38	λ_3 =	A_3 =
256	7	*Boreria alata*	*Borreria alata* (Aubl.) DC.
256	12	*ruderalle*	*ruderalle* (Jacq.) Cass.
256	13	*rutidosnermum*	*rutidospermum* DC.
256	20	*valerianifolia*	*valerianifolia* (Wolf.) DC.
256	21	*orocumbens*	*procumbens*
256	23	*Euohorbia*	*Euphorbia*
256	26	*paniculata*	*paniculata* L.
256	34	*benghalensis*	*benghalensis* L.
256	35	II	I
257	31	(1980)	(1987)

Correction on the Proceedings 1

Page	Line	Erratum	Correction
258	14	Blank	10. Coussen, R. 1987. Theory and reality of weed control threshold. Plant Prot. Quarterly 2 (1): 13-20.
268	10	+ – + –	– – + --
269	3	*lablab* and	*tablab, Trichosanthes cucumerina* and
311	25	Irial Java	Irian Java
311	38	is so that	is so strong that
312	2	undergroud	underground
312	40	pyhsical	physical
313	12	as ll . . . . a 501	as 1 μ 1 . . . . . . a 50μl
313	14	44 Ci/mg	44 μ Ci/mg
313	17	11	1 μ 1
313	18	200mm. 400m	200 μm . . . . . . 400 μm
316	2	EO cotent	EO content
316	3	suftactant	surfactant
319	4	254m and 190-254m	254 μm and 190-254 μm
319	6	240m and 196m	240 μm and 196μm
319	8	196m	196 μm
319	23	' 11	1 μ 1
319	25	11	1 μ 1
319	36	200m or 400μm	200 μm or 400μm
319	40	A_2 A_{20} A_7	$A_2 < A_{20} < A_7$
327	2	GENOTOXICTIES	GENOTOXICITIES

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The Eleventh Conference of the Asian-Pacific Weed Science Society
November 29-December 5, 1987 Taipei, The Republic of China

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