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PROCEEDINGS 1

THE TENTH CONFERENCE OF THE ASIAN-PACIFIC WEED SCIENCE SOCIETY

NOVEMBER 24–30 1985
CHIANGMAI THAILAND

DEPARTMENT OF AGRICULTURE
THAI PESTICIDES ASSOCIATION

THE TENTH CONFERENCE OF
THE ASIAN-PACIFIC WEED SCIENCE SOCIETY

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PREFACE

It was the Working Committee's original intention to publish all papers presented at the Tenth Conference of the Asian-Pacific Weed Science Society held on November 24-30, 1985 at Chiangmai, Thailand before the Conference so that participants would have on hand all complete papers and could follow the presentations with full information.

However, due to various factors, not least of which is time constraint, we were compelled to limit the number of papers included in this Proceedings, Volume I to what you see here.

The remaining papers will be published in Proceedings, Volume II after the Conference and will be mailed to all participants at completion.

I am most grateful to all those who devoted much of their efforts and valuable time in ensuring that the Proceedings, Volume I was published in time for the Conference with as few errors as possible in the limited time available.

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GENETIC ENGINEERING FOR HERBICIDE RESISTANCE

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ABSTRACT

Breeding of a crop plant which is resistant to herbicide has been one of research subject in weed science, but there have been no delightful advancement before 1980. The reasons for the impracticality of such breeding were: (a) Preference of breeding for disease tolerant crops, (b) Almost no appearance of herbicide-tolerant weeds, (c) An assumption of short market period of a herbicide, or (d) Complicated heredity of herbicide-resistance. Now the situation has been changed, because there were found a number of weeds tolerant or resistant to herbicides after the long-term use of such herbicides, some of them has been used for 30 years, and several examples of simple heredity of herbicide-resistance have been found. Then there can be found many merits to plan the breeding of herbicide-resistant crop plant.

In this review, the author would like to introduce the following items: resistance mechanisms of higher plants to herbicides, heredity of such resistance, and the methodology of breeding of herbicide-resistant crop plants mainly new biotechnology. The latter consists of the introduction of resistant gene by transformation, transduction, conjugation or cell fusion; selection of resistant ones by cell or tissue culture and regeration from callus culture; and mutagenic creation of resistant gene by chemical and rediation.

INTRODUCTION

Breeding of a crop plant which is resistant to a herbicide has been one of research subject in weed science, but there have been no delightful advancement before 1980. The reasons for the impracticality of such breeding had been assumed as follows: (a) Breeding for disease tolerant crops may have preference, (b) Almost no appearance of herbicide-tolerant weeds, (c) An assumption that the market period of a herbicide will be short, (d) The heredity of herbicide-tolerance is not simple, and (e) The number of herbicide-tolerant cultivarieties is so limited. These assumption was shown in a review[1] by Weed Research Organization in 1973.

Now the situation may be changed, because there found a lot of weeds which are tolerant or resistant to herbicides after the long-term use of such herbicides, some of them has been used for 30 years, and several examples of simple heredity of herbicide-resistance have been found. Then there can be found many merits to plan the breeding of herbicide-resistant crop plants.

Why breed a herbicide-tolerant cultiva5s of a crop plant? The answers to this quetion may be as follows: (a) We need a lot of moneys and years to develop a new selective herbicide for a crop; however, if we shall be able to breed a tolerant crop plant to an old herbicide, it will be valuable as like as the development of a new selective herbicide to the crop plant. (b) After long-term utilization of a herbicide, the weeds in general became to be more tolerant to the herbicide, then we should apply larger dosage of herbicides which causes crop injury. If we shall prepare a herbicide-tolerant varieties, such problem may be solved. (c) If we shall prepare many herbicides which can be utilized safely to a crop plant, the rotationary utilization of herbicides to a crop will be more easy, then the appearance of herbicide-tolerant weeds may be delayed.

In this review, the author would like to introduce the following items: resistance mechanisms of higher plants to herbicide, heredity of such resistance, and methodology of breeding of herbicide-resistant crop plants mainly with new biotechnologies.

Resistance mechanisms of higher plants to herbicides

Here the author wishes to use a definition of the terms of resistance and tolerance by the editors of an useful book "Herbicide Resistance in Plants"[2]. Resistance is defined as a decreased response of a population of animal or plant species to a pesticide or control agent as a result of their application. A working definition of a resistant weed is one that survives and grows normally at the usually effective dose of a herbicide. Resistance is the maximum tolerance that can be achieved. Resistant individuals are usually found in much lower frequencies than tolerant ones in natural, untreated populations.

Regarding the selectivity of herbicides between crop plants and weeds, the resistance mechanism of crop to the herbicide have been clarified as the differences in absorption, penetration or translocation, and activation or detoxification mechanisms.

On the other hand after long-term application, as like as in the case of insecticides or fungicides, a lot of weeds became to be tolerant or resistant to herbicides[3]. The most famous and frequent example is the case of atrazine. Over 27 species of weeds were reported to show the tolerance or resistance to atrazine. And some of the atrazine-resistant weeds show cross-resistance to simazine. Recently in Japan two species of *Erigeron, E. philadelphicus* (ERIPH)[4] and *E. canadensis* (ERICA)[5], were found to be tolerant to paraquat.

The resistant mechanism of maize to atrazine is detoxification, which consists of three ones; both glutathion conjugation and hydroxylation of chlorine atom and N-dealkylation of the side chains. In the case of rice plants to propanil, rice can hydrolyze the herbicide into 3, 4-dichloroaniline by rice aryl acylamidase I. Other many examples of detoxification of herbicides in the selectivity mechanisms have been reported.

In the case of atrazine-resistance in weeds, it has been reported that the action site has become to be resistant to the herbicide. The action site of atrazine or other so-called Hill reaction inhibitors is the B-protein in the electron transport system in photosynthesis in chloroplasts. The B-protein consists of 353 amino acids and has 32 kilodalton, and that of atrazine-resistant weeds has changed amino acid sequence of the protein at 228th from serine to glycine[6]. This simple change or mutation makes it resistant to atrazine. Other Hill reaction inhibitors can also act on the B-protein, but the change in the amino acid had shown almost no effect on the actions by these herbicide, i.e., diuron or ioxynil.

Here we should pay an attention to such difference in the atrazine resistances between crop plants and weeds. The difference makes the action of the herbicide on the photosynthesis different between them as follows: in maize it was at first inhibited completely and recovered until the control level, but in weeds no inhibition was recognized from the beginning of the atrazine treatment.

Such mechanism as the single amino acid change in the action site of resistant organisms can be compiled as shown in Table 1. These results showed us that a single mutation in DNA level having meaningful codon change will be able to make such organism resistant to the herbicide.

Table 1. Examples of herbicide resistance by single amino acid change in the target protein.

Herbicides	Target protein	Amino acid change Susceptible to Resistant	Leterature
Atrazine	B-protein in photosynthetic electron transport system	Serine to Glycine	(6)
Glyphosate	Enolepyruvinylsikimate-3-phosphate syntase in *Salmonera*	Proline to Serine	(7)
Sulfometuron methyl	Acetolactate synthase in yeast	Proline to Serine	(8)

Regarding the heredity mechanism, the author showed the propanil resistance in rice plants, the biosynthesis of rice aryl acylamidase I, can be controlled by a dominant single gene[9]. The resistance in tobacco plant to sulfometuron methyl was found to be controlled by a dominant or semi-dominant single gene[10]. On the other hand, the resistance of weeds to atrazine described above is controlled by cytoplasmic one, in other word it shows a maternal inheritance.

These simple inheritances will be able to be utilized to the genetic engineering of herbicide resistance in crop plants.

Methodology of breeding of herbicide-resistant crop plants

Faulkner[11] described that "Three alternative courses of action can be envisaged for creating a herbicide-tolerant cultivar that is as good as the best other cultivars in yields and quality, (a) Find alleles for herbicide tolerance and combine them with alleles for general agronomic traits, (b) Choose a superior but susceptible cultivar and improve its tolerance by intravarietal selection, and (c) Use mutagenesis to increase tolerance in an existing cultivar.". These have been done in the case of classical breeding systems, but the same methodology may be applied when we will use so-called new biotechnology, in which those are (a) introduction of resistant gene, (b) selection of resistant one, and (c) mutagenic creation of resistant gene.

Faulkner[11] also described in details the classical breeding of herbicide-resistant cultivars with 13 valuable summary items, one of which is "Breeding for tolerance to herbicides is a cheaper alternative than developing new herbicides as a means of combating weed problems.".

Here the author would like to add several examples of breeding of herbicide-resistant crop plants by so-called new biotechnology or genetic engineering.

Introduction of resistant gene into crop plants:

There are many methods in order to introduce resistant–gene or codes into crop plants as like as transformation, transduction, conjugation and cell fusion in the field of genetic engineering. However the practical experimental technics, for instance the selection of vectors, in higher plants is not fully advanced, then the examples with these methods are scarcely reported.

Gressel and others[12] reported segregation of atrazine resistance after protoplast fusion of a resistant black nightshade, *Solanum nigrum* L. (SOLNI), biotype with Potato. Protoplasts were isolated from sterile tip culture of both plants and fused under conditions that precluded the regeneration. Shoots were regenerated from 2,705 fusions derived from four potato lines. These were screened for mix leaf hair characters and pigmentation. All but 60 were discarded as being too similar to nightshade. The rests were tested for dissimilarity with the parents by response to atrazine, chromosome number, branching angle, hairs of the calyx, shape and pigmentation of leaves and flower morphology. Twenty–five clones had stable differences from both parents. Nine had enough mixed characters to suggest clear origin from fusants. Six clones and a reversible chlorotic mosaic in the presence of atrazine and were subcloned to sensitive and resistant plants. They succeeded in the fusion of protoplasts, fusate culture and regeneration from callus, and their poster showed fusant chromosome number was 96 came from both nightshade 72 and potato 24. However, to my question of "Has the fusant any potato tubers?", the answer was "No".

After the selection of herbicide–resistant microorganisms, the resistant gene will be able to transfer or introduce to crop plants if suitable vector system will be developed.

Selection of tolerant crop plants:

Selection is a very important process in the classical breeding method, and in the case of cellular engineering it will be done using cell or small colonies of tissue culture under a pressure of the herbicide which we want to use to the crop. Suspension or plate culture of both single cell or small callus will be screened by the pressure of such herbicide, and survival cells or callus will be transferred to the next medium with the same or higher concentration of the herbicide than the former one. These process will be repeated several times, and the survival cells or callus will be regenerated by the regulation of plant growth regulators, i.e. changes of components and concentrations. The regenerated plants will be tested for the resistance to the herbicide.

Sometimes haploid plants will be used as the source for selection, then in this case diploidization should be followed by the treatment with colchicine.

Chaleff and Parsons[13] used classical microbial mutant selection methods to isolate picloram–tolerant mutant in tabacco. The cell suspensions were plated on agar medium containing $5 \times 10^{-4} M$ picloram and after 1 to 2 months of incubation, growing colonies appeared. These colonies were isolated and any that continued to grow after a second picloram passage were induced to regenerate shoots. Of seven variant lines isolated from one experiment, plants could be regenerated from only six. Callus derived from the regenerated plants was picloram tolerant for five of the six tolerant cell lines. In four of these five lines, tolerance was transmitted to the progeny and was expressed in both plants and callus derived therefrom. In all four cases, segregation ratios are consistent with those expected for dominant single–gene mutations.

Very recently Chaleff and Ray[10] created sulfonylurea herbicide–resistant tobacco by the resemble methods. Sulfonylureas, in which group chlorsulfuron or sulfometuron methyl are contained, have extremely high herbicidal activity with practical dosage of 10 – 50 a.i. *g* per *ha* and a very low toxicity to animals with 5,500 *mg/kg* LD_{50} to rat, and seem to be an ideal type of herbicide. In their experiments, from haploid leaves of *Nicotiana tabacum* cv. "Xanthi" were treated with 2*ppb* of sulfonylurea herbicides along with mutagenic treatment of 1 *mM* ethyl nitrosourea. The regenerated resistant tobacco plants were found to show the same height as like as no treatment even at a spray of 100 *ppm* chlorsulfuron which is a practical dosage. At this dosage the susceptible usual one showed less than 20% of control. In the case of sulfometuron methyl resistance the inheritance was analyzed, and found to be simple dominant or semidominant gene control as described above and shown in Table 2[10].

Table 2. Segregation among progency of crosses with a mutant S4 regenerated plant (10).

Cross	Number of individuals			
	Resistant to sulfometuron methyl		Sensitive to sulfometuron methyl	
	Observed	(Expected)	Observed	(Expected)
N selfed	0		459	
R selfed	176		0	
R × N	311		0	
N × R	52		0	
(R × N) × N	39	(38)	37	(38)
(R × N) selfed	100	(100.5)	34	(33.5)

A plant regenerated from the sulfometuron methyl–resistant cell line S4 is designated R. Normal plants (N) were grown from seeds of the parent *N. tabacum* cv. "Xanthi".

Furusawa and others[14] isolated protoplasts from tobacco leaves and cultured them. And using the callus population selection was done under the screening pressure by atrazine or paraquat. They made atrazine–resistant tobacco already, and isolated paraquat–tolerant callus having 14 – 159 times stronger activity of superoxide dismutase which seems to detoxify superoxide redicals increase by the treatment of paraquat.

Mutation:

Before the selection described above, usually mutagenic treatment used to be added using radiation or mutagenic chemicals. Radin and Carlson[15] developed an unique method in this field as described below. They sprayed the immature leaves of mutagenized haploid tobacco plants with either bentazon or phenmedipham. As the leaves expanded, small green island appeared on otherwise yellow leaves.

These green sectors were excised and placed on a culture medium known to induce shoot regeneration. Plants were regenerated from almost all of the excised sectors, and 21% of the bentazone-selected plants and 13% of the phenmedipham-selected plants retained resistance to their respective herbicides.

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Mimosa pigra L.

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ABSTRACT

Mimosa pigra L. (Leguminosae) is named as one of the noxious weed in many parts of the tropical area of the world especially Thailand. The main problem created by *M. pigra* is the obstruction of the water flow and building up of sediment. Dispersal, problem and control of *M. pigra* in Thailand have been initiated. The effective control of *M. pigra* is integrated control i.e. cutting, burning and allowing the cut stumps to regrowth and the new seedlings germinated from seeds, then followed by herbicides application. Aerial spray is used in large infested area. Herbicides employed are fosamine (ammonium ethyl carbamoyl-phosphenete, glyphosate (N-phosphonomethyl glycine) and dicamba (3, 6-dichloro-o-anisic acid) for ground spray, and only fosamine and glyphosate have been used for large scale control by aerial application.

INTRODUCTION

Mimosa is a common name of a kind of plants with a characteristic of being able to fold the leaves when touched, known as the sensitive plants. In Thailand, there are three types of mimosa plants, the first one is the creeping mimosa *(Mimosa pudica)*, a small plant which can grow to the height of 50 to 75 centimeter with purple flowers, commonly found along the roadside and ditchbanks. The second kind is vine mimosa *(Mimosa invisa)*, an annual plant that can grow up to one and a half meter high with purple flowers produced on the nodes. This second species is commonly found along highways in northern Thailand. The third kind of mimosa is the giant mimosa *(Mimosa pigra* L.*)*, a noxious weed that causes tremendous problem to the government and private agency especially in the north since 1974.

M. pigra is known by various common names such as "giant mimosa" "giant sensitive plant", and many others. It is known as "Mai Yah Raap Yak" in Thai. *M. pigra* is native to the tropical parts of Central and South America but now certain parts of the world, mostly in the tropical parts, are now experiencing its destructiveness to some varying degrees including its native home in Central and South America. Right now the plant is considered as a noxious weed and was declared as such by many countries. In 1978, Australia, under the revision of the Noxious Weeds Act, *M. pigra* was declared as a noxious weed. The United States of America declared in the year 1984, and Thailand by the used of the Plant Quarantine Act declared in the year 1983.

M. pigra was first introduced to Thailand from Indonesia in the year 1960 to plant as a green manure and cover crop in tobacco plantations and later used to help control ditchbank erosion around Chiengmai area. *M. pigra* seems to be spreading rapidly and extensively. Around 1980, *M. pigra* infestations were reported from

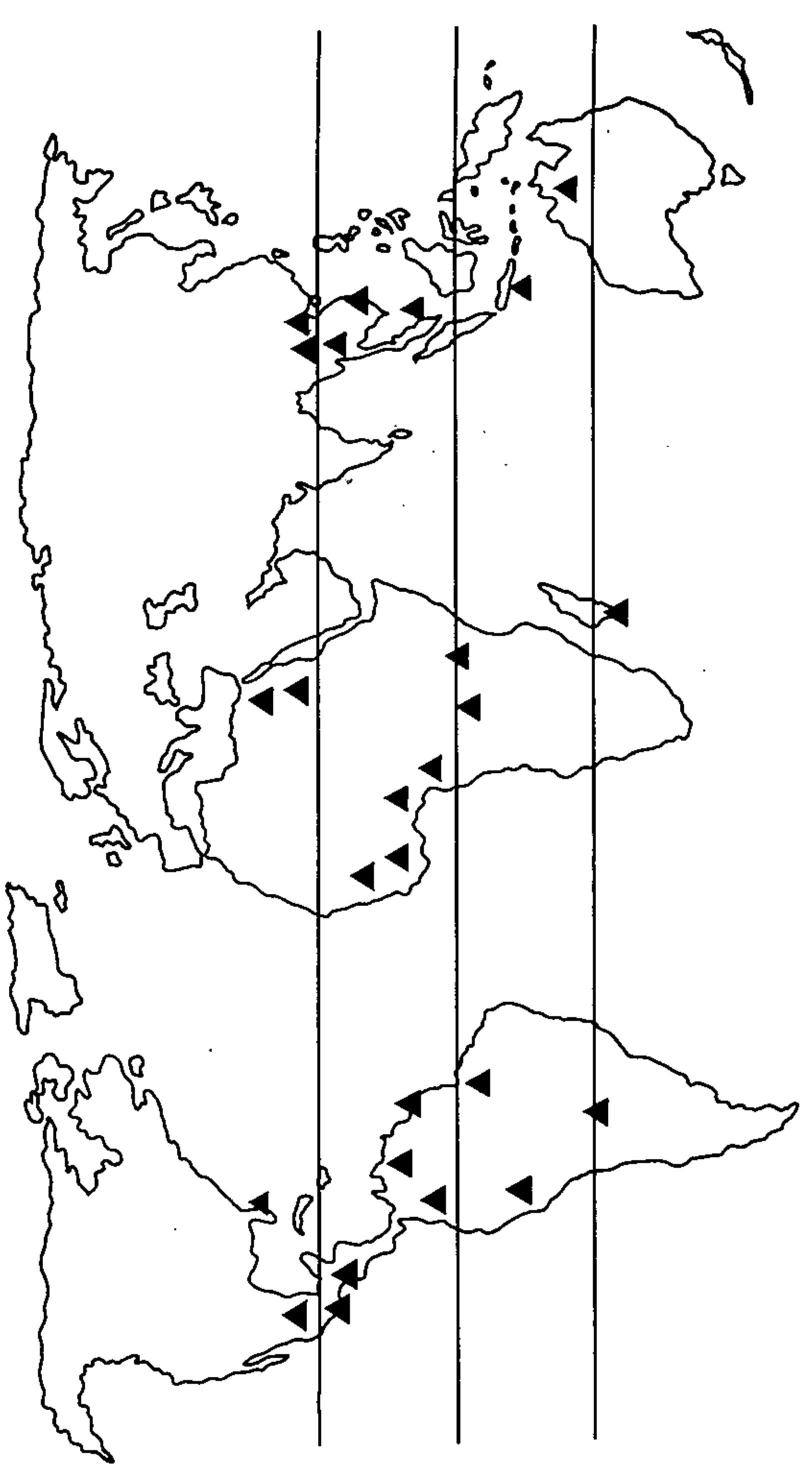
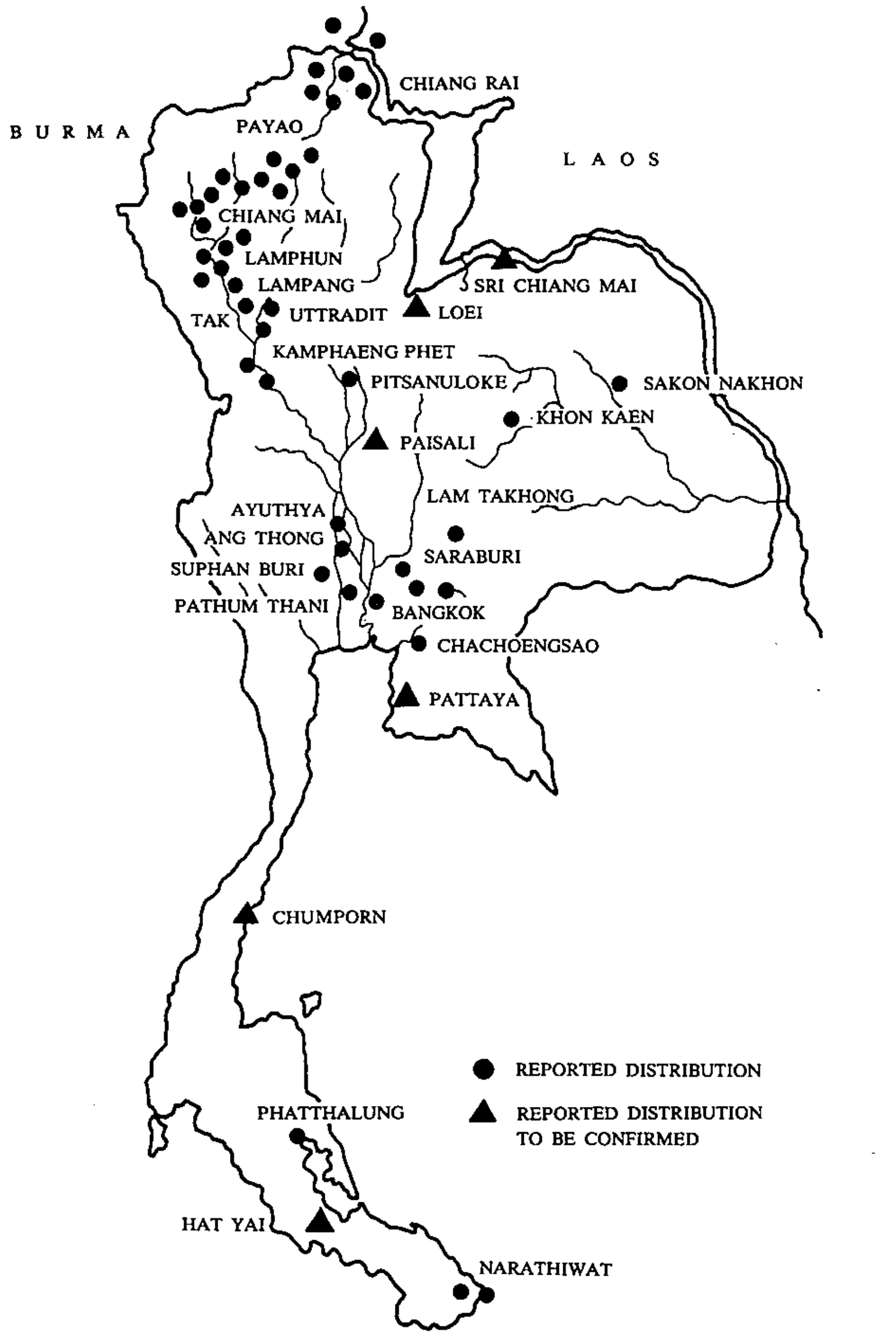


Figure 1. Geographical distribution of *Mimosa pigra* L.



Source: National Biological Control Research Center (NBCRC) Kasetsart University, Bangkok, Thailand

Figure 2. Distribution of *Mimosa pigra* L. in Thailand.

many parts of the country out of the north, especially the Lower Central Plain area which is the rice bowl of the country.

Biology

M. pigra is a perennial shrub in legume family. It has sharp thorn covering the branch and stem. It can grow up to five metres in height and disseminate by seeds produced almost year round from the purple flowers. The giant mimosa starts flowering at 1 year old. The flower is ball-shaped with a diameter of around 1 centimeter produced on the nodes. Young pods are produced in clusters and turn from green to dark-brown when mature. Each pod contains 10 to 25 seeds. There are one to sixteen pods in one bunch. The days between flowering to mature pods are about thirty five days. *M. pigra* will flower and produce seeds for 9 months per year. It was estimated that giant mimosa plant of less than 2 years old can produce up to 42000 seeds per season. Matured seeds in the pods fall off from the plants and disseminated in water and stay viable for not less than one and a half years. When conditions are favorable, these seeds will germinate to give new daughter plants.
M. pigra can grow and thrive in all kinds of soil, but moist sandy soil is most favorable. Therefore it is not surprising to find heavy infestation of this weed along streams, rivers and ditchbanks.

Problems

M. pigra is considered a noxious weed especially to the irrigation systems, because it obstructs and diverts water flow and cause excessive sedimentation when grows along irrigation ditches. Moreover, the weed has infested large areas of non-crop lands in the north and spreading southward via natural waterways. Currently the *M. pigra* infested area is estimated to be ten thousands hectares of land, mostly adjacent to water.

Men also play an important role in the dissemination of giant mimosa. The seed containing sand or soil from the infested river bed or land are transported and used for land filling. The seeds can also spread long distance by contaminating the equipment and vehicles involved in this earth moving operation.

Control

The control methods currently and commonly used for *M. pigra* are mechanical methods, such as manual cutting or removing using heavy equipments. This methods are not efficial control measure since the whole weed plants are not removes, resulting in new regrowth soon after practicing. In some case, the cut weed is burnt but new shoots can still be formed from the unburn parts beneath the soil. Moreover, burning helps breaking the seed dormancy, resulting in numerous young plants germinated from seeds.

Recently the chemical control method for the weed has been evaluated. The mostly concerned and important factor in this control method is selection of the chemicals that are effective against the weed and environmentally safe enough to use near or on the waters. Both ground and aerial applications are now under testing to find the suitable herbicides and application technology for economical control of the weed.

As far as the control measure are concerned, the practical and economical way for small plant is mechanical removal. If the infestation is heavy, chemical control is inevitable. Early rainy season before seeds are produced is a good time for chemical control.

The more practical and economical way to control *M. pigra* is the combined method, that is cutting, burning and allowing the cut stumps to regenerate and the young seedlings appeared, then followed by some suitable herbicides. In flooded areas the weed should be cut before flooding, to allow the plants to be flooded. The stubs thus remained will be killed if submerged for more than 30 days. In large area where the weeds have been found in the drawn down area, chemical method by aerial application have to be done. The best time is after the first rainy day.

Royal Irrigation Department is the first government agency that utilizes the results from the mimosa control research into practice. From 1979 the control measures have been aimed at removal of the plant from waterway drainage system, reservoirs, ditchbank and roadsides. Most of the works have been done in the northern part especially in Chiangmai and Lampang, Control is also being carried out on new isolated infestations away from the north, as in Klong Pleo, Saraburi in the central area and Narathiwat in the Penninsular area.

Control methods include both manual cutting and chemical ground and aerial spray. Herbicides that prove effective and used to control *M. pigra* in irrigation systems over the year are fosamine, glyphosate and dicamba for ground spray. Only fosamine and glyphosate have been used to control mimosa by aerial spray.

Research

If we look back, *M. pigra* has changed itself from an introduced plant to a noxious weed in less than 25 years. The weed is so important that a special task force committee has been set up by the government to tackle the problem. Coordinated control projects were established involving various concerned government agencies. Recommendation for the control measures have been issued and more research is underway to prevent further infestation of the weed. Biological control research program on *M. pigra* commenced in 1975 by the National Biological Control Research Center (NBCRC) on the survey and evaluation of native insects. Further studies on natural enemies of *M. pigra* in its native range and selection of potential biological control agents for introduction into Thailand were carried out under a cooperative program between NBCRC and ACIAR (Australia Center for International Agricultural Research). As a result the seed bruchids were introduced and released in 1984.

For chemical control, the research program is concentrated on the determination of herbicide applications compatible with different management strategies.

CONCLUSION

Mimosa problem is increasingly important to the country. In 1983 the Committee on National Rural Development endorsed *M. pigra* as the noxious weed, and included this weed in the national work plan.

The Ministry of Agriculture and Co-operative has decreed all provinces except Chiengmai, Chiengrai, Lampang, Lampoon, Kampangpeth, Utoradit, Tak and Payao as the area for total eradication of *Mimosa pigra* in accordance with the Plant Quarantine Act 2507.

By the use of the Plant Quarantine for *M. pigra* control and successful in every kind of research control include the coopertion from most people concerning with it, it is hope that mimosa population will be reduced to the under controled level in the future.

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A HABITAT OF *Erigeron philadelphicus* L. RESISTANT TO PARAQUAT

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ABSTRACT

In 1980, Watanabe et al. found a population of *Erigeron philadelphicus* L. resistant to paraquat in mulberry fields located on the river bank of the Arakawa River in Fukiage, Saitama, Japan. Itoh and Miyahara conducted the cross breeding experiments and revealed that a single dominant gene controls the paraquat resistance in the species.

E. philadelphicus with paraquat resistance had the different habitats through paraquat application. The mulberry fields with the paraquat application twice or three times annually during the preceding nine to twelve years had an extremely high proportion of paraquat resistant biotype in the species. No resistant biotype appeared in the two abandoned mulberry patches where paraquat had not been applied during last two or three years. The paraquat resistant biotype was observed to be only 0.0 to 16.1% of a population in the places where paraquat had never been applied before.

This biotype is possibly less fit than the susceptible biotype in the absence of paraquat treatment.

INTRODUCTION

In 1980. Watanabe et al. (1982 a) found a population of *Erigeron philadelphicus* L. resistant to paraquat in mulberry fields in Fukiage, Saitama Prefecture, 60 *km* north-west from Tokyo. Paraquat had been applied to the fields twice or three times annually for many years in the past. Presently, about 100-times more paraquat is necessary to control the population in the affected fields than the recommended dose for a common susceptible population. The paraquat resistant plants show cross-resistance to diquat, but are susceptible to glyphosate, bentazone and MCPA (Watanabe et al. 1982 a).

The resistant seedlings required a 250-times higher paraquat dosage to kill them-than the susceptible seedlings. In the genetical analyses of F_1 from crosses of Susceptible × Susceptible, Susceptible x Resistant, Resistant × Susceptible and Resistant × Resistant, the results provided evidence that a single dominant gene controls the paraquat resistance in *E. philadelphicus* (Itoh and Miyahara 1984).

Subsequent to the above findings, paraquat resistance in *E. philadelphicus* was also discovered in other mulberry fields in Saitama Prefecture (Hanioka 1983), in chestnut fields in Ibaragi Prefecture (Saka et al. 1985), and Kato et al. (1982) also found a population of *Erigeron canadensis* L. resistant to paraquat in grape fields in Osaka Prefecture.

This paper reports the detail distribution of resistant biotypes in the field where paraquat resistance in *E. philadelphicus* was first detected.

MATERIALS AND METHODS

Experiment I.

Preliminary investigation on occurrence ratio of resistant plants of *E. philadelphicus* population on the four mulberry patches shown in Fig. 1 was carried out by dividing a patch into six to twelve blocks. Leaf disks 8 *mm* in diameter were punched from 40 to 67 rosette leaves of individuals sampled at random with a block. The disks were immediately dipped into distilled water and carried back to a laboratory To determine the response of *E. philadelphicus* to paraquat, the disks were dipped into Petri dishes 5.5 *dm* in diameter filled with 10 *ml* of 10 *ppm* paraquat solution (Watanabe et al. 1982 a). The disks were incubated at 25 °*C* under fluorescent light with 5,000 *lx*. After 48 hours, the ratio of paraquat resistant biotype was analysed by observing changes in green coloration of the disks.

Experiment II.

Two belts as shown in Fig. 1 (A: about 400 *m*, B: about 800 *m*) were chosen April 20th and 21st, 1982. The belts were divided into several patches by different land utilization such as embankment, useless land, abandoned mulberry patches, mulberry patches with different weed control, the center of a rough road, causeway and so on. The leaf disks were punched and analysed by the method used in experiment I. The number of samples per block varied from 18 to 93 with a mean of 42 in belt A, and 24 to 68, with a mean of 51 in belt B. Four persons were engaged in the sampling process. In addition, the coverage (−, +, 1, 2, 3, 4 and 5) of *E. philadelphicus* and other weed species was checked in each block.

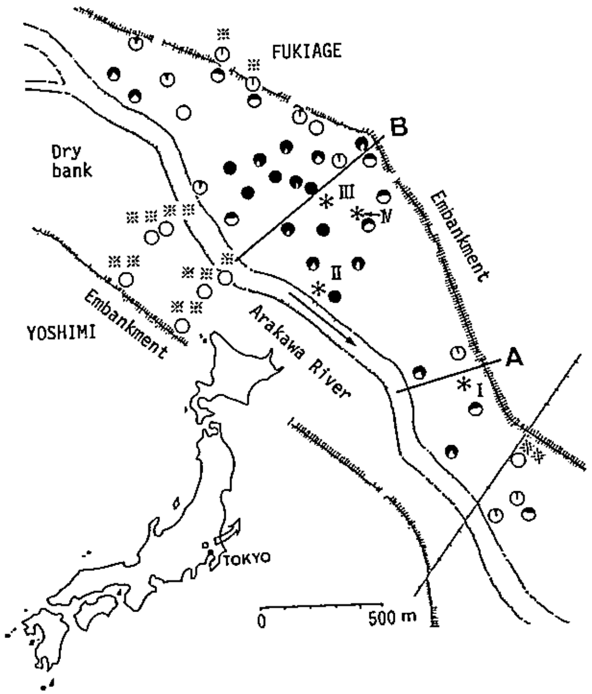

Fig. 1. Distribution of paraquat resistant biotype in *Erigeron philadelphicus* at mulberry fields in Arakawa River bank in April 1981 (Watanabe et al. 1982 b, Watanabe 1983) and experimental patches (I–IV) in Table 1 and experimental belts (A, B) in Fig. 2.

RESULTS

(1) Variation of resistant ratio on a mulberry patch

When a frequency of paraquat application was the same, the patches applied more recently with paraquat exhibited higher ratio of paraquat resistant biotypes to the total examined plants of *Erigeron philadelphicus* (Table 1). The difference of resistant–byotype occurrence ratios between the center and corner of the patches was not significant. From the micro–environmental view, the ratio of resistant *E. philadelphicus* under mulberry trees was of a low level.

Table 1. The occurrence ratio of paraquat resistant biotypes to the total examined plants of *Erigeron philadelphicus* at a mulberry patch controlled weed by a mulberry grower at Arakawa River bank in Fukiage in April 1982.

Field number	Size of the patch	Patch shape	Paraquat applied time	No. of partitions*	Ratio of resistant biotype mean	range	
	a		months before		%	%	%
I	9.6	rectangle	4	12	92.2	76.2–100	
II	17.8	square	5	10	82.1	65.5–100	
III	12.3	square	3	10	95.8	86.8–100	
IV	3.2	rectangle	12	6	74.3	34.5– 91.4	

* : The sizes of partition were 50 to 180 m^2.

(2) Variation of occurrence ratio of resistant biotypes under different land utilization

The occurrence ratio of paraquat resistant biotypes under different land utilization is shown in Fig. 2. The ratio was high in mulberry patches with higher population of *E. philadelphicus*. Whereas mulberry patches with lower population of the species, the ratio was also correspondingly low. This may indicate that the occurrence ratio of resistant biotypes is reflected by the frequency of paraquat application.

On the other hand, the ratio of resistant biotype was relatively low in other patches used as embankment, causway, road and so on, as shown in lower parts of the lines in Fig. 2.

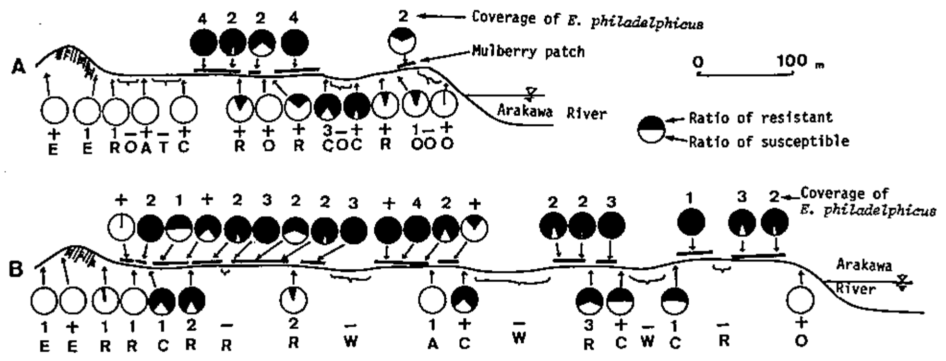

Fig. 2. The ratio of paraquat resistant biotypes to the total examined plants of *Erigeron philadelphicus* under the different land utilization.

Interviews with mulberry growers were conducted and the collected answers were grouped into four categories by a frequency of paraquat application. The categories are as follows: a) open fields where paraquat had never been applied, b) abandoned mulberry patches, c) vicinity of mulberry patches and d) mulberry patches (Table 2). The ratio of resistant biotypes in mulberry patches was the highest of all land utilization examined, and in the vicinity of the mulberry patches there was one–half as much land utilization as in mulberry patches. The resistant biotype was found to be extremely low ranging from 0.0 to 16.1% in places where paraquat had never been applied before.

Table 2. The mean occurrence ratio of paraquat resistant biotypes to the total examined plants of *Erigeron philadelphicus* under different frequency of paraquat application in April 1982.

Paraquat application	Land utilization	No. of samples	Mean ratio of resistant biotype
			%
Never	Open*	10	2.1
2–3 years ago	Abandoned mulberry patch	2	0.0
Sometime with mulberry field	Vicinity of mulberry patch**	14	47.5
Every year	Mulberry patch	24	80.5

* : Embankment, useless land and so on.
** : Center of a rough road and causeway.

DISCUSSION

Erigeron philadelphicus is an alien plant which has been introduced from North America since 1910's. The species was not found in the experimental area before 1958, but its encroachment on mulberry patches were found to increase rapidly since 1970's (Hanioka and Nakajima 1981, Watanabe 1983). The paraquat resistant biotypes in the population in Fukiage were abundantly developed in the mulberry patches without tillage as well as in areas with repeated application of paraquat.

It has been hypothesized that when a herbicide is used repeatedly, there was a very strong selection pressure against non–resistant individuals. And then the non–resistant biotype is relatively easy to be wiped out by herbicide application. In the case of *E. philadelphicus,* according to Macnair's assumptive calculation (1981) complete manifestation in resistant biotype will require only eight generations since single dominant gene involves paraquat resistance (Itoh and Miyahara 1984).

In general it is thought that living things that have survived toxic material (i.e. heavy metal, pesticide etc.) possessed lower genetic diversity, and have often less ecological fitness. This lack of fitness has been described in the repeated use of s–triazine herbicides (Conard and Radosevich 1979, Ahrens and Stoller 1983 and so on.). Little is known about the differental growth between resistant and susceptible biotypes, althouth photosynthetic, respiratory and transpiration rates are a little higher in the susceptible biotype than in the resistant one (Saka and Chisaka 1983). The observation results show that the ratio of paraquat resistant biotypes of *E. philadelphcus* population was the highest on the mulberry patches, and was the lowest in places where paraquat had not been applied during the past two or three years, or in areas without paraquat application of all examined fields. This suggests that the resistant biotype is possibly less fit than the susceptible one in the absence of paraquat application. Since a competitive study has not been carried out between two biotypes in the absence of herbicide, future studies are required to determine whether the competitive ability of the susceptible biotype is superior to the resistant one.

ACKNOWLEDGEMENTS

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ALLELOPATHY IN *Acanthospermum hispidum* DC

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ABSTRACT

Leaf leachates of *Acanthospermum hispidum* DC significantly reduced the per cent germination in musk melon, maize and ragi while the seed leachate reduced the per cent germination in french beans, okra, cucumber, maize and ragi. The root and shoot lengths of most of the crop species were significantly reduced when grown in leaf and seed leachates. Comparatively leaf leachate proved more detrimental than seed leachate for the seedling growth of most of the crop species. The leaf and seed leachates contained vanillic and *p*-hydroxy benzoic acids while their extracts contained *p*-coumaric acid and caffeic acids in addition to the two acids mentioned.

INTRODUCTION

The production and release of allelopathic substances by some plants into the environment having inhibitory and/or promotory effect on the growth of other crops has been well documented (Rice, 1979; Sukhada, 1975 and Leela, 1981 & 84). *Acanthospermum hispidum* DC is a common weed of dry lands, road sides and waste lands. But of late it has started invading horticultural crops especially the fruit and vegetable fields in great numbers. It propagates mainly through seeds, its fruit being a spinous achene. The fruits are produced in abundance by a single plant and dispersed to far off places by different modes of dispersal. We observed that this weed generally did not allow any other broad leaf weed to grow around it except *Lagasca mollis.* Till date, allelopathic effects of *A. hispidum* on other plants has not been reported by any worker. The present investigation was taken up with a view to study the presence and distribution, if any, of the inhibitory factor within the weed and its effect on the germination and seedling growth of some selected horticultural and cereal crops. The nature of the inhibitor and its estimation also formed part of the study.

MATERIAL AND METHODS

a) Collection of leaf and seed leachate from *A. hispidum*

100 *g.* each of leaf and seeds of *A. hispidum* were collected from natural stand of the weed. They were surface sterilised with 0.1 % mercuric chloride for 1-2 *minutes* and repeatedly washed with distilled water. Then they were cut into small pieces, air dried and soaked in 1.0 *litre* of distilled water for 48 *hrs.* at room temperature. The leachate was filtered and concentrated to give a final concentration of 1.0 *m* = 0.1 *g.* dry wt. of weed material. 20 seeds of the crop species viz., french beans, okra, fenugreek, cucumber, muskmelon, ridge gourd, green gram, maize, wheat

and ragi were germinated in Petri dishes containing 8 *ml* each of the leachate. Per cent germination and length of root and shoot of crop species were recorded.

b) Growth inhibitors from leaf and seed leachates and leaf and seed extracts of *A. hispidum*

5.0 *g.* of dried leaf and seed material were powdered and extracted separately in 80% methanol for 48 hours at room temperature (28° *C* D and 20.0 N). The extracts were filtered and the filtrates concentrated under reduced pressure. The residue was thoroughly shaken with petroleum ether, extracted with ethyl acetate and evaporated to dryness under reduced pressure at 40–50° *C*. The residue that was left in the flasks was extracted with 0.1 N $NaHCO_3$, acidfied to pH 2.5 with concentrated HCl and again extracted with ethyl acetate to a final volume of 250 *ml.* for the final separation of inhibitor. The acidic fractions were washed thoroughly in distilled water to remove last traces of HCl and concentrated. The remaining fraction was also concentrated similarly.

Both acidic and non acidic fractions were tested for their inhibitory property by wheat bioassay. Qualitative estimation of phenolic acids was done by descending chromatography. 0.5 *ml.* of the extract equivalent to 2.5 *g.* dry weight of the material was streaked on to the chromatography paper and run in 2% acetic acid along with various standard phenolic acids obtained from Sigma chemicals. The papers were subjected to various tests viz., (i) Fluorescence under Uv, (ii) treatment with 1.0% ferric chloride plus 1.0% potassium ferro cyanide and (iii) Spray with *p*-nitroaniline and 15% Na_2CO_3 for the identification of phenolic acids.

RESULTS

i) Effect of leaf and seed leachates of *A. hispidum* on the germination of crop species.

Leaf leachates of *A. hispidum* significantly reduced the per cent germination in musk melon, maize and ragi while the seed leachate reduced the per cent germination in french beans, okra, cucumber, maize and ragi (Table 1).

Table 1. Seed germination (%) of crop species treated with leaf and seed leachate of *A. hispidum.*

Treatment Crop species	Control	Leaf leachate	CD at 5%	Control	Seed leachate	CD at 5%
French beans	28.3	29.6	NS	70.0	40.0	9.9
Okra	28.3	30.0	NS	99.3	30.0	7.5
Fenugreek	100.0	100.0	NS	100.0	100.0	NS
Cucumber	60.0	60.0	NS	95.0	60.0	12.4
Musk melon	70.0	65.0	2.4	70.0	65.0	NS
Ridge gourd	80.0	80.0	NS	40.0	40.0	NS
Green gram	100.0	100.0	NS	100.0	100.0	NS
Maize	70.0	50.0	17.3	100.0	100.0	NS
Wheat	90.0	90.0	NS	99.3	99.3	NS
Ragi	100.0	65.0	7.5	78.3	20.0	14.3

ii) Effect of leaf and seed leachates of *A. hispidum* on seedling root and shoot lengths of the crop species.

Root length

Highest per cent reduction in root length over the control was seen in french beans followed by wheat, ragi and ridge gourd. In seed leachate, the most adversely affected crop species was ragi followed by cucumber, musk melon (both equally sensitive), okra and maize (Table 2).

Table 2. Effect of leaf and seed leachate of *A. hispidum* on the seedling root and shoot length of crop species.

Treatment Crop species	Root length (per cent decrease over control)		Shoot length (per cent decrease over control)	
	Leaf leachate	Seed leachate	Leaf leachate	Seed leachate
Ragi	80.4	82.5	16.7	60.0
Wheat	85.2	37.7	50.8	21.4
Maize	77.5	63.4	8.6	50.0
French beans	86.6	44.7	0.0	0.0
Ridge gourd	71.4	55.6	0.0	0.0
Fenugreek	50.0	41.7	53.0	24.3
Green gram	25.6	34.4	45.2	42.6
Okra	75.0	75.0	52.6	0.0
Cucumber	18.4	76.9	31.3	17.6
Musk melon	46.2	76.9	56.5	45.0

Shoot length

When grown in leaf leachate, highest per cent reduction in shoot length over the control was observed in muskmelon followed by okra, fenugreek and wheat. Here too, ragi showed maximum sensitivity when grown in seed leachate. This was followed by maize, muskmelon and green gram (Table 2).

iii) Growth inhibitors from leaf and seed leachates and leaf and seed extracts of *A. hispidum.*

The leaf and seed leachates contained vanillic and *p*-hydroxy benzoic acids while their extracts contained *p* coumaric and caffeic acids in addition to the above two acids. The Rf values are given in Table 3.

Table 3. Inhibitors in leaf and seed leachates and leaf and seed extracts of *A. hispidum*

Standard Phenolic acids	Rf values	Leaf leachate	Seed leachate	Leaf extract	Seed extract
p coumaric acid	0.39	–	–	0.39	0.4
Caffeic acid	0.46	–	–	0.49	0.49
Vanillic acid	0.54	0.53	0.51	0.55	0.53
p hydroxy benzoic acid	0.64	0.67	0.6	0.61	0.61

DISCUSSION

A. hispidum belonging to the Family Compositae is an obnoxious weed that invades fruit orchards and vegetable fields extensively. Each plant produces large number of leaves and fruits which on falling to the ground get mixed with soil and irrigation water resulting in the release of certain growth inhibitors into the soil. The present study revealed that both leaf and seed leachates contain phenolic acids and brought about inhibition of germination and reduction in seedling growth of crop plants at concentration as low as 0.8 g. dry weight. Leaf leachate brought about greater reduction in root length than seed leachate in case of wheat, maize, french beans, ridge gourd and fenugreek. Seed leachate brought about greater reduction in root length in ragi, green gram, cucumber and musk melon as compared to leaf leachate. Considering the fact that inhibition is brought about at such low concentrations as mentioned above, the problem encountered by crop plants in nature could be enormous especially when one thinks of cultivating the fallow fields where *A. hispidum* grows in abundance. Proper care should be taken to see that no residues of plant parts of *A. hispidum* are left in the soil before sowing of crop plants. This could be accomplished in one of the two ways given below. (i) Before such a land is put to cultivation, proper care should be taken to ensure that the land is free of this weed. (ii) the land should be well irrigated so that the inhibitors could be leached down to such strata of soil where they become unavailable to the crop seedlings.

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AQUATIC NOXIOUS WEEDS OF CALIFORNIA

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ABSTRACT

An account is given of the history, distribution, ecology and physiology of the noxious aquatic weeds of California as described by current state and federal regulations: nemely - alligatorweed, *Alternanthera philoxeroides;* hydrilla, *Hydrilla verticillata;* banana waterlily, *Nymphaea mexicana;* red rice, *Oryza rufipogon;* monochoria, *Monochoria vaginalis;* salvinia, *Salvinia auriculata* complex including *S. biloba, S. herzogii* and *S. molesta.* Waterhyacinth, *Eichhornia crassipes,* and limnophila, *Limnophila indica,* are also discussed. These two taxa are not proclaimed noxious weeds, but other species in these genera are so designated.

INTRODUCTION

By definition in the California Agricultural Code a noxious weed must be one that is difficult to control and causes significant economic loss to agriculture. Recently this definition has been broadened to include any pest that is detrimental to the environment so that native wetlands of California can be now included in the protection provided by declaring a plant species a noxious weed. The proclamation of a weed species as noxious in California also contains political implications as regards money available for any action against a particular weed.

The following aquatic species have been declared noxious weeds in California.

"A" rated pests, requiring eradication or containment wherever found in the state and to be rejected from any shipment sent into the state.

Alternanthera philoxeroides, alligator weed.
Hydrilla verticillata, hydrilla,

"B" rated pests, subject to eradication, control, or any holding action that the particular county agricultural commissioner wishes to enforce.

Nymphaea mexicana, banana waterlily.
Oryza rufipogon, red rice.

"Q" rated pests, permits a temporary action as if the weed is an "A" pest.

Salvinia auriculata complex, salvinia.
consisting of *S. auriculata, S. biloba,* S.
herzogii, S. molesta.

Alligatorweed, *Alternanthera philoxeroides,* was first found in the Los Angeles area in 1949. The area is a Flood control reservoir that impounds water flowing from the mountains, preventing damage to the cities around the area. The flood water in slowly released down the Los Angeles River which is concrete lined for a great deal of its length. Also water is run into settling basins below the dam to replenish the ground water. Alligatorweed became abundant in the reservoir and in the settling basins as well. Soil is removed from the settling basins to maintain their capacity to hold water. Alligatorweed plants were also removed and persisted for some time as terrestrial weeds in gardens where the soil had been spread. Even though the control program has reduced the Los Angeles County alligatorweed infestation to very few plants, the current expenditure is to find and treat the remaining plants is quite costly.

In 1965 alligatorweed was found in Tulare County in drainageways flowing down the east side of the San Joaquin Valley floor. In late summer the weed completely blocked the water channels. These channels end in the valley floor and do not connect to the flowing streams of the San Joaquin Valley. Therefore the sterile alligatorweed plants were not a threat to the drainage of the valley, unless carried by man from this area. Chemical control using vapam has been quite successful.

Hydrilla, *Hydrilla verticillata,* is the most serious aquatic weed in California. It was first found in California in a lake at Marysville, Yuba County in 1976, in the rice producing area of the state. This lake is behind a levee and below the level of the Sacramento River. The outflow from the lake is pumped into the river after passing through a screen. The weed population has been eradicated. As yet hydrilla has not been found in any other place in the Sacramento Valley.

A number of isolated infestations of hydrilla have been found in the state. The most serious one is in the canal system that supplies water for use by cities and agriculture in the Imperial Valley along the southern border of California. The canal system is estimated to be infested by hydrilla for a distance of four hundred eighty kilometers, seriously impeding the flow of water especially in the smaller canals. Drawing down the water level and drying the exposed hydrilla plants is very successful, particularly in late summer when there is the greatest growth of the weed. All types of mechanical means have been use to control hydrilla, restoring the flow in the canals. The most effective mechanical method has been a hydraulic dredge with a floating platform. A SCUBA diver directs the intake suction hose and the solid material is trapped in a screen, the water returning to the canal. Chemical control is possible with chelated copper in ponds and acrolein in running water. However, because of the urban, industrial and agricultural uses of the water, chemical control is not always acceptable.

Biological control of hydrilla is being started in 1985. Sterile triploid carp, produced by temperature shock to fertilized eggs, have been found in laboratory and field studies to be as effective as fertile grass carp in consuming the same amount of vegetation. Several thousand sterile triploid grass carp are being released in the upstream infested portion of the canal. If these carp prove successful the hydrilla eradication program will begin in 1986, by stocking carp in the largest canals. In 1987 the program will extend downstream in the rest of the canal system. At this time it is estimated that 20% of the carp will have to be replaced each year.

Hydrilla was an abundant weed of Lake Murray, the last reservoir before water enters the pipes of the City of San Diego water system. Initially the population was reduced by a draw down of the reservoir in late summer, drying out most of the plants. At present hydrilla control is being done by 5 SCUBA divers locating rooted plants, marking them with buoys and removing each weed and the soil below it by a hydraulic dredge.

Nymphaea mexicana, banana waterlily, is native in Mexico and is established in southern Arizona, southern and eastern Texas and southern Florida. The plants retain the basal portions of old petioles, resembling a bunch of bananas. It was purposefully planted in California in a waterfowl hunting area and escaped. First discovered in 1974, the weeds became abundant and seriously slowed the drainage of the San Joaquin River. The first chemical treatment of the infestations done by airplane were quite successful. Annual treatments by air are needed to keep the banana waterlily from blocking the river drainage again.

By contrast, *Nymphaea odorata,* white waterlily, native from Arizona and Texas north to eastern Canada, is not rated as a noxious weed. It is naturalized in a single lake in the floor of the Sacramento Valley where water collects from a large sink or swamp area. The waterlily plants do not interrupt the slow drainage from this swamp into the lake or the drainage of the lake into an irrigation canal. It is also established in the mountains in Lost Lake, San Bernardino County and in Mosquito Lake, Alpine County.

Oryza rufipogon, red rice, is rated as a "B" pest that can be contained or eradicated at the discretion of the county agricultural commissionier. In actual practice, this weed pest is treated as an "A" pest. Almost the entire California rice crop is planted using certified seed. The seed fields are inspected twice each year, and the finding of one or more plants of red rice removes that field for certification. Red rice can be found each year in the bulk shipments of California rice, but at such a low level it is no economic importance.

Plants of the *Salvinia auriculata* complex are not established as weeds in California, but have been intercepted in shipments of live plants. By listing the species of the complex; that is, *Salvinia auriculata, S. biloba, S. herzogii* and *S. molesta,* it is not necessary for a quarantine inspector to identify these taxa to species. In actual practice entry is refused for plants of any species of *Salvinia.* Probably somewhere in California's diverse climate salvinia could be a weed problem.

In addition to the California regulated species, there are the Federal Noxious Weeds. This list has been prepared with a great deal of input from personnel in the State of Florida, particularly as regards aquatic species. Florida has received numerous infestions of aquatic weeds which were able to become noxiously abundant under the tropical and subtropical conditions in that state. Plant material of these species cannot enter the United States or cross state boundaries unless a permit has been granted from the United States Department of Agriculture Plant Protection and Quarantine Programs.

Federal Noxious Weed Act.

Aquatic Weeds.
Azolla pinnata
Eichhornia azurea
Hydrilla verticillata
Hygrophila polysperma
Ipomoea aquatica

Limnophila sessiliflora
Monochoria hastata
Monochoria vaginalis
Sagittaria saggitifolia
Salvinia auriculata
Salvinia biloba
Salvinia herzogii
Salvinia molesta
Sparganium erectum
Stratiotes aloides

It is interesting to note that waterhyacinth, *Eichhornia crassipes,* does not appear as a noxious weed either in the Federal List or in the California List. This weed was recorded as established in the state in 1904, but dit not become a serious problem until the drought years of 1976 and 1977. The annual flushing of the waterhyacinth plants out of the Delta of the San Joaquin and Sacramento Rivers did not occur. The next two winters were very mild with very little frost damage to the waterhyacinth. By 1981 the Delta was choked with waterhyacinth plants, preventing navigation of small boats and blocking the transfer of water into canal systems. Mechanical removal of the plants was very expensive and did not accomplish sufficient clearing of the weed from the Delta. Chemical control, using primarily 2,4-D, has had remarkable success. A control program was developed in 1982, especially monitoring the residues in the water. In 1983, 507 acres were treated, dropping to 204 acres in 1984, and an estimated 25 acres in 1985. Two weevils and and a moth were released in 1982 for biological control, but it is too soon to evaluate any impact on the weed populations. Waterhyacinth will not be eradicated from California, but will approach near eradication and continued control measures will keep this weed from disrupting the environment of the San Joaquin-Sacramento Delta.

Limnophila sessiliflora, on the Federal List, is well-established in a lake and adjacent river at San Marcos, Texas. California had a single occurrence of plants of *Limnophila* in 1977 in disturbed soil at a pipe outlet in a rice field in the Sacramento Valley. The plants were identified as a hybrid of *Limnophila indica* × *L. sessiliflora* but varying towards *L. indica,* having glandular calyx lobes. Presumably such plants would be subject to federal quarantine action even though not named as such. This hybrid apparently has not been able to become established under California conditions.

Monochoria vaginalis has been present in California since 1954 at the Rice Experiment Station in the Sacramento Valley. Rice is planted on the Experiment Station in blocks of plants separated by open water half a meter to a meter apart. In this open water between the rice plots, monochoria is quite abundant. In commercial rice fields in California rice plants are grown in dense stands without any open water between plants. Therefore monochoria is not considered a threat to the rice industry of this state. This weed species has never spread beyond the fields of the Experiment Station, and as yet has not become a problem in the aquatic habitats of California. Monochoria is placed on the Federal List as a precautionary measure to protect the rice areas of other states.

The inclusion of *Ipomoea aquatica* on the Federal List is based on the establishment of this species in Hawaii where it may become abundant in old taro patches. It is grown as a vegetable crop on a limited scale in California.

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DISTRIBUTION AND SEED DORMANCY OF *Scirpus* spp. IN PADDY FIELDS IN AKITA PREFECTURE; JAPAN

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ABSTRACT

Recently the *Scirpus* weeds have become noxious weeds in paddy fields throughout the north-eastern district of Japan. Three species were identified in Akita Prefecture and adjacent areas, i.e. *Scirpus juncoides* Roxb. subsp. *juncoides* Roxb., *Scirpus wallichii* Nees and *Scirpus smithii* A. Gay subsp. *leiocarpus* (Komarov) T. Koyama.

Results of germination experiments suggested that the dormancy of seeds of *Scirpus wallithii* was weak and could be broken with in a wider range of temperatures during seed incubation compared with that of seeds of the other two species.

It was confirmed that the seed coat of dormant seed had an important role in seed dormancy and a certain substance eluted from seed coat inhibited luciferase activity. This inhibition related to the intensity of seed dormancy.

ATP content in germinating seeds increased more rapidly than respiration rates at initial stage of germination.

INTRODUCTION

Recently the incidence of perennial weeds has increased in paddy fields in Japan and particularly the *Scirpus* weeds (so-called "hotarui" in Japanese) have become noxious weeds throughout the north-eastern district of Japan (Takahashi, 1977). According to the latest statistics, about 60 % of the rice fields in this area have been invaded by these weeds which have become aggressive and troublesome.

The objectives of this paper were to survey their distribution in Akita Prefecture in the north-eastern district of Japan and investigate their seed dormancy.

MATERIALS AND METHODS

Description of survey area. The surveyed areas in 1981 consisted of paddy fields in Akita Prefecture and adjacent districts. The amount of weeds in the plots was estimated by visual observation.

Effects of combination of anaerobic conditions and temperature during seed storage on seed dormancy. Seeds were incubated in submerged soil at the constant temperatures of 5° , 10° , 15° , 20° , 30° and 35°*C*, for 7, 15, 30, 60 and 120 days, respectively.

Role of seed coat in seed dormancy. The seed coat was removed completely or partially from the portion located immediately above the embryo and the opposite site.

Germination experiments were conducted by using Petri dishes containing a filter paper, 5 *ml* water and 100 seeds were placed at 30 °*C* under light conditions.

Respiration rates were measured by an oxygen electrode.

ATP contents in germinating seeds were determined by using the luciferin-luciferase enzyme system.

RESULTS AND DISCUSSION

Among the several species of *Scirpus* observed in rice fields in Japan (Iwasaki et.al., 1980: Suto, 1975), three species were identified in the current study, i.e. *Scirpus juncoides* Roxb. subsp. *juncoides* Roxb., *Scirpus wallichii* Nees and *Scirpus smithii* A. Gay subsp. *leiocarpus* (Komarov) T. Koyama. As shown in Fig. 1 only *S. wallichii* was identified in the central region of Akita Prefecture. Both *S. juncoides* and *S. wallichii* were observed the southern and north-western regions of Akita Prefecture. In the northern part of Akita Prefecture and adjacent areas (Aomori, Iwate and Yamagata Prefectures) except for Waga area in Iwate Prefecture only *S. juncoides* was recognized. *S. smithii* was found in non-cultivated fields. (Nakamura et.al., 1983).

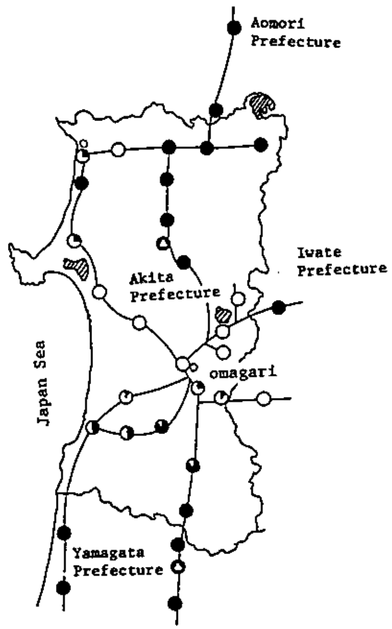

Fig. 1. Distribution of *Scirpus* spp. in Akita Prefecture and adjacent districts in Japan.

(Circles and triangles on the map correspond to *Scirpus* spp. Black symbols *Scirpus juncoides;* white symbols *Scirpus wallichii;* triangles stands for *Scirpus smithii)*

After incubation as previously described, the seeds were rinsed and germinated. The dormancy of seeds of *S. wallichii* was weak and could be broken with in a wider range of temperatures compared with that of seeds of the other two species. The seeds of *S. juncoides* and *S. smithii* still remained in dormancy at a high temperature (Table 1 and Fig. 2).

Table 1. Effects of anaerobic conditions and temperature during incubation on seed dormancy of *Scirpus* spp. (germination %).

Incubation length / Weed / temp.	7 days			15 days			30 days			60 days			120 days		
	W	J	S	W	J	S	W	J	S	W	J	S	W	J	S
5° C	0	0	2	6	1	10	6	44	21	39	84	39	33	94	70
10° C	12	0	0	50	41	37	86	86	47	98	95	41	97	90	47
15° C	34	21	0	77	69	3	97	82	7	100	79	1	99	89	3
20° C	78	30	0	91	44	0	100	73	1	100	81	0	99	2	2
25° C	76	2	0	87	2	0	96	5	0	98	0	0	93	0	4
30° C	66	0	0	75	1	0	86	2	0	86	0	0	30	0	0
35° C	74	2	0	75	2	0	72	1	0	66	0	0	4	0	4

Abbreviations W; *Scirpus wallichii*, J; *Scirpus juncoides*, S; *Scirpus smithii*. temp.; incubation temperature.

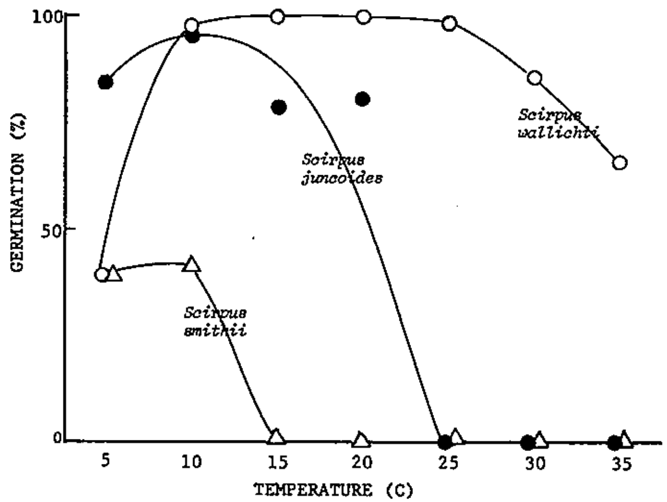

Fig. 2. Effects of incubation temperature on seed dormancy 60 days after treatment.

It was confermed that the seed coat of dormant seed contributed to seed dormancy as its removal was effective in awakening seeds from dormancy (Table 2).

It was deserved that a certain substance inhibited luciferase activity. This substance was eluted during the extraction process of ATP and its inhibition activity was found to be related to the intensity of seed dormancy (Fig. 3).

Table 2. Effects of removal of seed coat on seed germination (germination %)

Scarification / weed species	*S. juncoides*	*S. wallichii*	*S. smithii*
complete removal of seed coat	42	66	54
removal of portion above embryo	24	17	9
removal of part in the opposite site of embryo	0	0	0
control	0	0	0

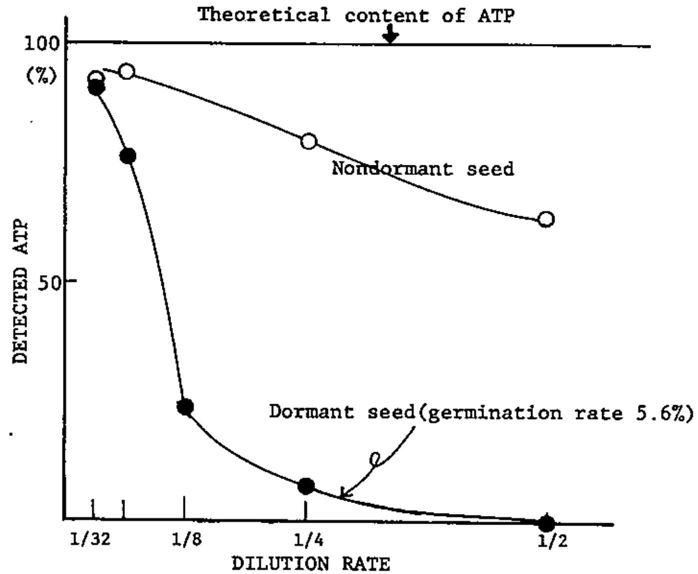

Fig. 3. Inhibition rate of soluble extracts from dormant or nondormant seed coats of *Scirpus wallichii* on luciferase activity.

Respiration rates and ATP content of germinating seeds were determined in hulled seeds. As shown in Fig. 4, ATP content increased during the 24 hours of germination. At that time of germination, no respiration nor shoot growth was detected. (Nakamura et.al., 1983).

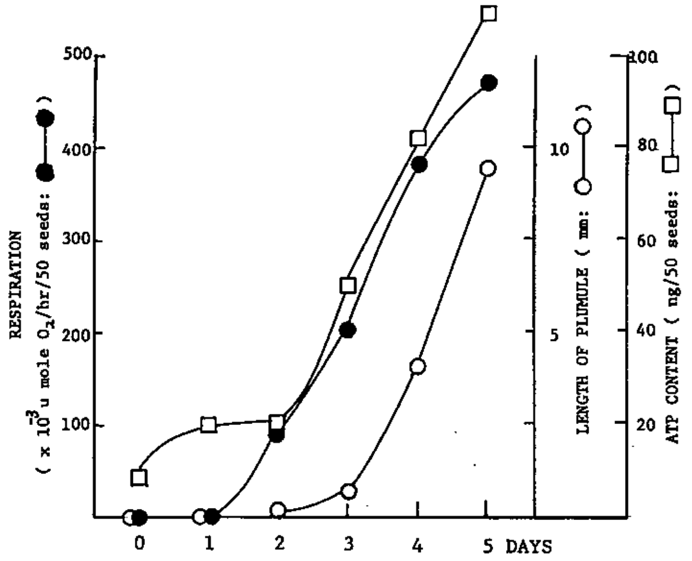

Fig. 4. Increase of ATP content, respiration rates and shoot growth in germination of *Scirpus wallichii.*

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EFFECT OF BUTACHLOR ON RICE MESOCOTYL ELONGATION

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ABSTRACT

The effect of butachlor [2-chloro-2′, 6′-diethyl-N-(butoxyethyl) acetanilide] on rice (*Oryza sativa* L.) mesocotyl elongation was studied using cultivars of different herbicide susceptibility. Mesocotyl length of the rice cultivars tested decreased in the order IR 9575, IR 36 and IR 52. The same order in severity of damage of butachlor to the rice cultivars was observed. With deeper planting when the rice escaped herbicide injury, mesocotyl length was not affected by the herbicide. Highly positive correlation between plant height and mesocotyl length was obtained at all seeding depths tested regardless of the susceptibility of rice cultivars to butachlor. Depth protection was due to the first node of the rice seedlings being positioned below the herbicide-treated layer. Under two rainfall regimes, depth protection was observed with the tolerant cultivar and the cultivar with intermediate tolerance but not with the susceptible cultivar.

INTRODUCTION

Butachlor is a selective herbicide primarily used as a preemergence treatment to control most annual seedling grasses and certain broadleaf weeds and sedges in direct–seeded and transplanted rice. Its herbicidal properties were first described by Baird and Upchurch (1970). Soil moisture regulates the activity of butachlor and for acceptable weed control a moist soil state at the time of weed germination is required.

Butachlor is typical of acetamides inhibiting seed germination or growth of seedlings or both. It is absorbed mainly by the germinating plant shoots (WSSA, 1979) between the seed and the first node (Joshi, 1974) and secondarily by root (WSSA, 1979). This was confirmed by Noriel and Mercado (1981) who reported that greater reduction in rice growth occurred when butachlor was applied to the mesocotyl and the coleoptile than when it was applied to the radicle.

Selective control of *Echinochloa crus–galli* (L.) Beauv. seedlings in rice with chloropropham (isopropyl *m*–chlorocarbanilate) was explained by Baker (1960) in terms of the position of their first nodes in the soil. *E. crus–galli* seedlings produced their first nodes at the soil surface and were killed by the chloropropham treatment; whereas rice seedlings which developed their first nodes well below the soil surface escaped injury. When molinate (S–ethyl hexahydro–1H–azepine–1–carbothioate) was applied on the soil surface, injury to rice decreased with increasing depth of planting (Chen *et al.,* 1968). Nako (1977) observed that thiobencarb (4–chlorobenzyl N, N–diethyl thiocarbamate) was not harmful to rice seeded 3 *cm* deep because the soil prevented the chemical from moving down to the vicinity of the seed.

Elongation of the mesocotyl in rice varied with the cultivar (Yasue and Kawai, 1977). Madrid (1980) reported that rice cultivars with long mesocotyls whose first nodes were near the soil surface were susceptible to preemergence herbicides, while those with short mesocotyls were tolerant. However, mesocotyl elongation is markedly affected by environmental factors such as light (Duke and Wickliff, 1969), gas (IRRI, 1980), temperature (Inouye *et al.,* 1969) and moisture (Takahashi, 1978).

The present study was undertaken to determine the effect of seeding depth and rainfall with butachlor application on rice mesocotyl elongation.

MATERIALS AND METHODS

Experiment 1. Post-germination growth of rice cultivars in the dark.

Twenty seeds of rice cultivars (IR 9575, IR 36 and IR 52) were placed on Toyo No. 2 filter paper in a 250 *ml* Erlenmeyer flask. They were moistened with 4 *ml* of distilled water. After sealing the flasks with a rubber stopper, they were placed in a dark incubator and maintained at 32°*C*. The shoot, radicle and mesocotyl lengths of each plant were recorded after 10 days. The experiment was repeated three times.

Experiment 2. The effect of seeding depth on rice mesocotyl elongation.

The experiment was conducted under natural condition in greenhouse. A sandy clay loam soil with 48.8%, 24.4% silt, 26.8% clay, 0.46% organic matter and pH 6.3 was used in the pot experiment. Air-dried soil was passed through a 3 *mm* sieve. The sieved soil was partially filled with plastic trays (32 × 24 × 11 *cm*). Six rows of rice were seeded per tray. Twelve seeds of each rice cultivar were placed in alternate rows and then covered with soil to the desired depth. After planting the rice seeds 2, 3, 4 and 5 *cm* deep, the trays were subirrigated and excess water was allowed to drain for 1 day. Butachlor prepared by diluting an emulsifiable concentrate formulation containing 58.8% active ingredient was then applied at rates ranging from 1 to 4 *kg* a.i./*ha*. Frequent watering to prevent drying and crusting of the soil surface was started 3 days after the herbicide application. There were four replications.

After excluding the border seedlings at each end of the row, data on plant height and mesocotyl length were taken for the remaining 20 seedlings of each cultivar in each tray 20 days after seeding (DAS). Plant height was measured from the soil surface to the tip of the tallest leaf and the mesocotyl length was the distance from seed to the first node. Comparisons of treatments were made where indicated by use of Duncan's multiple range test.

Experiment 3. The effect of rainfall on rice mesocotyl elongation.

Unless otherwise stated, the experiment followed the procedures used in Experiment 2. Seeds of three rice cultivars were planted 2 and 4 *cm* deep. Butachlor was applied at 2 and 4 *kg* a.i./*ha*. Simulated rainfall was achieved using a compressed air sprayer using a Teejet 8004 nozzle with a pressure of 2.1 kg/cm^2. The nozzle was held 20 *cm* away from the tray and the amount of water required for 2 and 10 *mm* rainfall was determined. The first simulated rainfall was given using the desired amount of water immediately after butachlor application. Further applications were made 24 and 48 hours later. Frequent light watering was started from 3 days after the final simulated rainfall.

RESULTS AND DISCUSSION

1. Post-germination growth of rice cultivars in the dark.

There were no great differences in shoot and radicle lengths of the rice cultivars studied. However, the mesocotyl lengths varied (Fig. 1). IR 9575 produced the longest mesocotyl among the tested rice cultivars, whereas the shortest mesocotyl was found in IR 52. The mesocotyl of IR 36 was shorter than that of IR 9575, but longer than that of IR 52.

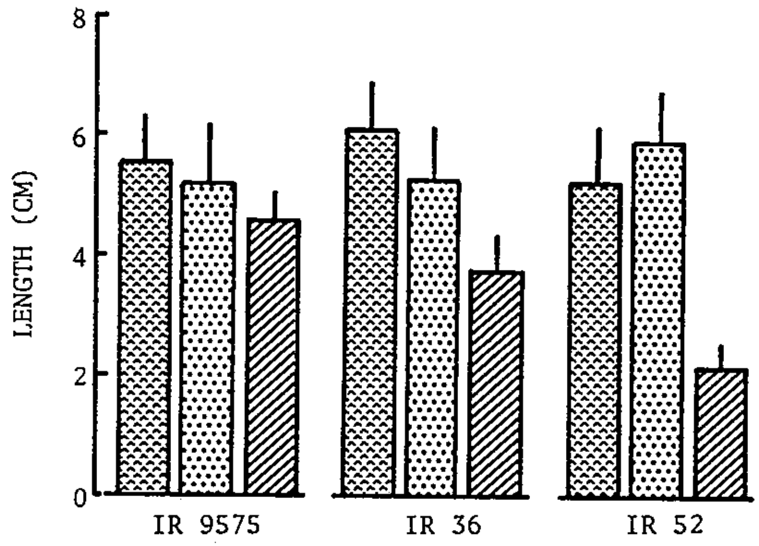

Fig. 1 Shoot ( ), radicle ( ) and mesocotyl ( ) lengths of rice cultivars grown in the dark. Means and standard deviations are presented.

Difference in mesocotyl lengths may determine the susceptibility of rice cultivars to herbicides. Based on the findings of Madrid (1980), tolerance of the rice cultivars to butachlor would expect to increase in the order IR 9575, IR 36 and IR 52.

2. The effect of seeding depth on rice mesocotyl elongation.

There was an intraspecific variation in susceptibility of rice cultivars to butachlor. The severity of damage of butachlor to the rice cultivars studied varied depending on seeding depth and herbicide rates (Fig. 2). IR 9575 when planted 2, 3, and 4 *cm*

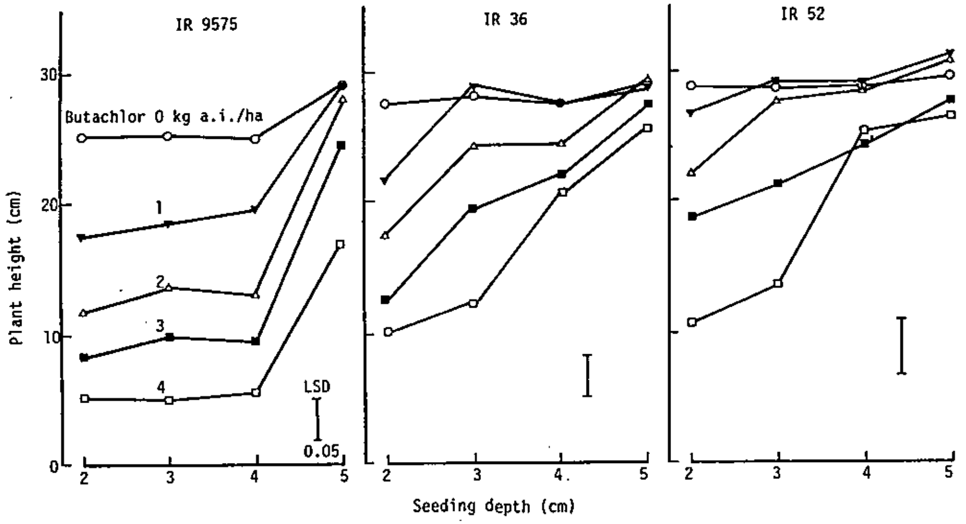

Fig. 2 Plant height of different rice cultivars as affected by seeding depth and butachlor rate.

deep was injured by all butachlor concentrations. IR 36 was affected by all herbicide concentrations when planted 2 *cm* deep. However, no reduction in plant height was observed when it was planted 3 *cm* deep and applied with butachlor at 1 *kg* a.i./*ha*. Significant plant height reductions were observed at higher application rates. With IR 52 butachlor applied at 1 *kg* a.i./*ha* did not significantly reduce plant height when the cultivar was planted 2 *cm* deep. When planted 3 *cm* deep, butachlor rates of 1 and 2 *kg* a.i./*ha* did not significantly affect plant height. Higher rates caused significant reductions in plant height. This result reveals that IR 9575 is the susceptible cultivar to butachlor, but IR 36 and IR 52 are intermediate in tolerance and tolerant to the herbicide, respectively. The susceptibility of rice to herbicide is related with mesocotyl length of the rice cultivars.

Depth protection to butachlor damage was achieved with all cultivars. The degree of damage decreased for all herbicide rates as depth of seeding increased for IR 36 and IR 52. When both of these cultivars were planted 5 *cm* deep none of the herbicide rates caused a significant reduction in plant height. With IR 9575, depth protection was only observed when the cultivar was planted 5 *cm* deep. At this depth rates of 1 and 2 *kg* a.i./*ha* did not cause a significant reduction in plant height. However, higher rates resulted in a significant reduction in growth.

The mesocotyl length was affected by seeding depth and herbicide rates (Table 1). The mesocotyl length of the three rice cultivars increased with the seeding depth up to 4 *cm,* irrespective of the rate of butachlor applied. The mesocotyl length of rice planted 5 *cm* deep was shorter than that of rice planted 4 *cm* deep because of the tendency of the rice to produce another internode below the coleoptile.

Response of the mesocotyl to the herbicide was similar to the response of plant height. There were significant positive correlations between plant height and mesocotyl length ($P < 0.01$ at all seeding depths for three rice cultivars studied). For IR 36 and IR 52 reduction in mesocotyl length was observed at the higher rates at the shallower seeding depths (Table 1). Mesocotyl elongation was not affected by butachlor when both cultivars were planted 4 or 5 *cm* deep. Depth protection was also observed with the susceptible cultivar, IR 9575 at the lower herbicide rates. The fact that herbicide damage occurred with IR 36 and IR 52 when they were planted 3 *cm* deep and not when they were planted 4 *cm* deep indicates that the herbicidal layer was located within 3 *cm* of the soil surface under the experimental condition. This is confirmed by the fact that IR 9575 whose mesocotyl was 20 *mm* or more in length when planted 4 *cm* or deeper was damaged at both these depths. The mesocotyls and first nodes of IR 36 and IR 52 were below the treated layer, whereas the mesocotyl of IR 9575 penetrated into the herbicidal layer.

Table 1. Mesocotyl lengths of rice cultivars as affected by butachlor rates and seeding depths.

Cultivar	Application rate (*kg* a.i./*ha*)	Mesocotyl length (*mm*) Seeding depth (*cm*) 2	3	4	5
IR 9575	0	9.5 a	13.4 a	24.3 a	21.6 ab
	1	7.3 b	12.5 ab	22.1 b	23.9 a
	2	5.8 c	10.9 ab	23.8 ab	20.7 ab
	3	4.4 d	10.0 b	22.2 b	19.1 b
	4	4.2 d	10.0 b	23.3 ab	19.5 b
IR 36	0	5.6 a	9.1 a	9.6 a	7.6 a
	1	5.1 ab	7.5 b	9.9 a	6.8 a
	2	4.7 ab	6.4 b	9.6 a	7.3 a
	3	4.2 b	6.9 b	8.9 a	8.4 a
	4	3.9 b	6.7 b	8.3 a	7.3 a
IR 52	0	3.3 a	6.7 a	7.6 a	5.0 a
	1	2.7 ab	6.1 ab	7.3 a	5.4 a
	2	2.6 ab	4.9 b	7.1 a	4.6 a
	3	2.5 ab	5.5 ab	7.0 a	4.2 a
	4	2.2 b	4.9 b	7.0 a	4.9 a

1/ In a column within each cultivar, means followed by a common letter are not significantly different at the 5% level by Duncan's multiple range test.

3. The effect of rainfall on rice mesocotyl elongation.

Under both rainfall regimes, protection from herbicide damage was observed when IR 52 was planted 4 *cm* deep, but not when it was planted 2 *cm* deep and treated with 4 *kg* a.i./*ha* butachlor (Fig. 3). No damage at either depth was observed when IR 52 was treated with 2 *kg* a.i./*ha* butachlor. For IR 36 depth protection was observed when it was treated with butachlor at 2 *kg* a.i./*ha* but at 4 *kg* a.i./*ha* significant reduction in plant height occurred at both seeding depths. At the higher herbicide rates significantly greater damage was caused at the shallower seeding depth. No depth protection was observed for IR 9575 at either rate of herbicide application. No differences in herbicidal injury on the basis of plant height were observed between two rainfall regimes for the three rice cultivars.

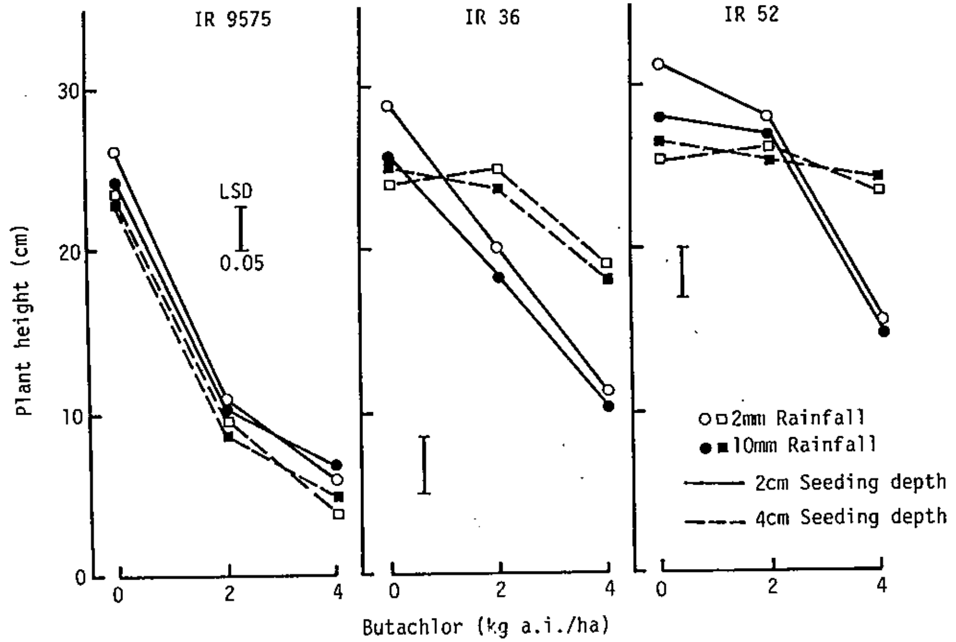

Fig. 3 Plant height of different rice cultivars as affected by the amount of simulated rainfall, seeding depth and butachlor rate.

This was probably due to the low amount of simulated rainfall applied which was insufficient for leaching of butachlor or the relatively low leachability of the butachlor. The water solubility of butachlor is only 23 *ppm* at 25 °*C* (WSSA, 1979) and butachlor applied at 2 *kg* a.i./*ha* is leached by the upper 2.8 *cm* soil layer with 20 *mm* rainfall (Takematsu and Konnai, 1978). The degree of damage was closely related to the mesocotyl lengths. Those plants which escaped herbicide injury had their mesocotyl lower than 3 *cm* in the soil (Table 2).

Table 2. Mesocotyl length of rice cultivars as affected by amount of simulated rainfall, seeding depth and butachlor rate.

Rainfall (*mm*)	Application rate (*kg* a.i./*ha*)	Mesocotyl length (*mm*)					
		IR 9575		IR 36		IR 52	
		Seeding depth		Seeding Depth		Seeding depth	
		2 *cm*	4 *cm*	2 *cm*	4 *cm*	2 *cm*	4 *cm*
2	0	8.2 a	24.2 a	5.3 a	9.8 a	2.6 a	6.2 a
	2	5.3 b	20.3 b	4.2 b	8.9 ab	1.8 b	5.9 a
	4	5.3 b	16.9 c	4.3 b	8.0 b	1.6 b	5.2 b
10	0	9.5 a	24.9 a	5.8 a	10.2 a	2.7 a	6.7 a
	2	4.9 b	21.9 b	4.5 b	9.4 a	2.0 a	6.3 a
	4	3.1 c	21.1 b	4.0 b	9.1 a	2.0 a	6.6 a

1/ In a column within each rainfall regime, means followed by a common letter are not significantly different at the 5% level by Duncan's multiple range test.

In herbicide-treated soil the mesocotyl and first node are responsible for herbicidal uptake by some plants (Prendeville, 1968; Joshi, 1974 ; WSSA, 1979; Schmidt and Pestemer, 1980). Nakamura *et al.* (1974) determined that the uptake of ^{14}C-thiobencarb by *E. crus-galli* seedlings decreased in the order mesocotyl, coleoptile, root and leaf. Although a similar uptake pattern was observed for rice, they did not distinguish the mesocotyl from the coleoptile. Murray *et al.* (1967) concluded that the mesocotyl of *Setaria faberii* Herrm which is similar in seedling development to *E. crus-galli* presented no more of a barrier to herbicidal uptake than the coleoptile.

The rice mesocotyl elongates at relatively early stages after germination and reaches a maximum length at 4 to 6 DAS, whereas the maximum coleoptile length is reached at 8 to 10 DAS (Yasue and Kawai, 1977). Thus the mesocotyl has greater opportunity to absorb herbicide at the early seedling stage. Noriel and Mercado (1981) reported that the rice mesocotyl was most efficient in absorbing butachlor since contact with the mesocotyl resulted in greater total inhibition to growth than contact with the coleoptile or radicle. In our experiment, the great reduction in rice mesocotyl length as a result of butachlor application indicates the importance of mesocotyl as a major site of herbicide entry. This agrees with previous reports (Joshi, 1974; Noriel and Mercado, 1981).

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EFFECT OF TEMPERATURE ON SELECTIVITY OF SIMETRYN AND DIMETHAMETRYN IN SEVERAL RICE CULTIVARS

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ABSTRACT

The effect of temperature on phytotoxicity, absorption, translocation and metabolism of simetryn and dimethametryn in seedlings of rice cultivars was studied. Rice cultivars tested were selected from *indica* - and *japonica*-types and their hybrid. Although the rice cultivars showed different tolerance among each other to the herbicides, phytotoxicity of the herbicides was observed to be increased generally in all cultivars when the environmental temperature was raised from the low level (25°C day, 20°C night) to the high level (32°C day, 27°C night). ^{14}C-simetryn and ^{14}C-dimethametryn was used to evaluate absorption, translocation and metabolism of root-applied herbicides. High temperature enhanced root absorption of simetryn and dimethametryn in all cultivars. Translocation rate of simetryn to shoots was greater than that of dimethametryn. High temperature also enhanced translocation of both herbicides. Greater amounts of ^{14}C-labeled compounds derived from ^{14}C-simetryn and ^{14}C-dimethametryn was detected in shoots of the plants which grown under higher temperature. Metabolism of both herbicides in the rice cultivars did not change significantly between the two temperature treatments. It was considered that greater absorption by roots and translocation to shoots resulted in greater concentration of the herbicides in a site of action and this seems to be a main factor of increased phytotoxicity under the high temperature condition.

INTRODUCTION

Simetryn [2, 4-bis (ethylamino) -6-methylthio-1, 3, 5-triazine] and dimethametryn [2-(1,2-dimethylpropylamino)-4-ethylamino-6-methylthio-1,3,5-triazine] are effective herbicides for control of broadleaf weeds and barnyardgrass in paddy rice fields. Rice varieties usually show outstanding tolerance to the herbicides. However, growth retardation of the plant at the vegetative stage by simetryn had occasionally been observed at high temperature in the southwestern regions of Japan. It was considered that physiological and/or biochemical characteristics of the plant were changed by temperature variation and resulted in increased phytotoxicity. Enhancement of simetryn absorption by increasing temperature was reported as one of factors of its phytotoxicity (1).

Cultivar difference in tolerance to simetryn also has been reported among rice plants (2, 6). Some of hybrid cultivars of indica - and japonica-types are less tolerant to the herbicide than japonica-type cultivars. It was clarified that differential tolerance in rice cultivars to simetryn resulted from their detoxifying metabolic activity (3).

The objectives of this research were : a) to compare tolerance of several rice cultivars to simetryn and dimethametryn in different temperature conditions, and b) to investigate absorption, translocation and metabolism of the herbicide and correlate them with the plants' tolerance.

MATERIALS AND METHODS

Seeds of rice cultivars were germinated and grown in Kasugai's nutrient solution as previously reported (4). The nutrient solution was changed every 3 days. Plants were cultured to the 3-leaf stage in a controlled environmental chamber with a 13 hour photoperiod at 25° *C* day and 20° *C* night with 22 *klux* illumination at plant surface. Two days before herbicide treatments, plants were divided into two groups and transferred to chambers where day/night temperatures were maintained 32°/27° *C* (high) and 25°/20° *C* (low) respectively. Relative humidity was kept 60% in both chambers.

To study cultivar tolerance to the herbicides, roots of intact plants were soaked in aqueous solutions of 0, 10^{-4}, 5×10^{-4}, and 10^{-3} *M* simetryn and 0, 10^{-5}, 5×10^{-5}, and 10^{-4}*M* dimethametryn for 1 hour at either 32° *C* or 25° *C*. After treatment the roots were removed from the solution, rinsed with distilled water and transferred to a herbicide free nutrient solution. Plants were then grown in their respective temperature conditions for another 11 or 12 days. Each treatment replicated 3 times with 5 plants each and the experiment was repeated.

For the absorption and translocation studies roots of each cultivar at the 3-leaf stage was soaked in 1.7×10^{-6} *M* solution of ^{14}C-simetryn (sp. act. 3.6 *mCi/mmole*) or 3.8×10^{-6} *M* solution of ^{14}C-dimethametryn (sp. act. 3.5 *mCi/mmole*). At the time of treatment the plants were kept under continuous light at different temperatures and hervested at various time intervals. At harvest the plants were sectioned into roots and shoots and the fresh weight of each section was determined. Radioactivities in them were determined by a sample combustion methods. This experiment was conducted with 3 replications of 5 plants each.

For metabolism studies roots of each cultivar was soaked in 9.4×10^{-6} *M* solution of ^{14}C-simetryn or 3.2×10^{-6} *M* solution of ^{14}C-dimethametryn for 2 hours. After treatment the plants were transferred to herbicide-free nutrient solution and harvested thereafter at several time intervals. At harvest the plants were sectioned into roots and shoots, and the fresh weight of each section was determined. Plants were then homogenized in 10 ml per *g* fresh weight of a methanol : water (9 : 1 *v/v*). The homogenates were filtered *in vacuo* and the residues was extracted again. The filtrate was evaporated to water under vacuum at 40° *C* and partitioned between water and dichloromethane. Metabolites in each fraction was investigated as previously described (5). This experiment was conducted with 2 replication of 30 plants each.

RESULTS AND DISCUSSION

Difference in tolerance to simetryn was observed between cultivars Nihonbare (japonica-type) and IR-8 (indica-type) at low temperature treatment. Cultivar Nihonbare was more tolerant to the herbicide than IR-8 (Figure 1). This result is consistent with a previous paper that rice cultivar has differential tolerance to simetryn and japonica-type cultivars were more torelant than indica – and hybrids

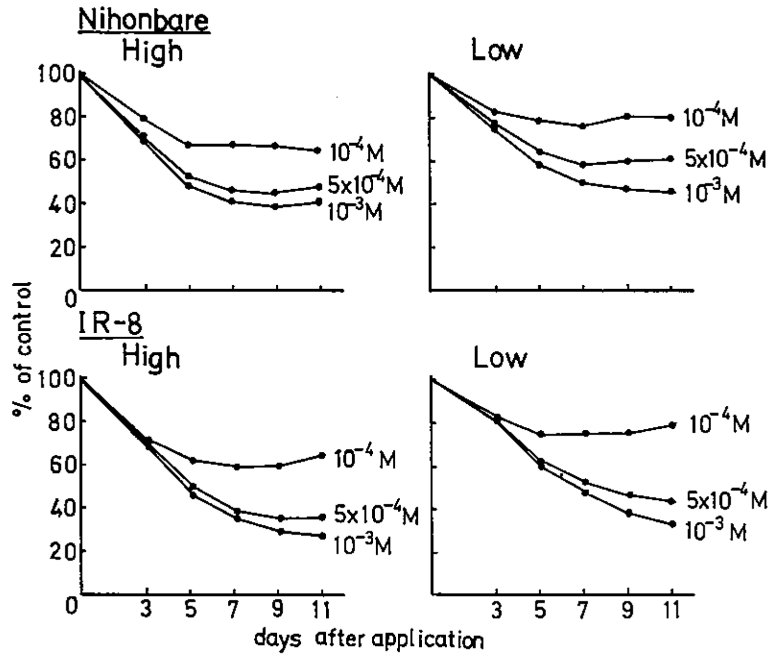

Figure 1. Effect of simetryn on the growth of rice cultivars in high (32°/27° *C*, day/night) and low (25°/20° *C*, day/night) temperature conditions.

of indica – and japonica-types (6). High temperature enhanced simetryn phytotoxicity to rice cultivars. In high temperature treatment, severe injury symptom of the herbicide was observed even in tolerant cultivar at higher dosage and difference in tolerance between two cultivars became indistinct.

The phytotoxicity of dimethametryn also increased with increasing temperature in all cultivars (Figure 2). It was found that tolerance of rice cultivar to dimethametryn also differed and cultivar CH-45 was less tolerant than the other cultivars. Injury symptom to rice cultivars by dimethametryn was observed at lower concentration compared with simetryn. It was considered that dimethametryn had higher phytotoxic activity to rice cultivars than simetryn. A mechanism of differential herbicidal activity of the herbicides will be studied.

Because a marked influence of temperature variation on phytotoxicity of simetryn and dimethametryn was observed, absorption, translocation and metabolism of ^{14}C-simetryn and ^{14}C-dimethametryn in different temperature conditions were investigated.

During the treatment periods absorption of ^{14}C-simetryn and ^{14}C-dimethametryn by rice cultivars increased with time at both temperature treatment (Table 1). The data showed that absorption of the herbicides by roots increased significantly with increasing temperature in all cultivars. However, increasing rates by temperature increase varied with cultivar and time.

Translocation rates were indicated as percentages of ^{14}C in shoots to the total ^{14}C activity in plant from root-applied ^{14}C–simetryn and ^{14}C–dimethametryn (Table 2). The data indicated that simetryn moved to shoots faster than dimethametryn especially in low temperature condition. Enhancement of translocation of ^{14}C from ^{14}C–simetryn by temperature increase was not evident because of its greater rate of translocation in low temperature condition. In contrast, translocation of ^{14}C from ^{14}C–dimethametryn was significantly enhanced by temperature increase in all cultivars.

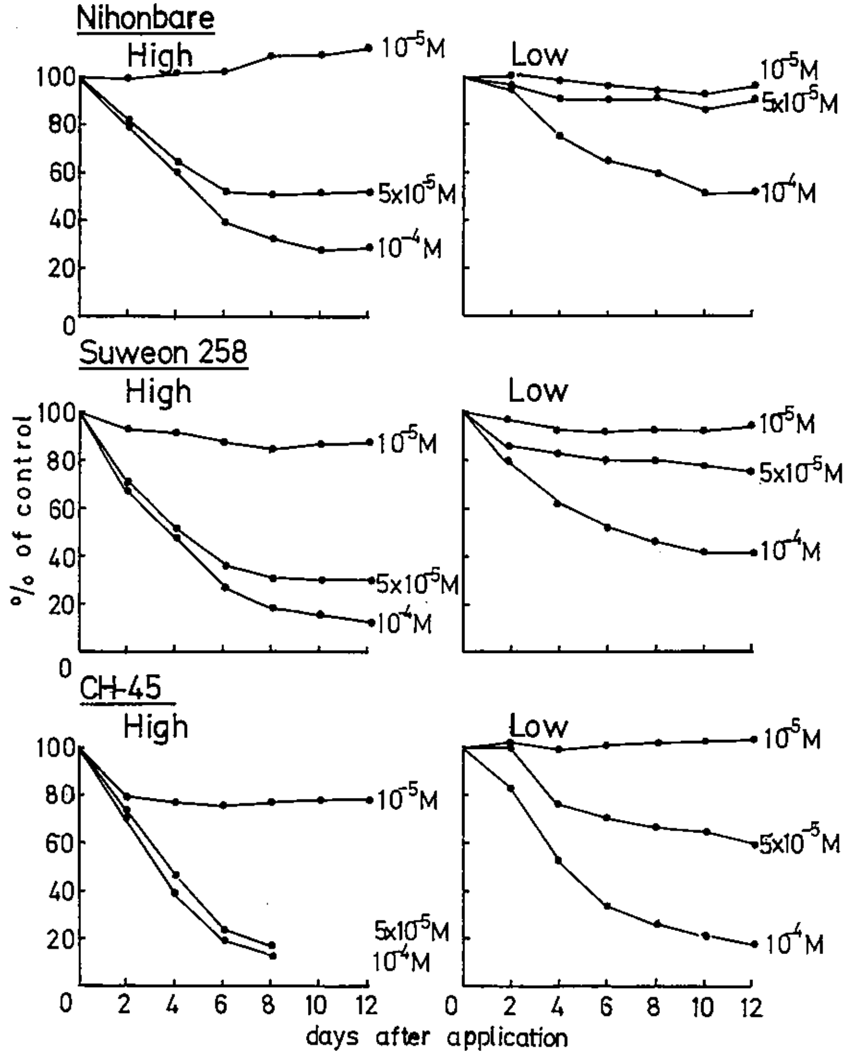

Figure 2. Effect of dimethametryn on the growth of rice cultivars in high (32°/27° *C*, day/night) and low (25°/20° *C*, day/night) temperature conditions.

Table 1. Absorption of ^{14}C–simetryn and ^{14}C–dimethametryn by roots of rice cultivars in different temperature conditions.

	^{14}C Absorption ($\times 10^3$ *dpm/mg* dry weight of roots)					
Simetryn	Nihonbare		Tongil		IR–8	
hrs	High (32–27° C)	Low (25–20° C)	High (32–27° C)	Low (25–20° C)	High (32–27° C)	Low (25–20° C)
1	0.52	0.32*	0.56	0.35**	0.69	0.37**
3	0.99	0.60**	0.98	0.62**	1.02	0.65**
6	1.59	1.01**	1.30	0.92*	1.60	0.97*
24	5.76	5.01*	5.08	3.15**	5.57	3.81*
Dimethametryn	Nihonbare		Suweon 258		CH–45	
1	1.45	1.00*	1.05	0.97	1.14	0.89**
3	1.89	1.19**	1.90	1.09**	1.33	1.19
8	3.47	1.98**	3.37	1.80*	3.19	2.00**
24	7.63	5.66**	6.80	5.19**	7.74	5.86*

Values are means of three replications.

Significantly different from comparison between high and low temperature treatment at 95% (*) and 99% (**) of confidence according to t–test.

Table 2. Translocation of ^{14}C from ^{14}C–simetryn and ^{14}C–dimethametryn from roots to shoots of rice cultivars in different temperature conditions.

	^{14}C Translocation (%)					
Simetryn	Nihonbare		Tongil		IR–8	
hrs	High (32–27° C)	Low (25–20° C)	High (25–27° C)	Low (25–20° C)	High (32–27° C)	Low (25–20° C)
1	26.9	16.6*	16.6	13.1	18.8	19.5*
3	45.3	33.5*	33.7	27.6*	32.6	36.0
6	53.4	51.7	45.5	43.6	45.3	49.7
24	74.5	72.7	65.7	64.5	71.4	62.1*
Dimethametryn	Nihonbare		Suweon 258		CH–45	
1	28.1	10.1**	22.8	8.9**	21.6	10.4*
3	39.1	26.4**	31.6	17.3**	33.8	14.3*
8	60.7	30.4**	51.8	33.1**	42.4	19.2**
24	60.9	38.6**	55.6	37.2**	38.8	22.0**

Values are means of three replications.

Significantly different from comparison between high and low temperature treatment at 95% (*) and 99% (**) of confidence according to t–test.

In the high temperature condition, much greater concentration of ^{14}C from ^{14}C-simetryn and ^{14}C-dimethametryn was detected in shoots of all cultivars (Table 3). It was considered that the greater concentration of the herbicides in shoots at the high temperature resulted from increased absorption and translocation. The authors previously showed that simetryn inhibited an electron transport in photosynthesis and photophosphorylation (7). ^{14}C concentration in shoots to be a important factor for determine the phytotoxicity of the plant. It was considered that the enhancement of root absorption and translocation to shoots were the main reasons for the increase of the herbicides' phytotoxicity.

Table 3. Concentration of ^{14}C in shoots from root-applied ^{14}C-simetryn and ^{14}C-dimethametryn in different temperature conditions.

Simetryn

	^{14}C Concentration (*dpm/mg* dry weight of shoots)					
	Nihonbare		Tongil		IR-8	
hrs	High (32–27° C)	Low (25–20° C)	High (32–27° C)	Low (25–20° C)	High (32–27° C)	Low (25–20° C)
1	54.3	17.1**	32.8	16.6**	40.7	21.5**
3	177.8	68.5**	116.9	61.8**	104.9	72.4*
6	389.3	148.6**	212.1	126.7**	229.4	136.4**
24	1955.0	1095.9**	1217.0	668.0**	1251.0	702.9**

Dimethametryn

	Nihonbare		Suweon 258		CH-45	
1	99.0	31.7**	85.6	27.5**	59.2	28.7*
3	193.7	93.0**	180.6	70.6**	118.7	53.4*
6	576.5	174.7**	533.1	215.4**	297.0	121.9**
24	1298.2	624.1**	1366.2	681.8**	834.5	348.3**

Values are means of three replications.

Significantly different from comparison between high and low temperature treatment at 95% (*) and 99% (**) of confidence according to t-test.

Metabolism of ^{14}C-simetryn and ^{14}C-dimethametryn incorporated in rice cultivars was traced sequentially by extraction with 90% methanol and fractionation with water and dichloromethane. ^{14}C activity in each fraction was determined by liquid scintillation spectrometer and insoluble residue by the sample combustion method (Figure 3). During 24 hours after treatment, cultivar Nihonbare metabolized simetryn at a considerably high rate to water-soluble compounds and methanol-insoluble residue. Cultivar IR-8 also metabolized simetryn in the same pathway with Nihonbare, however, percentages of the fractions were much smaller than Nihonbare. Although metabolic activity of simetryn differed in the cultivars, little difference was detected in the percentage of each fraction in the cultivar treated at high and low temperatures. The percentages of metabolic products in dichloromethane-soluble fractions between plants treated at the high and low temperatures were also little different (data not shown).

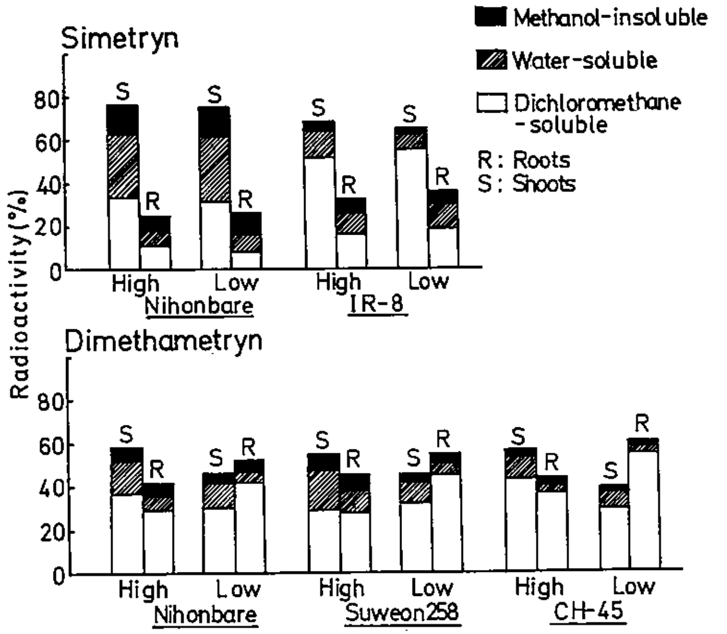

Figure 3. Metabolism of ^{14}C-simetryn and ^{14}C-dimethametryn at 24 hours after treatment in high (32°/27° *C*, day/night) and low (25°/20° *C*, day/night) temperature conditions.

Rice cultivars metabolized dimethametryn to water-soluble compounds and methanol-insoluble residue, however, there was also little difference in the rate of degradation between two temperature treatments. In cultivar Nihonbare, smaller percentages of the fractions were detected in the plant treated with dimethametryn compared with the plant treated with simetryn. It was considered that the rice cultivar was difficult to metabolize dimethametryn than simetryn.

These results indicated that the metabolic activity of neither cultivar affected by temperature increase and that therefore in this case metabolism was not a factor of increased phytotoxicity. It was concluded that increasing phytotoxicity of simetryn and dimethametryn with increasing temperature mainly resulted from increased absorption and translocation of the herbicides.

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EFFECTS OF NAPROANILIDE, GIBBERELLIN AND BAP ON TUBERIZATION OF *Cyperus serotinus* AND *Eleocharis kuroguwai,* PERENNIAL PADDY WEEDS

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ABSTRACT

The tuber innitiation from rhizome of *C. serotinus* was inhibited by the naproanilide[1-(2-naphthoxy) propionanilide] and BAP(6-benzylaminopurine) application prior to the tuberization, while that of *E. kuroguwai* was inhibited by naproanilide and gibberellin. The increasing effect on daughter hill production and the formative effect on rhizome were observed in *C. serotinus* treated with naproanilide and BAP, although the increasing and formative effects of naproanilide differed essentially from those of BAP in mode of action. In *E. kuroguwei,* the rhizome abnormality was observed in the naproanilide-treated plant.

New tuber initiation was inhibited by naproanilide and gibberellin treatment during tuberization of *E. kuroguwai,* while the tuber enlargement was inhibited not only by naproanilide and gibberellin but alson by BAP in both of the pre-and newly-intiated tubers. Among the chemicals, naproanilide broke the dormancy of some tubers linked to the entire plants in the pots, whereas the bubers in the control plot were completely dormant. Dormancy of the freshly harvested tubers was broken to some extent by napronilide and BAP, when directly applied to the tubers in petri dish. The longer the storage period of dormant tubers under low temperature after harvest, the more remarkable the breaking effects of naproanilide and BAP on tuber dormancy.

INTRODUCTION

C. serotinus and *E. kuroguwai* are cyperaceous perennial weeds which have recently become the most troublesome weeds in paddy fields in Japan. Since these perennial weeds propagate or regenerate principally by their underground parts such as rhizome and tuber, they are rarely eradicated by herbicide even if their aerial parts are killed. Inhibition of tuberization by chemical substances, therefore, is an important step to take for the control of most perennial weeds.

Harada et al. (1978) reported that the foliar application of some growth regulators inhibited the tuberization of *E. kuroguwai,* and Kobayashi et al. (1983) reported that naproanilide [1-2-(naphthoxy)propionanilide], which has a auxin-like activity and a selective herbicidal activity on cyperaceous and broad-leaved weed at young growth stage in rice fields(Takasawa et al., 1975), inhibited the tuberization and stimulated RNA synthesis in rhizcme of *C. serotinus,* regardless of growth atage at the time of treatment, and suggested that naproanilide inhibited tuber initiation through its action on RNA synthetic process which is related to the development of rhizome into tuber.

The objective of this study was to compare the effects of naproanilide, gibberellin and BAP (6-benzylaminopurin) on the tuberization of *C. serotinus* with that of *E. kuroguwai,* and also to investigate the effect on the dormancy of *E. kuroguwai* tuber.

MATERIALS AND METHODS

The sectioned tubers of *C. serotinus* and the dehulled tubers of *E. kuroguwai*, each with a bud, were sprouted in an incubator at 30°*C* for 3 days. Uniformly sprouted tubers were transplanted into round plastic pots filled with sand which was applied with compound fertilizer(8-8-6). Plants were kept in a controlled room under a long-day condition; continuous 30*klux* illumination provided by metal halide lamps for 8 *hr* with additional 15 min illumination of 10 *klux* 8 *hr* after the begining of the dark period. After 4 weeks culture under the long-day condition, the plants were transferred to a short-day condition; 8 *hr* illumination of 30 *klux* and 16 *hr* dark, in order to enhance their tuberization. The temperature was maintained at 28℃ in the light and 23℃ in the dark, respectively. The onset of tuberization was observed after 2 weeks under the short-day condition.

Naproanilide, gibberellin and BAP were treated just before transferring the pot to the short-day condition(the pre-tuberization treatment) or after 5 weeks culture under the short-day condition which was during tuberization. One hundred ml of aqueous solution(5 *mol/ha*) of each chemical containing 1% acetone and 0.01% Tween 20 was poured into the water in the pot. In order to distinguish the effects on tuber initiation and on tuber enlargement, the tubers which had already formed were marked with paint prior to the treatment during tuberization. Harvests were made 5 weeks after treatment, unless otherwise noted.

Dormant tubers of *E. kuroguwai* were obtained from the plant grown under the short-day condition at the designated growth stages. Uniformly matured tubers separated from the plant were placed in glass pot containing the $3\times10^{-5}M$ solution of naproanilide, gibberellin and BAP with 0.5% acetone and 0.1% Tween 20 at several time intervals after tuberization, and then the glass pot were placed in the incubator at 30℃ for 2 weeks to investigate the number of sprouted tubers.

RESULTS AND DISCUSSION

Data on the effects of naproanilide, gibberellin and BAP treated at the pre-tuberization on the tuberization and on the growth of *C. serotinus* and *E. kuroguwai* are shown in Table 1. In *C. serotinus,* it was found that the tuberization was completely inhibited by naproanilide and BAP, while the tuberization of the gibberellin-treated plant was enhanced. Naproanilide increased the number of daughter hills to some degrees and induced the abnormality such as swelling and twisting in rhizome but suppressed the rhizome production from shoot. BAP greatly proliferated the number of daughter hills, rhizomes from shoot and branched rhizomes. The tuberization of *kuroguwai* was remarkably inhibited by naproanilide and gibberellin but little by BAP. Naproanilide induced the rhizome abnormality similar to that of *C. serotinus.* However, the daughter hill production was not affected by naproanilide and BAP.

With treatment during tuberization, the effects of chemicals on the tuber initiation and on the tuber enlargement were separately investigated, and the results are shown in Table 2. The number of newly-formed tubers of naproanilide- and BAP treated plant of *C. serotinus* was much fewer than that of control. The individual dry weight of the newly-formed tuber was suppressed by naproanilide and BAP but that of already existing one was little affected by these two chemicals. Gibberellin had little effect on them. In *E. kuroguwai,* the new tuber formation was inhibited by naproanilide and gibberellin, and the dry matter growth of newly-and already-formed tubers was suppressed by naproanilide, gibberellin and BAP.

Table 1 : Effects of naproanilide, gibberellin and BAP treated at pre-tuberization on the growth and tuberization of *C. serotinus* and *E. kuroguwai*[1).]

Weeds	Chemicals (5 *mol/ha*)	Shoot No.	Shoot Dry wt (*mg*)	Root Dry wt (*mg*)	Rhozome No.	Rhozome Dry wt (*mg*)	Tuber No.	Tuber Dry wt (*mg*)	Whole Dry wt (*mg*)
C. s[2]	0	100% (3.7)	100% (1925)	100% (144)	100% (18.3)	100% (340)	100% (13.4)	100% (136)	100% (2545)
	Naproanilide	135	51	46	37	42	0	0	47
	Gibberellin	89	80	65	67	84	177	185	85
	B A P	386	105	74	213	50	0	0	90
E. k[3]	0	100% (4.0)	100% (1288)	100% (161)	100% (19.6)	100% (155)	100% (12.7)	100% (691)	100% (1406)
	Naproanilide	93	81	87	97	115	24	5	61
	Gibberellin	100	120	124	92[k]	136	2	3	87
	B A P	93	54	85	112	106	87	42	56

1) Data are presented as percent of control except for values in parentheless indicating one per pot.
2) *C. s : C. serotinus*
3) *E. k : E. kuroguwai*

On the other hand, the dry matter growth of shoot and/or root of *C. serotinus* and *E. kuroguwai* was suppressed by some of the chemicals treated at the pre-tuberization (the younger growth stage)(Table 1), but the suppressing effect was scarcely observed when they were treated during the tuberization(the other growth stage), as shown in Table 2. These results indicated that the inhibitory effect of chemical on tuberization was induced regardless of their effects on the dry matter growth of shoot and root.

Table 2. Effects of naproanilide, gibberellin and BAP treated during tuberization on the initiation and enlargement of *C. serotinus* and *E. kuroguwai* tubers[1].

	Chemicals (5 *mol/ha*)	Shoot Dry wt (*mg*/pot)	Tubers existing before treatment No. (per pot)	Tubers existing before treatment Dry wt (*mg*/tuber)	Tubers formed after treatment No. (per pot)	Tubers formed after treatment Dry wt (*mg*/tuber)
	0	100% (3472)	100% (8.4)	100% (16)	100% (62.7)	100% (25)
	Naproanilide	111	100	106	3	32
C. s[2]	Gibberellin	119	99	106	77	100
	B A P	97	95	75	41	60
	0	100% (958)	100% (7.3)	100% (53)	100% (7.3)	100% (47)
	Naproanilide	88	125	43	27	36
E. k[3]	Gibberellin	108	110	60	23	45
	B A P	82	114	64	92	38

1) Plants were harvested 3 weeks after treatment.
2) *C. s : C serotinus.*
3) *E. k : E. kuroguwai.*

With the treatment during tuberization of *E. kuroguwai,* it was observed that naproanilide had a breaking effect on the dormancy of tuber which was linked to the entire plant in the pot(Table 3), where the sprouted tuber was observed not only in the matured tuber but also in the immatured one. The sprouting activity of dormant tuber, after separating from the entire plant and husking, was suppressed to some degree by BAP but not by naproanilide and gibberellin. By the direct application to the tuber after separation from the entire plant, none of the chemicals had the breaking effect on the dormancy of the tuber harvested 4 weeks after the onset of tuberization(Table 4). But, the dormancy of tuber harvested 14 weeks after tuberization was broken remarkably by naproanilide and slightly by BAP. The breaking effects of naproanilide and BAP were found to some degree on the dormant tubers stored for 2 weeks in low temperature, and the breaking effect became more remarkable with the passage of storage period, where the breaking effect of naproanilide was more remarkable than that of BAP at any storage period(Fig. 1). The results demonstrated that the longer the time after tuberization passed, the more remarkable effect of naproanilide and BAP on tuber dormancy was, whatever the tuber linked to the entire plant or not. However, gibberellin had no breaking effect on the tuber dormancy.

Table 3. Effects of naproanilide, gibberellin and BAP treated during tuberization on the dormancy and sprouting activity of *E. kuroguwai*[1].

Chemicals (5 *mol/ha*)	No. of sprouted tubers (%)[2]	Sprouting activity (%)[3]
0	0	76
Naproanilide	32	78
Gibberellin	0	86
B A P	0	55

1) Plant was harvested 3 weeks after treatment.
2) The number of sprouted tubers which were linked to the entire plant in the pot was counted at the harvest time.
3) The unsprouted tubers were separated from the entire plant at the harvest time, dehulled and placed in the incubator at 30℃ for 2 weeks.

Table 4. Effect of naproanilide, gibberellin and BAP on the dormancy of the freshly harvested tubers of *E. kuroguwai*[1].

Chemicals ($3 \times 10^{-5}M$)	No. of sprouted tubers, Time after the onset of tuberization: 4 weeks	14 weeks
0	0	0
Naproanilide	0	27
Gibberellin	0	0
B A P	0	7

1) The freshly harvested tubers were placed in the solution of each chemical at $3 \times 10^{-5}M$, and the number of sprouted tubers was counted 2 weeks after incubation at 30℃.

These results suggested that the chemical directly inhibited tuber initiation through their action on the developmental function of rhizome in *C. serotinus* and/or *E. kuroguwai.* It should be emphasized that the sensitivity of tuberization to the chemicals differed in *C. serotinus* and *E. kuroguwai.* It was noted that the sensitivity of dormant tuber of *E. kuroguwai* to chemical varied with time after tuberization.

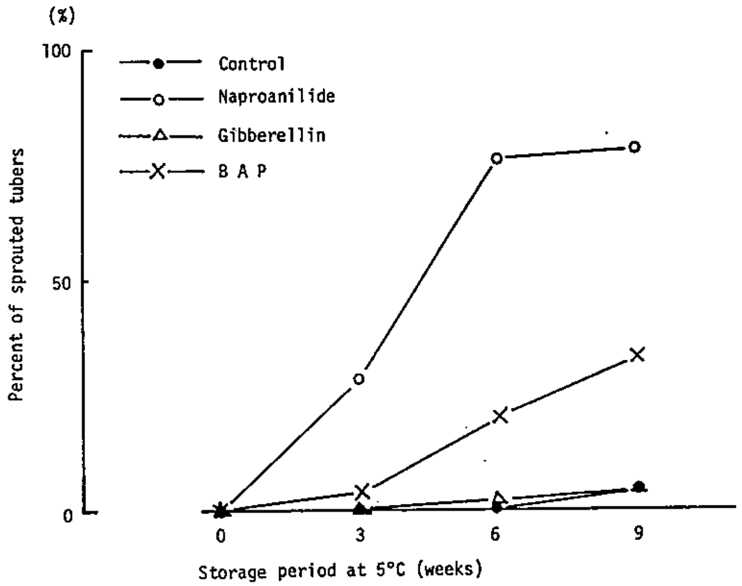

Fig. 1. Effect of naproanilide, gibberellin and BAP on the dormancy of *E. kuroguwai* tuber stored at 5°C for several weeks[1].
1) The number of the sprouted tubers was counted 2 weeks after incubation at 30°C.

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IDENTIFICATION OF WEEDY SEEDLING GRASSES IN CROPS

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ABSTRACT

The grass family (Poaceae) is the most important and one of the largest in the world. Its range in Florida (USA) is from the temperate zone to the subtropics and includes 500 species. With so many species, grass identification becomes very difficult even though complete descriptions and keys are available. Vegetative characteristics have such a narrow range of expression that identification must depend on having a mature plant with a seedhead (inflorescence) present. Control of many weedy grasses must be done in a seedling or vegetative state. Identification of all but a few species by vegetative means is almost impossible. However, when agricultural field crops in Florida are surveyed only nineteen grasses appear as common weeds. This limited number have sufficient differences to be separated vegetatively. One character is seldom so different that it alone leads to the identification. Combinations of characters must be used. More than one plant should be examined so that the average of the characters can be used. Often the characters are only fractions of a millimeter in length and a good hand lens or dissecting microscope may be necessary in order to view the structures. Comparisons between and among the following species will show how identifications can be accomplished: *Brachiaria mutica, Brachiaria plantaginea, Brachiaria platyphylla, Brachiaria ramosa, Brachiaria subquadripara, Cenchrus incertus, Cynodon dactylon, Dactyloctenium aegyptium, Digitaria bicornis, Digitaria ciliaris, Eleusine indica, Panicum adspersum, Panicum dichotomiflorum, Panicum maximum, Panicum repens, Panicum texanum, Paspalum urvillei, Pennisetum purpureum, Setaria magna.*

INTRODUCTION

The grass family (Poaceae) is the most important and one of the largest in the world. Rice, wheat, corn, sorghum and other grains form the foundation of most cultures. Also, many animals other than man forage on grasses as the main component of their diet. The bamboos are used as timber and utilized in building, furniture making, boat building, basketry, food and other domestic uses. Extensive geographical areas are covered exclusively with grass.

Florida (USA) stretches from the temperate zone to the subtropics. Florida, too, has many grasses with 500 species found within the state. With so many species, identification becomes very difficult even though complete descriptions and keys are available. Vegetative characteristics have such a narrow range of expression that identification must depend on having a mature plant with a seedhead (inflorescence) present. Control of many weedy grasses must be done in a seedling or vegetative state. Identification of all but a few species by vegetative means is almost impossible. However, when agricultural field crops are surveyed only nineteen species of grasses are found as common weeds in Florida. This limited number could have sufficient differences to be separated vegetatively.

The sheath or lower portion of the blade has several characteristics which may be used for identification. The body of the sheath may or may not have hairs. The hairs may be stiff and erect or soft and usually bent. Either or both types can be present in a species. The margin of the sheath may or may not have hairs independent of the rest of the sheath. At the top of the sheath on the side towards the stem is a ligule. The ligule stretches from side to side. It is composed of a membrane, or of hairs, or of a membrane with hairs along the top. The junction of the leaf sheath and the blade is called a collar. The margin of the collar and the top of the margin of the sheath frequently have bundles of hairs of different kinds which can be helpful in identification. The blade can have various kinds of hairs. The hairs can be soft and flexible or stiff and erect. Some species have minute soft hairs at the base of the blade just above the ligule. Any combination of these types is possible on any one species. The margin of the blade may have long stiff hairs at the bottom just above the collar. These hairs usually have a raised or pustulate base. The base of the blade can narrow abruptly or gradually to the sheath. Sometimes it is very broad such that the base appears flat and is visibly wider than the sheath.

MATERIALS AND METHODS

Live specimens as well as dried herbarium specimens of the nineteen grasses commonly found in Florida agricultural field crops were selected for examination. These specimens were chosen from widely separated areas within the state so that any variations in structure due to climate would be represented. The upper sheath, lower blade and the ligule were examined with a dissecting microscope and a ten power hand lens. The ligule was measured with a clear plastic ruler.

RESULTS

Even though seedling grasses have very few vegetative characters by which they can be identified, when a limited number of species is compared they can be separated and identified. The results of one such study are as follows:

Brachiaria mutica **(Forssk.) Stapf [*B. purpurascens* (Raddi) Henr.], Paragrass**
Perennial, sheath with stiff hairs, sheath margin with fringe of hairs at top, ligule membranous to 0.4 *mm* long with a fringe of hairs to 1.9 *mm* long, blades with very fine hairs just above ligule and long hairs on margin at base.

Brachiaria plantaginea **(Link) Hitchc., Alexandergrass or Creeping Signalgrass**
Annual, sheath with or without hairs, sheath margin fringed with long hairs, ligule membranous to 0.2 *mm* long with a fringe of hairs to 1.0 *mm* long, blade usually with a few scattered hairs.

Brachiaria platyphylla **(Griseb.) Nash, Broadleaf Signalgrass**
Annual, sheath with or without hairs, sheath margin fringed with hairs at top, ligule membranous to 0.2 *mm* long with a fringe of hairs to 0.6 *mm* long, blade with very fine hairs at base just above ligule and fringe of hairs on margin at base.

Brachiaria ramosa **(L.) Stapf, Browntop Millet**
Annual, sheath with or without hairs, sheath margin usually fringed with fine hairs and with a tuft of longer hairs at the top, ligule membranous to 0.3 *mm* long with a fringe of hairs to 1.2 *mm* long, blade usually with very fine hairs at base just above ligule and with or without hairs.

Brachiaria subquadripara **(Trin.) Hitchc., Small-flowered Alexandergrass**
Perennial, sheath with stiff hairs, sheath outer margin usually fringed with hairs, ligule membranous to 0.5 *mm* long with a fringe of hairs to 1.0 *mm* long, blades with a few long stiff hairs on margin at base and with or without hairs otherwise.

Cenchrus incertus **M. A. Curtis [*C. pauciflorus Benth.*], Coast Sandspur**
Annual, sheath usually without hairs, sheath margin with some scattered hairs near the tip and with long hairs at the tip, ligule membranous to 0.2 *mm* long with a fringe of hairs to 1.1 *mm* long, blade with many short scabrous (sandpapery) hairs on upper surface.

Cynodon dactylon **(L.) Pers., Bermudagrass**
Perennial, sheath with or without hairs, sheath margin with long hairs at collar, ligule membranous to 0.15 *mm* long with a fringe of hairs to 0.1 *mm* long, blade with or without hairs.

Dactyloctenium aegyptium **(L.) Beauv., Crowfootgrass**
Annual, sheath lacking hairs, ligule membranous to 1.0 *mm* long with a fringe of hairs to 0.8 *mm* long, blade with or without hairs, blade margin with long ciliate hairs from base almost to tip.

Digitaria bicornis **(Lam). R. & S. ex Loud., Tropical Crabgrass**
Annual, sheath usually with hairs, ligule membranous to 2.7 *mm* long with an irregular margin, blade usually with hairs.

Digitaria ciliaris **(Retz.) Koel., Southern Crabgrass**
Same characteristics as Tropical Crabgrass.

Eleusine indica **(L.) Gaertn., Goosegrass**
Annual, sheath with hairs on margin and long hairs at margin of collar, ligule membranous to 0.8 *mm* long with a fringe of hairs to 0.1 *mm* long, blade with or without hairs, blade margin lacking hairs.

Panicum adspersum **Trin., Broadleaf Panicum**
Annual, sheath usually with hairs along upper margins, ligule membranous to 0.5 *mm* long with a fringe of hairs to 0.6 *mm* long, blade usually without hairs.

Panicum dichotomiflorum **Michx., Fall Panicum**
Annual, sheath with or without stiff hairs, ligule membranous to 0.8 *mm* long with a fringe of hairs 2.2 *mm* long, blade with long fine hairs on upper surface and with or without hairs on the lower surface, blade margin with or without but usually with a few long stiff hairs at base.

Panicum maximum **Jacq., Guineagrass**
Perennial, sheath with stiff short hairs, sheath margins with a fringe of hairs, ligule membranous to 1.3 *mm* long fringed with hairs to 0.3 *mm* long, blade with turf of long hairs at base otherwise with or without other hairs.

Panicum repens **L., Torpedograss**
Perennial, sheath with or without hairs, sheath margin fringed with short hairs and with long hairs at top, ligule membranous to 0.6 *mm* long fringed with hairs to 0.6 *mm* long, blade with long soft hairs and long hairs on margin at base.

Panicum texanum **Buckl., Texas Panicum**
Annual, sheath with both long stiff and shorter soft hairs, ligule membranous to 0.6 *mm* long with a fringe of hairs to 1.2 *mm* long, blade with both long stiff and shorter soft hairs.

Paspalum urvillei **Steud., Vaseygrass**
Perennial, sheath with hairs, ligule membranous to 5.1 *mm* long with an irregular margin, blade with tuft or fringe of long hairs at base just above ligule other wise with or without other hairs.

Pennisetum purpureum **Schumach., Napiergrass or Elephantgrass**
Perennial, sheath at the bottom of the plant with hairs, without hairs on the upper parts of the plant, ligule membranous to 0.6 *mm* long with a fringe of hairs to 4.3 *mm* long, blade with or without long, stiff hairs.

Setaria magna **Griseb., Giant Bristlegrass**
Annual, sheath with long hairs on upper margins, ligule membranous to 1.4 *mm* long with a fringe of hairs to 3.4 *mm* long, blade sandpapery (scabrous) on both surfaces.

CONCLUSION

One character is seldom so different that it alone leads to the identification. The entire leaf (sheath, ligule, blade) should be carefully examined. If possible, more than one plant should be examined so that the average of the characters can be used for camparison. Often the characters are only fractions of a millimeter in length. A good hand lens or dissecting microscope may be necessary to properly identify species.

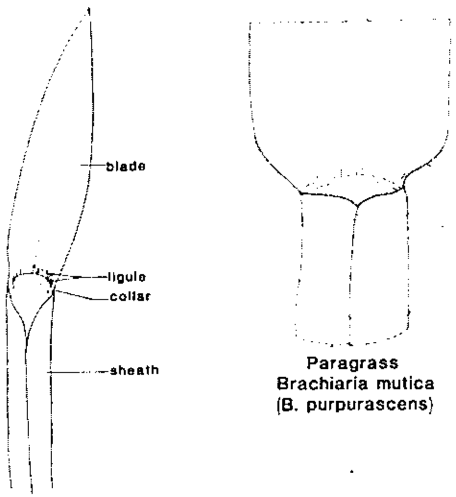

Figure 1. Grass leaf showing arrangement of parts (left); portion of leaf of weedy grass showing upper side at ligule (right).

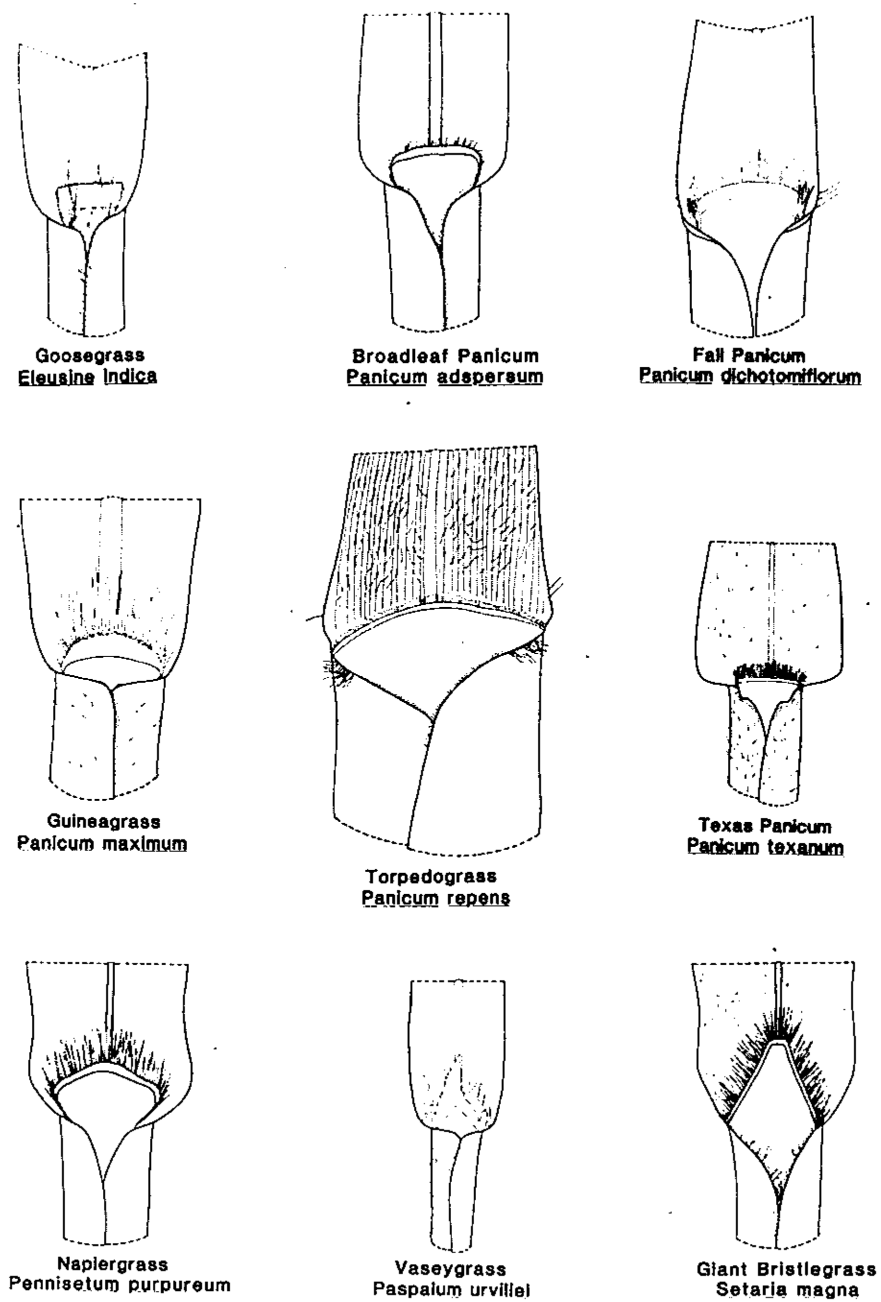

Figure 2. Portion of leaves of weedy grasses showing upper sides at ligules.

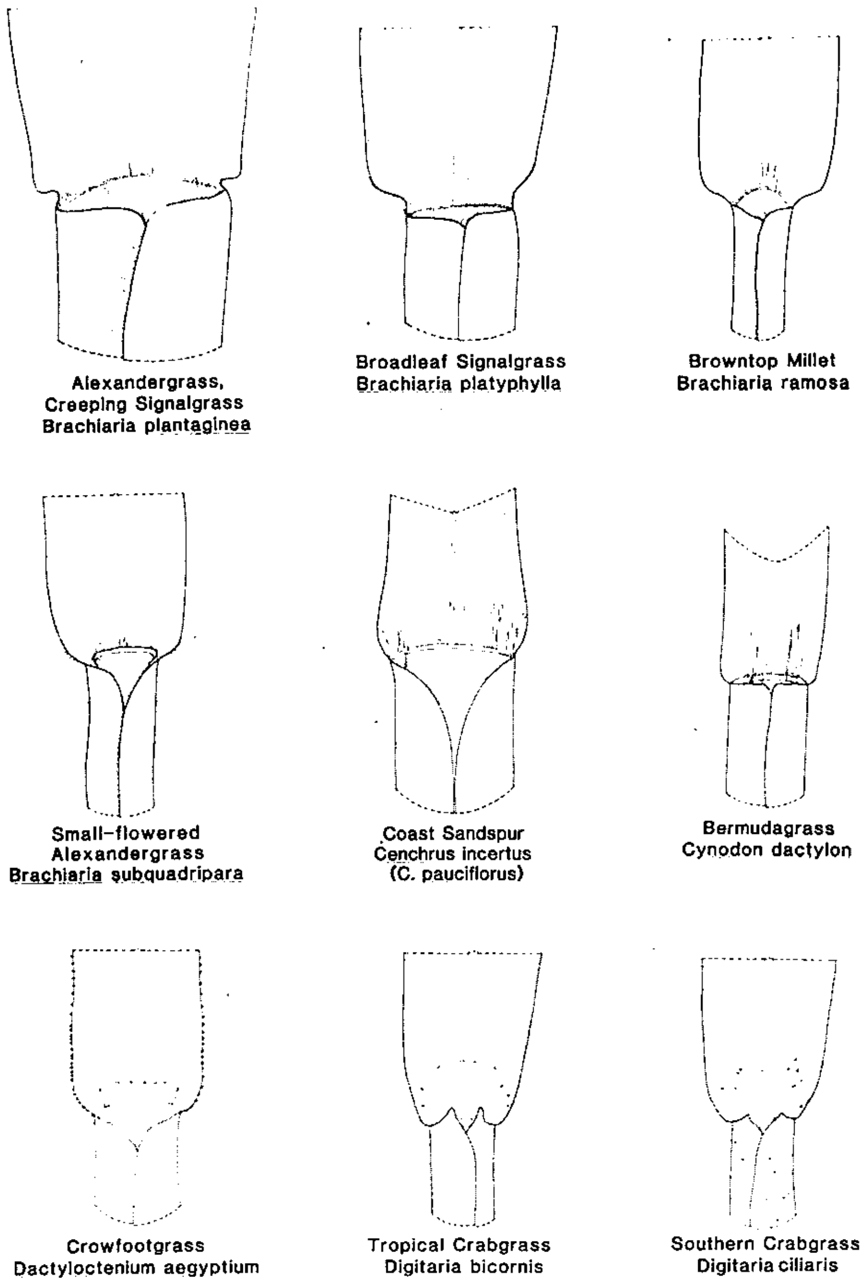

Figure 3. Portion of leaves of weedy grasses showing upper sides at ligules.

PLANT SUCCESSION AND WEEDS IN A NEWLY RECLAIMED POLDER IN JAPAN

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ABSTRACT

Plant succession was studied from 1977 to 1983 at a newly reclaimed polder on the Inland Sea of Japan.

Three results were obtained: 1) A sere where there was no direct disturbance of the soil. 2) Salt tolerant weed species. 3) Colonization methods for the weed species.

Pioneer plants consisted of a few kinds of halophytic plant species. These halophytic plants were replaced by *Aster subulatus*. A more advanced stage was included many kinds of annual plant species. The final stage in wetter sites was a *Phragmites communis* community and in dryer sites a *Solidago altissima* community.

Clear zonation by several kinds of plant species was observed in the early stage of succession. A good correlation between the distribution of each plant species and edaphic conditions was shown by a cluster analysis. The salinity of the soil reduced by rainfall and drainage yearly. The main factors which controlled the speed of succession were the salinity level and moisture content of the soil.

Cultivation experiments using many kinds of crops were started in 1980. 17 species were salt tolerant weed species. Among the 290 species of plant found in the polder, 70 species grew as weeds in the experimental field. 7 methods of colonization for the weed species were found. Most troublesome weeds are *Chenopodium glaucum, Solanum nigrum, Sonchus oleraceus,* and *Aster subulatus* now.

INTRODUCTION

Newly reclaimed polders are one of the best fields to study plant succession. The virgin soil formed on the bottom of the sea contains hardly any weed seeds. If the polders are used for agriculture, they provide the best opportunity for weed scientists to study the colonization of weeds. In addition, we can study the problems of salt tolerance of crops and weeds.

Some interesting life-history studies of a few plant species in newly reclaimed polders were made in the Netherlands (Bakker 1959). There are many studies of plant zonation in salt mashes (Ranwell 1972, Vince & Snow 1984), but there are few studies on weed problems in polders in Japan.

The study area was located on Kasaoka Bay in the Inland Sea of Japan and was about 1200*ha*. The purposes of this study are to :

1) Investigate the flora and edaphic conditions of a polder every year and to clarify the features of plant succession and to select the main factors controlling the sere or speed of succession there.

2) Determine which weed species are salt tolerant.

3) Investigate the weed flora in newly reclaimed cultivated land and to determine how each weed species arrived there.

METHODS OF INVESTIGATIONS

1) Lists of plants in the whole area were made every year by walking about the whole area.

2) 26 permanent belt transects *5m* wide were established in 1978. Each belt was from 30 to 250*m* long and was parallel to the gradient of the land. The altitude ranged from 1 to -5*m* sea level. The species composition and soil in each belt were investigated during the autumn in 1978-1983 by dividing them into smaller stands (5 × 5*m*). Samples of the soil up to 5*cm* below the surface were brought back to the laboratory and the bulk density, water content, pH, salinity, chlorine content, organic matter content, and soil particle components were analyzed.

3) Weed flora of the experimental field situated in the central part of the polder was investigated every month.

RESULTS AND DISCUSSION

Mean values of soil moisture and mean and maximum values of chlorine content of the soil for each plant species grew is shown in Fig. 1. The sequence of plants from upper right to lower left in Fig. 1 corresponds well to the patterns of plant species distribution from the front part to the back part of each trancect.

A good positive correlation between salinity and chlorine content of the soil was found. Soil moisture content was positively correlated with the rate of silt in the soil. Soil pH was negatively correlated with the organic matter content in the soil. Mean values of several characteristics of the soil in which each kind of plant species grew were used for a cluster analysis. From the cluster analysis, a dendrogram representing the classification of 30 main species from 6 soil characteristics was obtained and is shown in Fig. 2. The first cluster is composed of halophytic plant species only. The second cluster is composed of hygrophytes. The third cluster is composed of weeds that can grow even in soil which contains relatively high levels of chlorine. The fourth cluster is composed of many kinds of non-halophytic plants, except for *Spergularia marina*, and included many Japanese upland weeds.

Relatively clear zonations of the plants were observed in many transects in 1978, and the changes of several soil characteristics were regular and did not fluctuate. Salinity increased as one moved from the back to the front of each transect and this relationship was maintained even though salinity in each stand decreased yearly. Table 1 shows the percentage of ground covered by the main species in the same belt transect for 6 years.

Plant succession where there was not any direct disturbance of the soil is shown as a scheme in Fig. 3. The virgin soil of the bare ground contained so much salt that no plant could grow there at the beginning of this study. Also, the soil moisture was very high except where there was a lot of sand in the soil. Where the soil salinity

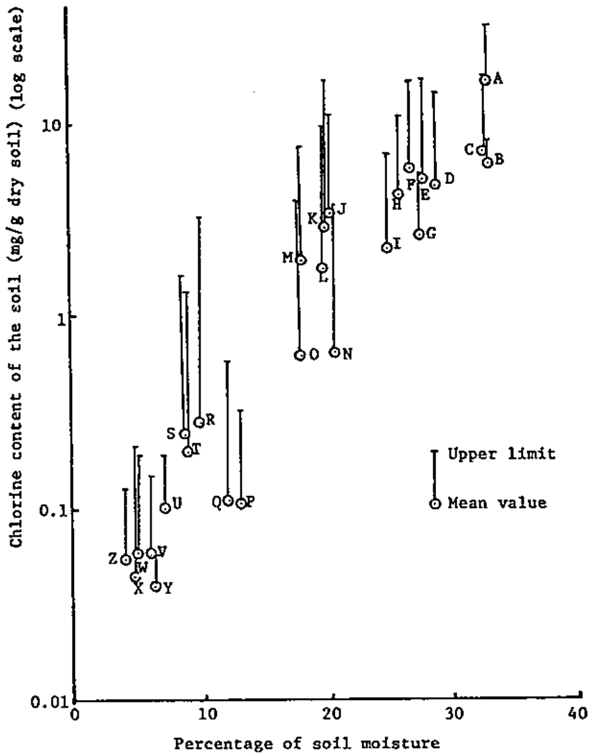

Fig. 1 Correlations between mean values of moisture content and mean values and upper limit of cholorine content of the soil for each species.

A:Front bare ground, B:*Chenopodium glaucum*, C:*Aster tripolium*, D:*Suaeda asparagoides*, E:*Atriplex hastata*, F:*Kochia scoparia* var. *littorea*, G:*Typha angustifolia*, H:*Diphachne fusca*, I:*Phragmites communis*, J:*Polypogon fugax* K:*Sonchus oleraceus*, L:*Aster subulatus*, M:*Echinochloa crus-galli*, N:*Eclipta prostrata*, O:*Chenopodium album*, P:*Bidens frondosa*, Q:*Solanum nigrum*, R:*Erigeron canadensis*, S:*Chenopodium ambrosioides*, T:*Erigeron floribundus*, U:*Andropogon virginicus*, V:*Miscanthus sinensis*, W:*Solidago altissima*, X:*Digitaria adscendens*, Y:*Artemisia princeps*, Z:*Polygonum cuspidatum*

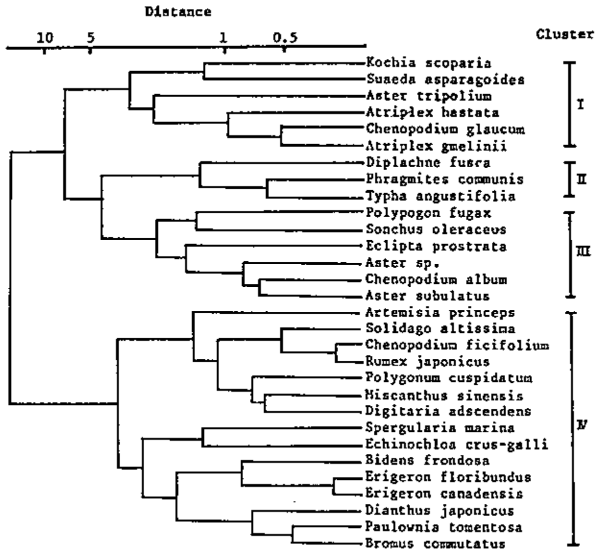

Fig. 2 A dendrogram, representing the classification of 30 species from 6 soil characteristics (salinity, chlorine content, moisture content, organic content, percentage of silt, pH) from vagetation on Kasaoka Bay Polder in Japan.

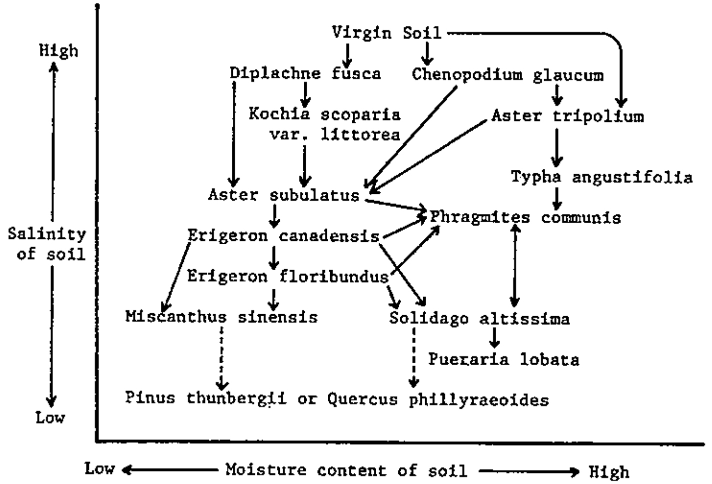

Fig. 3 Sere of newly reclaimed polder at Kasaoka Bay in Japan. Arrows indicate the direction of plant succession. Broken lines show the direction of succession in the near future, if no disturbances occur.

Tab. 1. Coverage of main species for six years in a belt transect (No. 225).

Plant name	back ← position → front		Plant name	back ← position → front	
Miscanthus sinensis	31 +	'78	*Aster subulatus*	+323 1112222	'78
	31 1	'79		+++1 + +2221	'79
	31++1 +	'80		++++11223421+1 +	'80
	221++1+1+++++	'81		++ ++++2232	'81
	2212 2+1++1+++++	'82		+23342	'82
	1212 2221+11211+	'83		++++	'83
Solidago altissima	1121 +	'78	*Phragmites communis*	1 241	'78
	+343++	'79		+ 454+	'79
	+343+1112+ ++	'80		++344311+11+	'80
	14433332321121+	'81		+24443333433	'81
	134434435421322+	'82		+12243344333	'82
	1344344554323331+	'83		1224234555	'83
Erigeron floribundus	+21231221+	'78	*Aster tripolium*	22431	'78
	+22212231+	'79		4555	'79
	+2222222211+1 + .	'80		24333455	'80
	1212+32221+12221+	'81		+2+233	'81
	+++1++11++2322221 +	'82		21133	'82
	+++122++111222++	'83		1++	'83
Erigeron canadensis	232345431	'78	*Kochia scoparia* var. *littorea*	+1232242	'78
	345555421	'79		23	'79
	1234555223221	'80		44433+	'80
	+12+2232 1 2231	'81		++	'81
	+1112+ +++332	'82		+	'82
	+ +1 +++	'83			'83

Figures or marks in table indicate percentage of ground covered by each plant species. 5 : 100~50, 4 : 50 25, 3 : 25~10, 2 : 25~10, 1 : 10~1, + : less than 1.

decreased, several halophytic plant species including, *Chenopodium glaucum, Kochia scoparia* var. *littorea, Suaeda asparagoides, Atriplex gmelinii, Aster tripolium,* and *Diplachne fusca* grew there as pioneer plants. Where the soil salinity decreased gradually but mositure content remained high, a sere was observed to start with *Aster tripolium* and change to *Typha angustifolia* or *Aster subulatus* and stablize as a *Phragmites communis* community.

Salinity and moisture content of the soil in most parts of the polder declined yearly. Halophytic plants were replaced by *Aster subulatus* and they, in turn, were replaced by *Erigeron canadensis* and *E. floribundus.* The *Erigeron* stage included many kinds of plant species *Chenopodium, Bidens, Echinochloa, Sonchus, Polypogon, Rumex,* etc. Most of these species were annual plants. In the next stage, sites with lower soil moisture content changed to *Solidago altissima* or *Miscanthus sinensis;* whereas, *Solidago altissima* grew in wetter sites. The number of species in this stage was less than in the preceeding stage. *Artemisia princeps* also grew in this stage. The ratio of perennial plants to annual plants increased in this stage.

61 families and 290 species of vascular plants were found in the polder in 1980. 19 families and 70 species were found in the experimental field. The most troublesome weeds were *Chenopodium glaucum, Sonchus oleraceous, Senecio vulgaris, Solanum*

nigrum, and *Aster subulatus*. Weed species which could grow in the soil of high salinity were, *Portulaca oleracea, Spergularia marina, Chenopodium glaucum, C. album, C. ficifolium, C. ambrosioides, Atriplex hastata, Oenothera laciniata, Solanum nigrum, S. americanum, Artemisia capillaris, Aster subulatus, Eclipta prostrata, Senecio vulgaris, Sonchus asper*, and *S. oleraceus*.

Weed colonization to cultivated land is summarized in Table 2. Although direct evidence that some species were introduced into the cultivated land by man was not found, these weed species could only be found in cultivated land. Therefore, we may conclude that these species were introduced to the cultivated land as a result of farming.

Tab. 2 Colonization methods for weed species in the newly reclaimed cultivated land in Kasaoka Bay Polder.

With rice straw for mulching	*Ludwigia epilobioides, Eclipta prostrata, Aneilema keisak, Echinochloa oryzicola, Cyperus difformis*
With stable manure	*Chenopodium album, Medicago sativa, Solanum nigrum*
With transplanting crop seedings	*Polygonum longisetum, P. persicaria, Capsella burasa-pastoris, Lamium amplexicaule, Veronica arvensis, V. persica*
Escape from pasture	*Panicum dichotomiflorum, Paspalum distichum, Lolium perrenne*
Resulting from farming	*Portulaca oleracea, Stellaria neglecta, Cardamine flexuosa, Achyranthes bidentata, Brassica juncea, Rorippa indica, R. islandica, Sisymbrium orientale, Centipeda minima, Eleusine indica, Echinochloa crus-galli, Poa annua, Cyperus brevifolius* var. *leiolepis, C. iria*
By birds	*Phytolacca americana, Solanum nigrum, S. americanum*
By wind	*Polygonum cuspidatum, Artemisia princeps, Aster subulatus, Crassocephalum crepidioides, Erigeron annuus, E. floribundus, Erechtites hieracifolia, Lactuca indica, Senecio vulgaris, Sonchus oleraceus, S. asper, Solidago altissima, Andropogon virginicus, Typha angustifolia*

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SECONDARY SUCCESSION AT THE SHIFTING CULTIVATION SITE IN NORTHEAST THAILAND

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ABSTRACT

Weed dynamics of experimental shifting cultivation site and its abandoned part were observed from 1980 to 1984. The site is located in the basin of the Nam Phrom Plateau about 140 *km* west of Khon Kaen in northeast Thailand.

Crassocephalum rubens firstly appeared after burning in all kinds of treatments and continued to dominate until the second year under weeding condition. While under non-weeding condition, *Ageratum conyzoides* and *Eupatorium odoratum* increased.

E. odoratum immediately dominated and formed dense bush in the abandoned part. Plant height of *E. odoratum* reached more than two metres and its leaves completely covered the ground surface in 4 years after burning. In the abandoned part seedling growth of trees and other species except *Saccharum* and *Musa* species were remarkably depressed.

INTRODUCTION

There has been an increased demand in Thailand recently for the export of crops such as corn, kenaf and cassava (5). These crops have been raised sometimes using tractors in vast areas previously covered by forest. They are usually cultivated over long periods, as compared with traditional shifting cultivations. This type of cropping system is generally called "new-type shifting cultivation".

This new type of shifting cultivation is leading to serious destruction of the forest and to soil erosion. Forest areas occupied 58% of Thailand in 1959 but decreased to just 25% in 1977(13), mainly as a result of such cropping.

In northeast Thailand, few research works on the succession of weed flora in shifting cultivation areas had previously been carried out (4,11).The dynamics of weed communities in shifting cultivation fields and at abandoned sites from 1980 to 1984 are described in this paper.

MATERIALS AND METHODS

The dynamics of weed communities were investigated at the experimental site constructed to carry out the Thai-Japan cooperative project, "Ecological studies on shifting cultivation and its transformation process to sustained upland farming" (11) and at a corn field where original forest had been cleared 14 years prior belongs to the local farmer. These sites are situated on the Nam Phrom Plateau about 149 *km* West of Khon Kaen in northeast Thailand.

The sites are in a tropical zone with distinct wet and dry seasons. Rainfall is very scarce in December and January and abundant in May and September. The elevation of the experimental site is approximately 800 *m* while that of the local farmer is rather lower.

The vegetational survey was done at shifting plots (nocultivation, nofertilization and burning in the dry season every year) and at improved plots (cultivation, fertilization, weeding and burning at the same time as shifting plots) at the experimental site in October 1980, September 1981, November 1983 and July 1984. Coverage and plant height of each species, and stem length and cross section of *Eupatorium odoratum* were measured. Suwan No 1, a variety of corn was sown before the rainy season every year.

In the local farmer's corn field, plant height and coverage of all weeds were measured in October 1980.

RESULTS AND DISCUSSION

1. Succession of weed community under cropping systems.

It was useful to use SDR_2-sequence relations (7, 8, 10) for analysis of the undulatory process of establishment and degradation in the organization of weed communities on the shifting cultivation site. SDR_2-sequenc relations of weed species which appeared in the shifting cultivation plot at Nam Phrom experimental site from 1980 to 1984 are shown in Figure 1. SDR_2 computed here was based on the mean relative value of coverage and that of the height of each species.

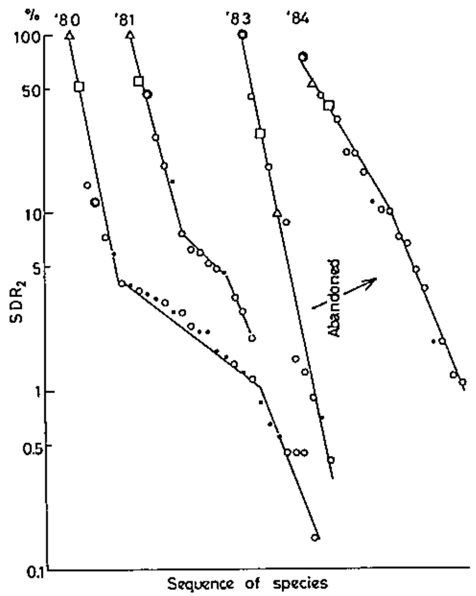

Figure 1. Changes in the SDR_2-sequence relations of species on the shifting cultivation plot.
note: □ :*C. rubens* ○ :*A. conyzoides* and △ :*E. odoratum*

In 1980, within a year after the first burning, two Compositae, *E. odoratum* and *Crassocephalum rubens*, dominated. Sprouts from different kinds of stumps and undergrowths, such as Zingiberaceae, partially eliminated by fire, were present, and the total number of species in this year was the highest of the entire period of survey. The SDR_2-sequence relation showed log-normal series; therefore, this community is regarded to promote inter-specific competition and to have unsteady status.

In 1981, after the second burning, the SDR_2-sequence relation continue to show nearly the same pattern as in 1980. However the total number of species decreased in accordance with the decrease in sprouts.

After the fourth burning, in November 1983, the number of sprouts decreased markably, and the undergrowth disappeared. The total number of species in this plot was ten and its SDR_2-sequence relation showed a geometric series. The yearly burning and crop cultivation is regarded as having promoted the "balance-of-power" among the weed species screened.

This site was abandoned the next year. The number of species invading the site increased in 1984 and the community situation reverted to an unsteady state.

Yearly changes in the relative dominance of *C. rubens, Ageratum conyzoides* and *E. odoratum* over the period at the shifting plot and improved plot are shown in Figure 2. *C. rubens* dominated and simultaneously flowered at the shifting plot in the early stage after the first burning, but *E. odoratum* had become dominant by October 1980 when the first investigation was done.

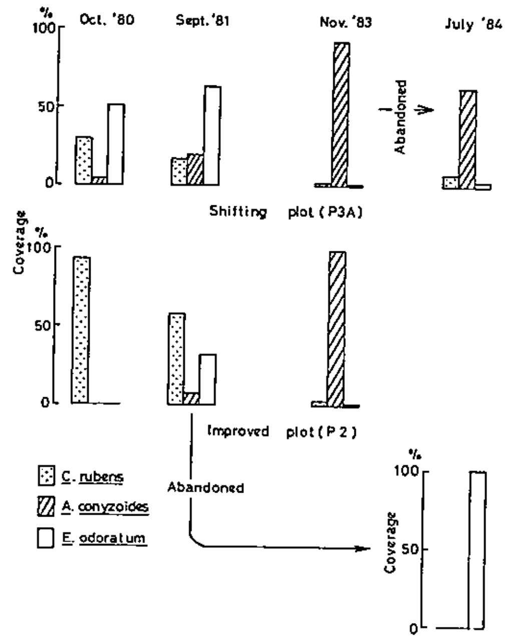

Figure 2. Changes in coverage of invading three species at shifting cultivation, improved cultivation and abandoned sites. The first burning was carried out January 1980 and both cultivation sites were burned every year.

In the shifting plot *E. odoratum* continued to dominate up until 1981; after the second burning, however, in 1983 *A. conyzoides* replaced *E. odoratum* as the dominant species. At the same time, a small amount of *Pennisetum pedicellatum,* a troublesome grass weed (5, 6) in the shifting cultivation fields of Nam Phrom Plateau, was observed. Other grass weeds i.e. *Eleusine indica* and *Digitaria adscendens* were also found to be increasing. Weeding was done for the first time at this site in 1983 and it is assumed that *E. odoratum* was greatly affected by the weeding.

In the improved plot *C. rubens* dominated for the first two years after the burning. In 1981 *E. odoratum* and *A. conyzoides* invaded and, as with in the shifting plot, sprouts from stumps markably decreased. After the fourth burning, in November 1983, *A. conyzoides* replaced *C. rubens* as the dominant species, that is, the dominant species was the same as in the shifting plot in the same year.

The mean plant heights of *C. rubens, A. conyzoides* and *E. odoratum* are shown in Figure 3. The plant heights of the above-mentioned species in their improved plot were lower than those in the shifting plot in the first two years. However, in November 1983 the plant heights of *C. rubens* and *A. conyzoides* in the improved plot were superior to those in the shifting plot. The findings in 1983 may have been caused by the difference in soil fertility. The fertilizer in the improved plot accelerated the growth of the quickly developing *C. rubens* and *A. conyzoides* seedlings which invaded after weeding. *E. odoratum* invaded the improved plot after the second burning and its shorter height showed the influence of weeding.

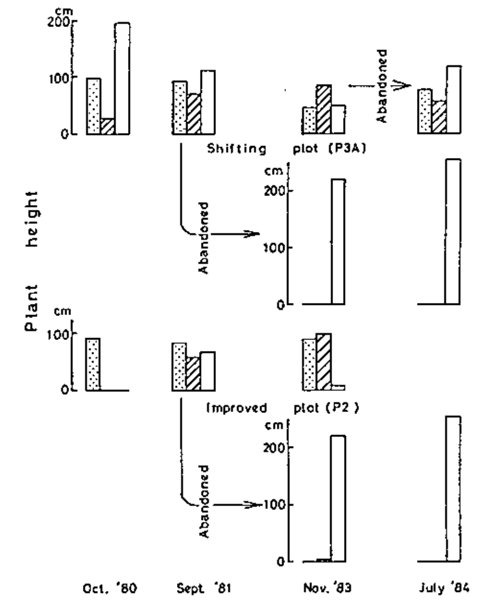

Figure 3. Changes in plant height of invading species in different treatment plots. The measurement were taken in the same areas as the coverage shown in Figure 2.
See Figure 2. for symbols.

When the weeding was done frequently, the bare area ratio increased as did the colony of the small prostrate type weed, *Oxalis corniculata. C. rubens* and *A. conyzoides* scarcely appeared under such conditions(4).

Weed communities were also investigated at a local farmer's corn field on Nam Phrom Plateau where the original forest had been cleared 14 years prior. The field was burned, cultivated by tractor and cropped with corn without fertilizer every year. *P. pedicellatum* and *Euphorbia geniculata* dominated in the field. The mean plant height of *P. pedicellatum* was 89 *cm* and of *E. geniculata 71 cm*, and the mean coverage of the former was 16% and that of the latter 21% on October 10th 1980. Weeding is usually done once after the corn sowing, therefore the coverage of *P. pedicellatum* increases in the heading time in late November. *Eleusine indica* and *A. conyzoides* grow together with dominant species.

Almost pure communities of *P. pedicellatum* were sometimes found in the corn-cultivated areas on Nam Phrom Plateau in late November. In some areas *Imperata cylindrica* partially invaded and corn growth in those parts was inferior to that surrounding.

2. Secondary succession in abandoned cultivation areas.

E. odoratum immediately invaded and dominated in the non-cropping abandoned area at the experimental site where crops had never been cultivated after clearing and burning. The total biomass of the above-ground part of *E. odoratum* in October 1980 was 223 $g\ DW/m^2$ and this increased to 680 $g\ DW/m^2$ in October 1981(11).

E. odoratum also dominated in the plot where corn cropping was carried out for the first two years and then abandoned. In this case (P-2 Abandoned See Figure 2) *E. odoratum* completely covered the ground surface within four years after burning. Figure 4 shows the correlation between stem length and the cross section of the stem at ground surface of *E. odoratum* at the P-2 Abandoned site in July 1984. Length and cross section of *E. odoratum* does not change linearly as shown in Figure 4. The

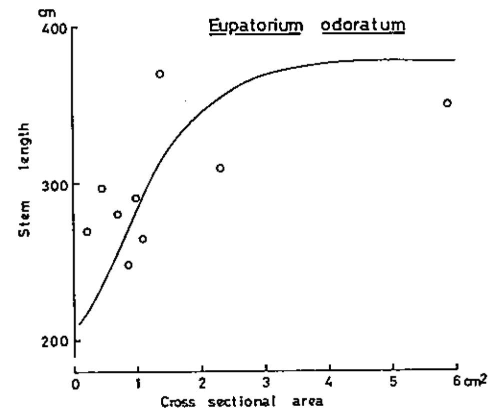

Figure 4. Correlation between stem length and cross section of stem at ground surface of *E. odoratum* in plot where the last burning had been carried out 4 years prior.

elongation of stems stopped here at less than four meters, moreover the top of their stems hung down, while the tall individuals e.g. *Saccharum* sp., *Musa* sp., tree sprouts and seedlings grew over the leaf layer formed by the *E. odoratum* population and gradually cover *E. odoratum* individuals which were shorter than 50 *cm* were observed and their growth was depressed by adult *E. odoratum.*

Where corn cropping had continued for four years and was then abandone at the P-3 Abandoned site, *A. conyzoides* dominated for two years following the final burning, in spite of the non-burning and non-weeding condition. However, the plant height of *E. odoratum* had taken over that of *A. conyzoides.* Therefore the site is likely to be soon dominated by *E. odoratum.*

3. Ecological characteristics of dominant weeds at the shifting cultivation site.

One dominant weed alternated with another in response to the way of management at the shifting cultivation site (Figure 5). It is therefore important to know about the ecological characteristics of these species in order to control them ecologically. *C. rubens,* an annual compositae, often invades just the clearing and/or burning of forest in Thailand, as it does in warm temperate zones in Japan(3, 9). The first *C. rubens* invaders simultaneously covered the ground surface at the experimental site. They grew, flowered and scattered their numerous comospore all over the Nam Phrom Plateau during the rainy season(4). The growth phase and size of each individual in the site becomes gradually irregular from one generation to the next due to the heterogeneity of their micro-environments e.g. topography, soil properties. *A. conyzoides* gradually invaded the spaces resulting from the irregular growth of the *C. rubens* population. It was not clear what effect the poor weeding had on the grain yield of corn during the *C. rubens*-dominated period(1).

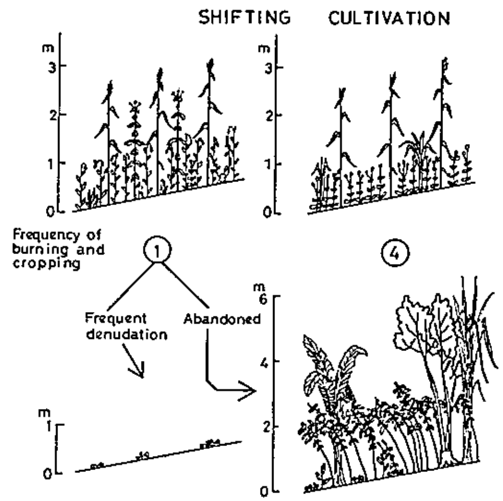

Figure 5. Diagram illustrating the vegetation structure influenced by burning, cropping and weeding at Nam Phrom experimental site, northeast Thailand.

A. conyzoides, the dominant species second to *C. rubens,* is also an annual compositae. It may produce 40000 seeds per plant and in some areas one half of the seeds germinate shortly after they are shed. The life cycle of *A. conyzoides* may be completed in less than two months(2). *A. conyzoides* showed high variability at experimental plots; for example, within a 50 *cm* x 50 *cm* quadrate the largest individual grew to 87 *cm* and had numerous flowers while the smallest flowering adult reached only 30 *cm* (4). Both in shifting and in improved plots *A. conyzoides* more effectively used the "available" space, compared with *C. rubens* and *E. odoratum,* after four years of burning and cropping.

Pennisetum spp., *P. pedicellatum* and *P. polystachyon* are annual grasse and troublesome weeds in shifting cultivation areas in northeast Thailand. They flower and produce numerous seeds in the early dry season, November to December, in this area. Both species become dominant in upland tropical hills and croplands when shifting cultivation has been practiced. They can become dominant in fire climax when the soil fertility has declined(2).

E. odoratum, a shrub of compositae, spreads almost entirely by airborne seeds. Seed germination occurs mainly after the rainy season(2). The plant formed a tangle of bush about 2 meters in height when burning and cropping were abandoned. Early invaders of *E. odoratum* showed a high growth rate but that of seedlings surrounded by adult plants was extremely depressed(12). At the experimental site *E. odoratum* was infected with stem rot which contributed to the regulation of its population(12).

Just after the clearing and burning of the forest *C. rubens* dominated both in improved and in shifting plots, but its period of dominance was not long. *A. conyzoides* took over from *C. rubens* in the weeded and fertilized improved plot. In the shifting plot *E. odoratum* succeeded *C. rubens* initially, but *A. conyzoides,* the same species as in the improved plot, dominated four years after burning. Several years after clearing the forest *Pennisetum* spp., troublesome weeds, invaded the crop cultivated field. After abandonment the site was soon recovered by the tangled shrub *E. odoratum,* which was then gradually replaced by tall grasses and trees.

ACKNOWLEDGMENTS

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SOME BIOLOGICAL CHARACTERISTICS OF *Pennisetum* spp. IN THAILAND

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ABSTRACT

Three species of *Pennisetum pedicellatum, P. polystachyon* and *P. purpureum* distribute throughout Thailand, provide serious weedy problems in not only upland arable lands but also unarable, areas, especially roadsides or abandoned fields with low fertility. In order to know basic information of three *Pennisetum* species to establish their feasible, effective control measures, several experiments on the biology of these *Pennisetum* spp. were performed in NWSRI Project.

As a result, some biological characteristics could be revealed. Dormancy of the seeds of *P. purpureum* and the other two species almost end in 4 and 6 month respectively. The most adequate temperatures range from 20°*C* to 35°*C*. In general, Pennisetum seeds are a light-fovorite type in germination, though response to light in *P. purpureum* is very low compared with the others.

Pennisetum spp. belongs to a long life cycle group of weeds in Thailand and *P. polystachyon* is most prolific, produces abundant seeds of 23536 per plant.

No regrowth of plant cut is seen in *P. pedicellutum* and *P. polystachyon*, but vigorous regrowth exists in *P. purpureum.*

INTRODUCTION

Three species of *Pennisetum pedicellatum, P. polystachyon* and *P. purpureum*, have been known as the serious weeds distributing in the tropical and subtropical areas of the world and all of them are existing in Thailand (Holm et al., 1977). At present, they are called "Communist grass" in Thailand, one of the most serious weed not only in upland arable lands, but also in non-arable areas. Syamanands (1971) reported that *P. polystachyon* and *P.edicellatum* widely dominate in farmlands, highlands and forest of the Northeast Thailand and give several kinds of weedy problems. With a consideration of the above status, biological experiments have been started in order to learn basic information to establish adequate controlling procedures of these weeds. An outline of the results obtained is introduced in this paper.

METHODS AND RESULTS

Dormancy.

The seeds of three pennisetum species were harvested from November 4 to 9, 1983 and their germination ability was investigated at several month intervals as shown in Fig. 1. *P. purpureum* almost got the highest percent of seed germination around

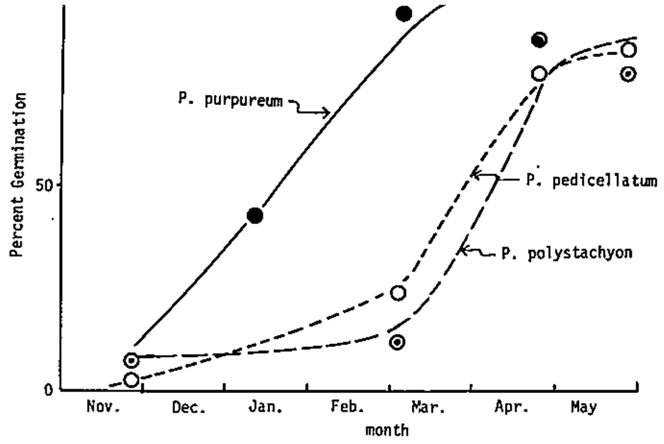

Fig. 1. Changes of Percent Seed Germination of Pennisetum spp.

Fig. 1. Changes of Percent Seed Germination of Pennisetum spp.

early March when others indicated 20 or less percent. Other two species, however, acquired the nearly maximum percent around late April. There seems to be no essential difference between *P. pedicellatum* and *P. polystachyon* in germination dynamics of seeds.

As a result, the seed dormancy of *P. purpureum* and a group of *P. polystachyon* seem to end in about 4 and 6 months, respectively.

Mott (1980) already reported that the seed dormancy of *P. pedicellatum* was vanished after finishing a dry season, and Pemadasa (1982) reported that initial and maximum times of seed germination of *P. polystachyon* are in March and April, respectively. The results of ours should verify these reports.

Germination.

Several experiments to know the relationship between the seed germination of three *Pennisetum* spp. and the conditions of temperatures and/or light were conducted in laboratory during May to November of 1984.

Experiment 1 (shown in Table 1) revealed the seed germination of *P. pedicellatum* and *Polystachyon* in distinctly enhanced by a ligh condition but that of *P. purpureum* in less affected.

In experiment 2 (shown in Table 2), the influence of light on the seed germination of three Pennisetum could be confirmed, and it was further learned that the most adequate temperatures range from 20° *C* to 35° *C*.

Experiment 3 (shown in Table 3) reconfirmed that the range of adequate temperatures as well as the influence of light on seed germination. The most adequate temperatures range from 20° *C* to 30° *C*, the highest limit somewhat differed compared with experiment 2. Further, An alternative temperature of 29 and 38° *C* also gave a good germination.

Table 1. Seed germination of three *Pennisetum* spp. under light and dark conditions.

Weed species	Light	Dark
	%	%
P. pedicellatum	76.0 bc	10.7 c
P. polystachyon	68.7 c	28.0 d
P. purpureum	99.3 a	86.7 ab

Notes: Values are the means of three replications. Means followed by a common letter are not significantly different at the 5% level. Incubated 50 seeds per petridish in a 30° C temperature. An experiment was performed from 7 to 27 of May 1984.

Table 2. Effect of temperatures and light on the seed germination of *Pennisetum* spp.

Temp.	Light	*P. pedicellatum*	*P. polystachyon*	*P. purpureum*
		%	%	%
20° *C*	Light	80.7 a	85.3 a	91.3 ab
	Dark	60.7 c	56.7 bc	98.0 a
30° *C*	Light	80.7 a	74.0 ab	95.3 ab
	Dark	46.0 d	57.3 bc	81.3 b
35° *C*	Light	74.7 a	83.3 a	94.0 ab
	Dark	18.0 c	52.0 c	98.0 a
40° *C*	Light	66.7 c	62.0 bc	93.3 ab
	Dark	2.7 f	11.3 d	82.7 ab

Notes: Values are the mean of three replications. In each column, means followed by a common letter are not significantly different at the 5% level.
Incubated 50 seeds per petridish. An experiment was conducted in laboratory from 15 to 21 of May, 1984.

Table 3. Effect of temperatures and light on the seed germination of *Pennisetum* spp. (add. test)

Temperature	Light	*P. pedicellatum*	*P. polystachyon*	*P. purpureum*
		%	%	%
20° *C*	Light	84.7 ab	94.0 a	96.7 a
	Dark	69.3 ab	58.7 bc	96.0 a
30° *C*	Light	82.0 ab	75.3 ab	98.7 a
	Dark	44.7 c	42.0 ed	95.3 a
40° *C*	Light	64.0 bc	49.3 c	71.3 b
	Dark	3.3 d	6.0 c	69.3 b
29-38° *C*	Light	86.7 a	74.0 ab	94.7 a
	Dark	12.0 d	20.0 dc	74.7 b

Notes: See Table 2. An experiment was conducted from 3 to 13 of July, 1984.

Further, some additional experiments were performed to know the limit of the lowest and highest temperatures of the seed germination of three *Pennisetum* spp. under the conditions of 15° *C*, and 50° *C*. Constant 50° *C* perfectly suppressed the seed germination under the both of light and dark condition. 15° *C* reduced to less than 20 percent in light.

Further experiment revealed the effect of term length under a 50° *C* condition. A 18 - hours treatment already gives serious reduction of percent germination, especially in *P. polystachyo*, and that in dark influenced more seriously than in light. A 48 - hours treatment almost perfectly suppressed the seed germination.

As the results of a series of the above-mentioned experiments, it can be summarized that the most adequate temperatures of seed germination range between 20° *C* and 35° *C* as shown in Fig. 2. A light condition enhances more than a dark one, but its enhancement is rather less in *P. purpureum* than the other spp.

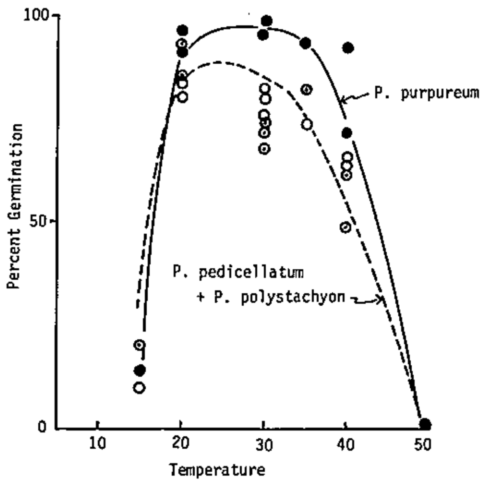

Fig. 2. Summary of the relation of temperatures to the seed germination under a light condition.
○ *P. pedicellatum*
⊙ *P. polystachyon*
● *P. purpureum*

Life cycle and seed production.

Noda et al (1983) reported that principal weeds in Thailand can be classified in three groups of short, intermediate and long in the term of a life cycle from emergence to seed bearing. *Pennisetum* spp. belongs to the long group.

Three species of *Pennisetum* sown at the three times of a year were investigated to confirm their growing behaviors. Material plants were sown in wagner pots, May 21, August 28 and September 28, 1984. Five stands per pot were grown at three replication.

The initial times of heading, flowering and seed bearing was investigated. They occured from October to December in order of *P. pedicellatum, polystachyon* and *purpureum*. The great difference of sowing times becomes less in the times of heading, flowering and seed bearing.

Material plants after seed ripening were harvested and their ecological charactors and seed production were measured as shown in Table 4.

Table 4. Ecological characters and seed production of *Pennisetum* spp. sown on May 21.

Item	*P. pedicellatum*	*P. polystachyon*	*P. purpureum*
Max. Plant height cm	138.2	223.3	199.6
Spike length cm	6.00	8.67	8.57
No. spikelets/spike	14.21	17.84	20.00
No. spikes/plant (A)	57.8	68.3	14.0
No. seeds/spike (B)	120.7	344.6	321.2
No. seeds/plant (AxB)	6,976.5	23,536.2	4,496.8

Note: Sown on May 21, and havested on December, 1984. Grown in Wager pots, five plants per pot, used three pots for each species.
Investigation was made on a dominate head of a plant. Values are the means of 15 plants of three replicated pots.

P. polystachyon and *P. purpureum* have more stout habit than *P. pedicellatum*. *P. purpureum* is very inferior in the number of spikes per plant that is most closely bearing to seed production. Number of seeds per plant obtained from AxB is most prolific in *P. polystachyon*, amounted to 23536.

Regrowth.

Regrowth from the stub of plants cut in the height of 5 and 10 cm was observed. *P. pedicellatum* and *P. polystachyon* gave no regrowth but *P. purpureum* did vigorous regrowth as shown in Table 5. It is considered that *P. purpureum* posses rather higher perrenial-type activity than the others.

Table 5. Regrowth of *Pennisetum* sp. cut after harvest

Group	Species	No. of spikes emerged/pot		Regrowth *g* fresh wt./pot	
		5 cm	10 cm	5 cm	10 cm
1	*P. pedicellatum*	0	0	0	0
	P. polystachyon	0	0	0	0
	P. purpureum	13.5	42.5	155	185
2	*P. pedicellatum*	0	0	0	0
	P. polystachyon	0	0	0	0
	P. purpureum	30.5	53.0	183	193

Notes: Cut on January 16 in 5 and 10 *cm* height and investigated on March 11.
Values are the means of two replications (pots).
Group 1 and 2 were sown on May 28 and August 28, respectively.

CONCLUSION

This paper dealed with some biological characteristics of three *Pennisetum* species such as seed dormancy, seed germination, life cycle, seed production and regrowth after hervest. These information is sure to be very important, useful to establish the control methods, but further collaborate approaches should be necessary from a standpoint of not only control but also utilization of *Pennisetum* species.

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TOLERANCE OF FINGER MILLET TO PROPANIL

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ABSTRACT

The selectivity of both foliar- and root-applied propanil was studied among gramineous plant species. In both application, finger millet showed considerable tolerance to propanil, although it is less tolerant compared to rice. Large crabgrass, goose grass and barnyardgrass were found susceptible to propanil. Metabolic change of ^{14}C-propanil in roots and shoots of rice was much greater than finger millet and barnyardgrass. Finger millet as well as barnyardgrass hydrolyzed no propanil at all, while rice hydrolyzed it remarkably. Rates of absorption of ^{14}C-propanil by shoots were increased in the following order; barnyardgrass > rice > finger millet. Rate of translocation of ^{14}C-propanil from roots to shoots of finger millet was comparatively less than that of rice and barnyardgrass.

Photosynthesis of the three species of plants was severely inhibited immediately after foliar application. However the inhibition in rice was recovered soon after in 24 hours, while the inhibition in finger millet required much longer time (1 week) for complete recovery. Inhibition in barnyardgrass was not eliminated at all. It is concluded that tolerance of finger millet to propanil is not due to hydrolytic degradation of propanil, but less accumulation of the chemicals in shoots resulted from less absorption by shoots or less translocation from roots to shoots may contribute to the tolerance.

INTRODUCTION

Propanil is a well known herbicide which controls barnyardgrass in rice paddy fields. Mechanism on its refined selectivity between such closely related species of plants has been investigated intensively. Propanil is detoxified rapidly in rice, while unchanged propanil is accumulated in barnyardgrass to a lethal concentration. This difference in enzymatic activity was proposed as the major factor for the selective action of propanil between rice and barnyardgrass (1, 7). Propanil has been reported to inhibit both photosynthesis (4) and respiration (5). Hofster and Switzer (4), showed that photosynthetic activity of tolerant plants to propanil was recovered quickly from the inhibition but not of susceptible plants.

The objective of the present study is to survey tolerant species of plants to propanil other than rice and to investigate the mechanism of tolerance of finger millet to propanil with respect to its absorption, translocation, metabolism and change of photosynthesis or respiration in leaves. Relationship between effect of propanil on photosynthesis, a site of action, and concentrations presented there was also studied with leaf discs.

MATERIALS AND METHODS

1. Application of propanil and effects on growth

Rice (*Oryza sativa* L. cv. Nihonbare), finger millet (*Eleusine coracana* (L.) Gaertn.), barnyardgrass (*Echinochloa oryzicola* Vasing.), large crabgrass (*Digitaria ciliaris* (Retz.) Koeler) and Goose grass (*Eleusine indica* (L.) Gaertn.) were grown to the designated leaf stage seedlings in water culture under the controlled conditions. Application was made as follows; either shoots or roots of intact plants at the 4th leaf stage were dipped for 90 min or 3 hours in a 1% acetone aqueous solution of propanil at various designated concentrations, respectively.

2. Absorption, translocation and metabolism of propanil

^{14}C-propanil labelled at the carboxyl carbon position, with a specific activity of 4.13 $\mu Ci/mg$ and a radiochemical purity of above 98% was synthesized (8). Either shoots or roots of gramineous plants were placed in ^{14}C-propanil solution for the given periods. Shoots and roots were separately combusted and total ^{14}C-radioactivity was measured for determination of absorption and translocation. To determine metabolic change, shoot and root parts were then homogenized and extracted in 90% methanol 24 hours after the treatment. The concentrated methanol extracts were applied to silica gel thin-layer chromatography *(tlc)* using a mixture of chloroform : methanol : pyridine (100 : 5 : 1) as a developing solvent.

3. Enzyme assay

Enzyme preparations from the plants were made by the method of Akatsuka (2). Amounts of propanil remained in reaction media were determined by the procedure of Goto and Sato (3). Hydrolyzed 3, 4-dichloroaniline was also determined directly by a modification of Rinden and Hopkin's procedure (2).

4. Measurement of photosynthesis and respiration of intact plants

Shoots of intact plants at the 5th leaf stage were dipped for 90 min in a 1% acetone aqueous solution of propanil at 4.59 × 10^{-4} *M*. Leaf slices (1 *mm* × 2 *mm*) of the treated youngest leaf blades were used to determine the activity of photosynthesis and respiration in leaves by an oxygen electrode. The buffer used for the determination was 50 *mM* HEPES solution (pH 7.2 with NaOH) contained 0.1 *M* $NaHCO_3$, 0.33 *M* sorbitol, 1.0 *mM* $MgCl_2$, 1.0 *mM* $MnCl_2$ and 2.0 *mM* EDTA.

5. Measurement of photosynthesis in leaf discs and determination of remained concentration of ^{14}C-propanil in leaf discs

Before treated with propanil, the youngest leaf were cut into discs (2.0 *mm*) with screw punch. Thirty leaf discs were incubated in 5 × 10^{5} *M* propanil buffer solution for the given periods. Photosynthetic activities were then measured by the same method as described in the previous paragraph.

Definite amounts of ^{14}C-propanil was applied to leaf discs, and they were exposed to it for designated periods. Leaf discs were combusted in a sample combustion system. Concentrations of ^{14}C-radioactivity originated from propanil in leaf discs were determined, as well as percentages of ^{14}C-propanil remained in them.

RESULTS AND DISCUSSION

1. Effects of propanil on plant growth

Figures 1 and 2 indicate that finger millet is much more tolerant to both foliar - and root-applied propanil than other gramineous plants such as large crabgrass, goose grass and barnyardgrass, although rice showed a tolerance slightly stronger than finger millet.

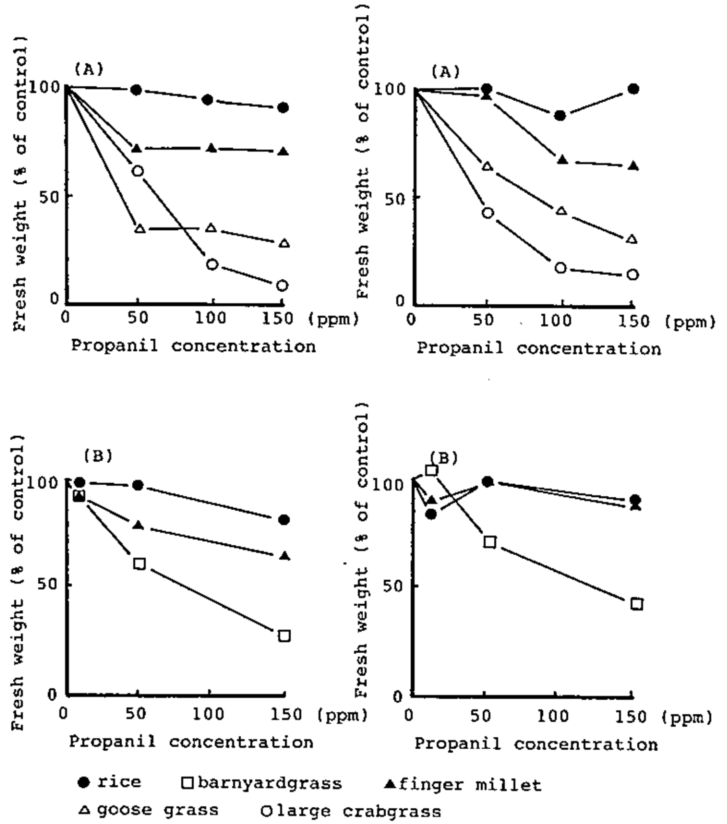

Figure 1. Relative effect of foliar-applied propanil on growth of gramineous plants.

Figure 2. Relative effect of root-applied propanil on growth of gramineous plants.

2. Metabolism of propanil in intact plants

After application of ^{14}C-propanil to plants, relatively large portion of ^{14}C-radioactivity in plant tissues was found in 90% methanol insoluble residue in rice, while in finger millet, as well as barnyardgrass, most of radioactivity was found in methanol soluble extracts in both foliar and root application (Table 1). All of the ^{14}C-radioactivity in the methanol extracts was found as propanil in both barnyardgrass and finger millet 24 hours after treatment, but not in rice. Most of radioactivity in methanol extracts from rice was detected at the origin on the tlc plate after development. It was supposed to be metabolic products, although not identified yet.

Table 1. Metabolism of root - and shoot-applied ^{14}C-propanil in roots and shoots of gramineous plants over a 24 hour period.

	Rice				Barnyardgrass				Finger millet			
	Shoot*		Root*		Shoot		Root		Shoot		Root	
	S**	R**	S	R	S	R	S	R	S	R	S	R
90% MeOH												
insoluble	29.4	19.6	27.4	53.9	3.9	2.6	11.1	23.3	4.2	1.1	5.2	7.4
soluble	70.6	80.4	72.6	46.1	96.1	97.4	88.9	76.7	95.8	98.9	94.8	92.6

* ^{14}C-propanil fed part in each plant
** Plant part analyzed for radioactivity after feeding experiments
S and R represent shoot and root, respectively.

3. Hydrolytic enzyme activity

As shown in Figure 3, no enzyme activity for propanil hydrolysis was shown in finger millet or barnyardgrass while marked activity was detected in rice.

This finding suggests that the tolerance of finger millet to propanil is not based on detoxified hydrolysis of the herbicide, but on other alternative processes.

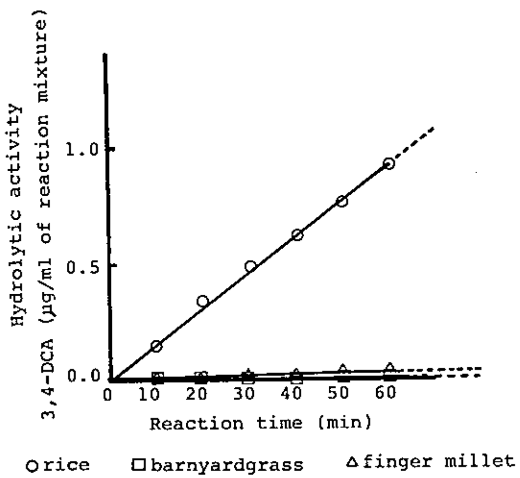

Figure 3. Arylacylamidase I activity in leaves of gramineous plants.

4. Absorption and translocation of ^{14}C-propanil

Rates of absorption of ^{14}C-propanil by shoots were very different among plant species (Figure 4), and increased in the preference : barnyardgrass > rice > finger millet.

In root application concentration of ^{14}C-propanil in roots of finger millet increased in time course much more than rice and barnyardgrass (Figure 5 (A)). But ^{14}C-propanil accumulated in shoots of finger millet much less than barnyardgrass (Figure 5 (B)). In both foliar and root application, the concentration of ^{14}C-propanil in shoots of finger millet and rice was less than that in barnyardgrass.

In conclusion, finger millet showed relatively high tolerance to propanil although it has no detoxifying hydrolytic enzyme and lower absorption of propanil by shoots or lower translocation from roots to shoots resulted in less accumulation of the herbicide in shoots, which might reflect on the greater tolerancy of finger millet to propanil, as compared with barnyardgrass.

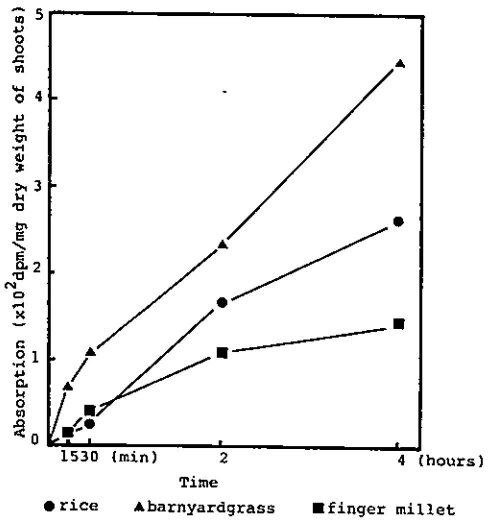

Figure 4. Absorption or ^{14}C-propanil by leaves of gramineous plants.

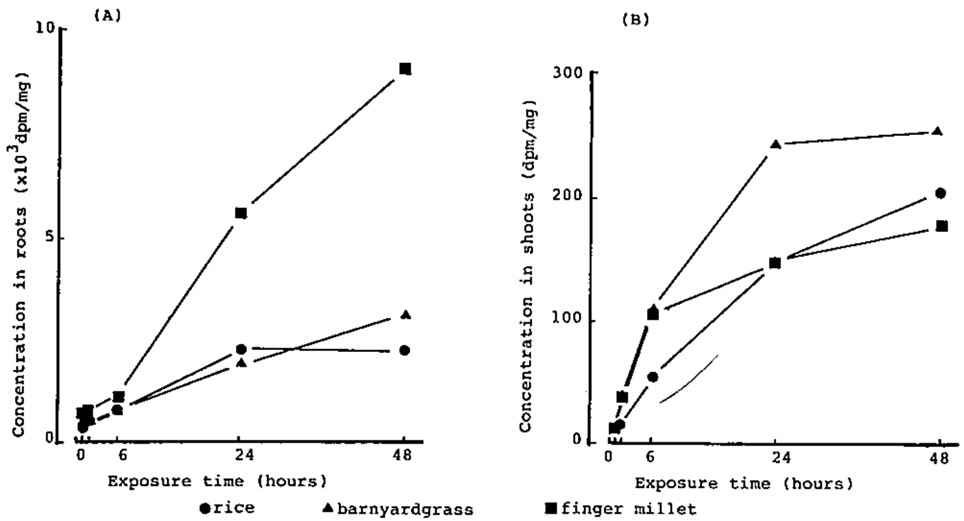

Figure 5. Changes in concentration of root-applied ^{14}C-propanil in roots (A) and shoots (B) of rice, barnyardgrass and finger millet.

5. Effect of foliar-applied propanil on photosynthesis and respiration in intact plant.

Immediately after applied to plants, propanil inhibited both photosynthesis and respiration of the three plant species, but only rice plants were recovered from the inhibition of photosynthesis almost completely in relatively short periods (Figure 6). In contrast photosynthesis of finger millet plants was recovered gradually, but no recovery was found in barnyardgrass. There were no significant differences in recovery of respiration among the three plant species.

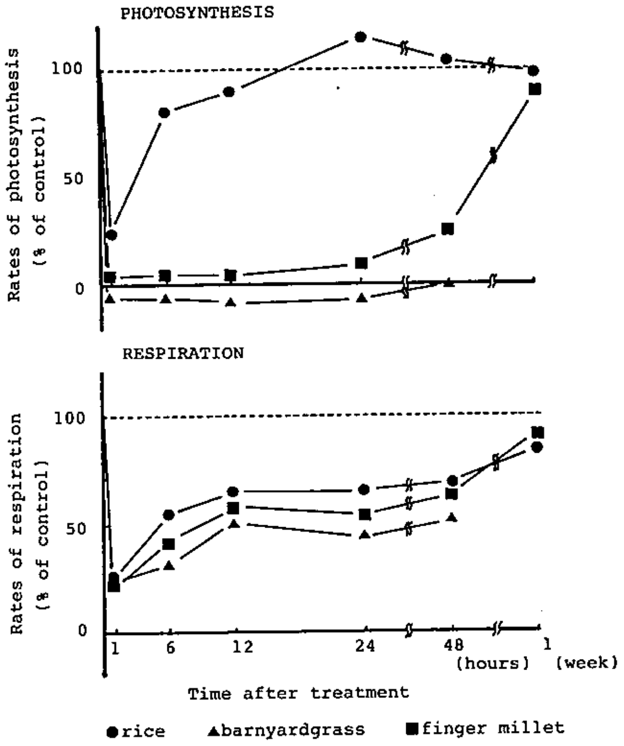

Figure 6. Effect of foliar-applied propanil on photosynthesis and respiration of gramineous plants.

6. Relationship between effect of propanil on photosynthesis and changes in ^{14}C-propanil in leaf discs.

It was confirmed that propanil was accumulated in leaf discs of the three plant species at similar rates, and released out of the discs at not much differential rates (Figure 7). Even if amounts of ^{14}C-radioactivity remained in leaf discs of finger millet were nearly same as barnyardgrass, recovery was different from the other two plants (Figure 8 (A)). When leaf discs of finger millet plants were exposed to propanil for 10 min and transferred to propanil-free solution, inhibition of photosynthesis was recovered much, while less obtained in barnyardgrass. However, at the longer exposure periods, only slight recovery was obtained even in finger millet (Figure 8).

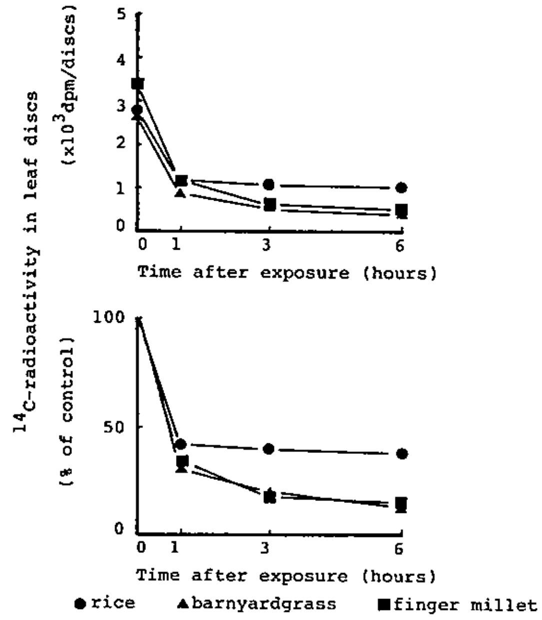

Figure 7. Changes in ^{14}C-radioactivities in leaf discs exposed to ^{14}C-propanil for 10 minutes.

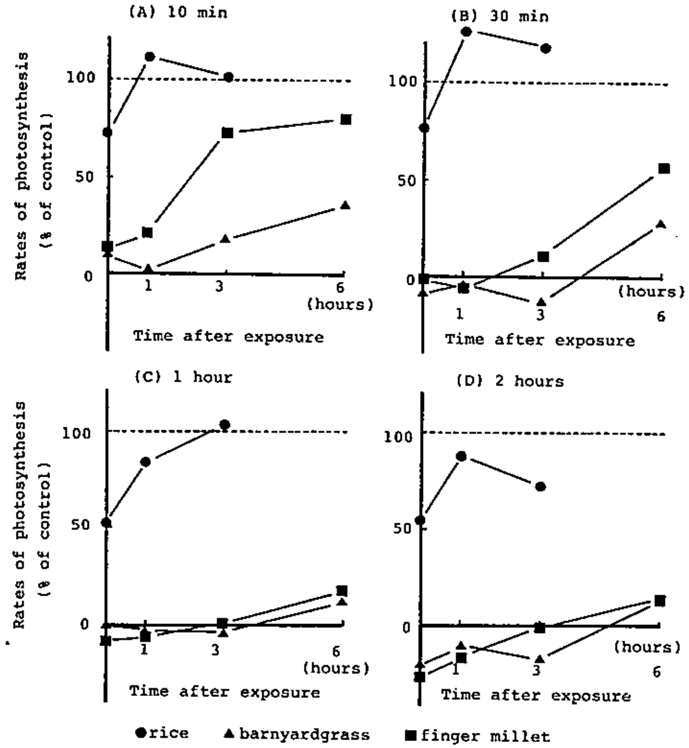

Figure 8. Photosynthetic activities of leaf discs of gramineous plants exposed to propanil for different periods.

Immediately after the exposure for various periods, amounts of ^{14}C-radioactivity found in the discs of the three species were found similar among each other (Figure 9 (A)). But if the discs were kept in propanil-free solution after exposure, amounts of ^{14}C-radioactivity in the discs were detected differently among the species, more in rice particularly (Figure 9 (B), (C), (D)). Out of ^{14}C-radioactivities found in discs, most of them were detected as propanil in finger millet and barnyardgrass (Figure 10). Propanil in discs of rice was rapidly decreased, and was significantly less than both barnyardgrass and finger millet. It was confirmed that ^{14}C-radioactivity was retained tightly in discs of rice because of metabolic change of propanil. Propanil seems to move in and out of discs comparatively freely. Tolerance of rice to propanil could be explained by its hydrolyzing activity in not only intact plants but also leaf discs. Tolerance of finger millet is concluded to be mainly contributed by less accumulation of propanil in shoots, not by the hydrolysis. It was suggested that chloroplasts of finger millet may possibly have a tolerant mechanism to propanil compared with barnyardgrass.

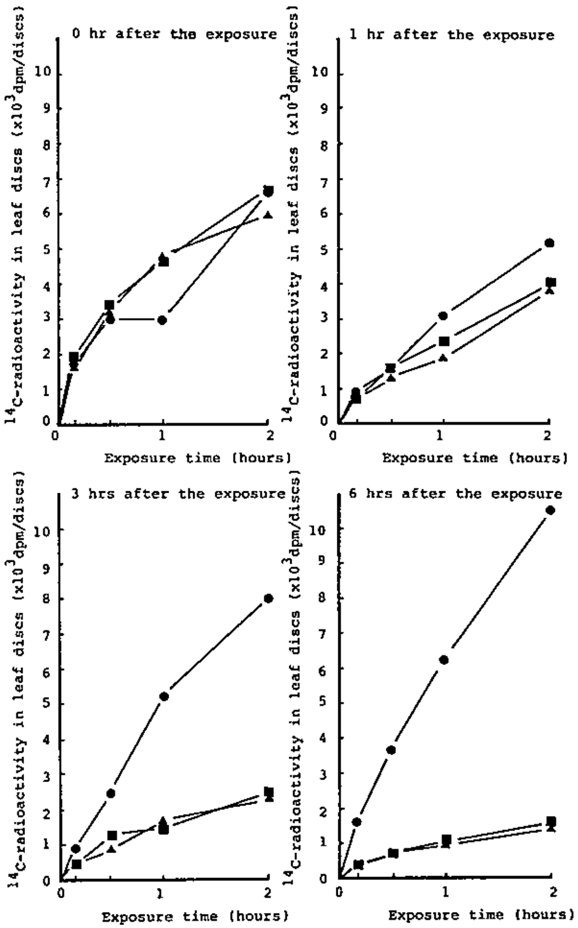

Figure 9. Remaining amounts of ^{14}C-radioactivity in leaf discs exposed to ^{14}C-propanil for various periods.

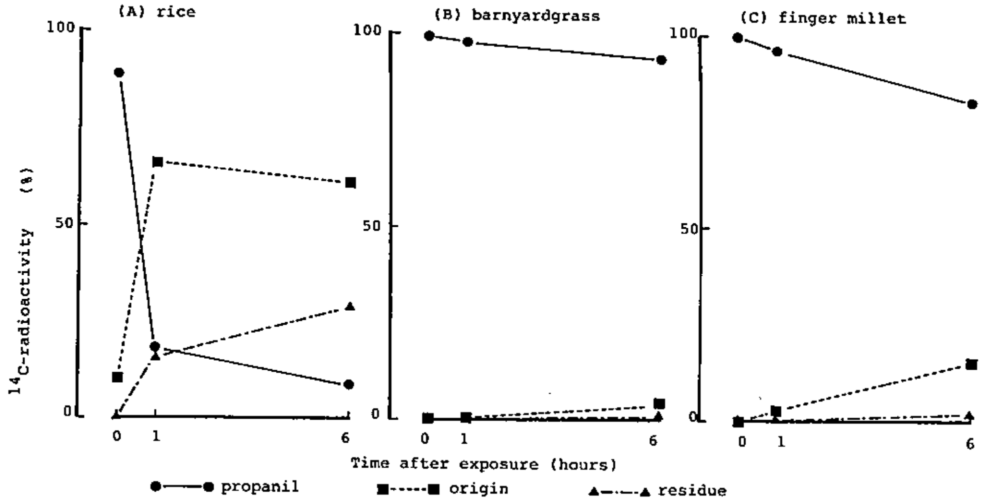

Figure 10. Changes in time course of ^{14}C-radioactivities in leaf discs of rice, barnyardgrass and finger millet exposed to ^{14}C-propanil for 10 minutes.

ACKNOWLEDGEMENTS

The authors express their thanks to Mr. N. Fukasaku, Daiichi Pure Chemicals Co., Ltd., for generous assistance and valuable advice in carrying out synthesis of ^{14}C-propanil.

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VEGETATIONAL ANALYSIS OF LAWNS IN SINGAPORE

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ABSTRACT

The floristic compositions of two artificial short-grass communities are described. The number as well as the species composition of the weeds that invaded these communities (lawns) were influenced by the surrounding vegetation as well as the efficiency of maintenance of the lawn. The species of weeds that successfully established within these communities were those with creeping habits or low growing points.

INTRODUCTION

Singapore's natural plant communities have been adequately described: Holttum (1954) on the *Adinandra* belukar (=secondary woody vegetation); Gilliland and Jabil (1958) on the *Adinandra* and *Eugenia/Arthrophyllum* belukars; Gilliland (1958) on the *Rhodamnia/Champereia* belukar; Burkill (1919) on a 30 year old *Arthrophyllum/Anisophyllea* belukar; and Gilliland and Wantman (1959) on the regenerating high forest. The distribution of the various vegetational types on the island has also been reported (Wee, 1964). On the other hand no published information is available on the cultivated, short-grass communities; the lawns of private compounds, golf courses, etc. As the evergreen lawns of Singapore form an excellent backdrop for good landscaping, their maintenance and vegetational composition are therefore important. This paper thus provides information on the floristic composition of two types of such lawn communities: one within an urban environment and the other exposed to the influence of a forest environment.

MATERIALS AND METHODS

The short-grass communities at the upper quadrangle of the Institute of Education campus at Bukit Timah Road and by the MacRitchie Reservoir catchment forest at Lornie Road were studied. The former was planted decades ago as an ordinary lawn and exposed to constant trampling by generations of students. Occasionally, the impact of vehicular traffic was seen. The latter community was part of a golf course lawn bordering the forest. In both cases maintenance involved regular mowing to keep the grasses short. A preliminary survey showed that the two communities were not uniform, therefore separate analyses of each area were made.

The point quadrat method was used to sample the vegetation (Goldsmith and Harrison, 1976). The apparatus used consisted of a metal frame holding 10 steel pins placed 5 *cm* apart. Eight random throws were made per analysis so as to give a total of 80 points. Each throw involved moving each of the 10 pins vertically down and recording the hits the pins made on the vegetation. If a pin touched the base of a plant or a rooting node of a rhizome, a hit was recorded. If it touched the leaf or stem without touching the base of the plant, a miss was recorded. Basal cover was calculated on the basis of the number of hits out of a total number of 80 points for the eight throws. The "B" value of Gilliland and Wantman (1959) was used to indicate the "belongingness" of the various species of the communities. If a species occurred in all eight throws within an area, the "B" value was thus 8. The higher the "B" value, the more a species "belonged" to that particular area. Species with values of, say 2 or 1, were thus considered to be mere casuals.

RESULTS AND OBSERVATIONS

The grass plot at the campus of the Institute of Education consisted of an *Axanopus compressus/A. affinis* community as cover these two grass species took up 14.2% of the total basal of 18.2 (Table 1). These two species were evenly distributed within the community as they both had "B" values of 8, that is, each was recorded in every one of the eight throws. The other seven species of plants composed of four grasses, one sedge and two dicotyledonous herbs. Except for *Zoysia matrella* which had a fairly uniform distribution, the others were casual members.

Table 1. Composition of a grass plot at the upper quadrangle of the Institute of Education campus.

Species	Basal cover (%)	"B" value
Axonopus compressus (Swartz.) Beauv	8.6	8
Axonopus affinis Chase	5.6	8
Zoysia matrella (L.) Merr.	1.5	6
Ischaemum indicum (Houtt.) Merr.	0.9	3
Lindernia crustacea (L.) F.v.M.	0.6	3
Desmodium triflorum (L.) DC.	0.5	2
Fimbristylis capilliculmis Ohwi	0.3	2
Chrysopogon aciculatus (Retz.) Trin	0.1	1
Eragrostis elongata (Willd.) Jacq.	0.1	1
Total cover	18.2	-
Bare ground	81.8	-

The floristic composition of the peripheral strips were very much different from the main area (Table 2). The predominant species was still *A. compressus,* but its intensity of occurrence was much reduced. *A. affinis,* one of the two major species of the main area, played a minor role in the species composition. Its place was taken over by *Z. matrella*. The original nine species increased to 20, but the total basal cover was reduced from 18.2% to 15.8%. The total number of grass species increased from six to nine, the dicotyledonous herbs from two to nine and the sedge from one to three. *Desmodium heterophyllum,* which did not occur in the main

Table 2. Composition of the peripheral area of the grass plot at the upper quadrangle of the Institute of Education campus.

Species	Basal cover (%)	"B" value
Axonopus compressus (Swartz.) Beauv.	5.5	8
Zoysia matrella (L.) Merr.	3.3	7
Desmodium heterophyllum (Willd.) DC.	0.9	4
Digitaria longiflora (Retz.) Pers.	0.5	4
Axonopus affinis Chase	0.9	3
Ischaemum indicum (Houtt.) Merr.	0.9	3
Fimbristylis ovata (Burm.) F. Kern	0.5	3
Imperata cylindrica (L.) Beauv.	0.5	2
Torenia polygonoides Bth.	0.4	2
Desmodium triflorum (L.) DC.	0.3	2
Borreria alata (Aubl.) DC.	0.3	2
Sporobolus fertilis (Steud.) W.D. Clayton	0.3	2
Borreria sp.	0.3	2
Alternanthera triandra Steud.	0.6	1
Cyperus polystachyos Rottb.	0.1	1
Lindernia crustacea (L.) F.v.M.	0.1	1
Borreria laevicaulis Ridley	0.1	1
Oxalis corniculata L.	0.1	1
Fimbristylis capilliculmis Ohwi	0.1	1
Chrysopogon aciculatus (Retz.) Trin	0.1	1
Total cover	15.8	-
Bare ground	84.2	-

grass area, played a major role in the peripheral community. The peripheral community was *A. compressus/Z. matrella,* still a short-grass community, but because of less meticulous maintenance, the number of species had increased considerably by the invasion of weed grasses, sedges and dicotyledons. *Imperata cylindrica,* a noxious grass, had made its entry with a basal cover of 0.5% or approximately 3% of the total basal cover.

The short-grass community bordering the secondary forest of the MacRitchie Reservoir had a different floristic composition (Table 3). This was an *Ischaemum indicum/I. muticum* community with *A. compressus* also occurring in abundance. There were a total of 10 species, of which eight were grasses. The total basal cover was a low 12.2%, much lower than the communities at the campus. *I. cylindrica* was again encountered as a casual weed, taking up about 5% of the total basal cover. The noxious nature of this weed was obvious in the nearby area where it dominated the other species with a basal cover of 6.7% or about 50% of the total basal cover, and a "B" value of 8 (Table 4). *I. indicum* and *A. compressus,* two of the three grass species that dominated the nearby area were insignificant here with the invasion of *I. cylindrica,* although the thrid species, *I. muticum,* maintained its importance.

Table 3. Composition of a grass plot by the MacRitchie Reservoir forest.

Species	Basal cover (%)	"B" value
Ischaemum indicum (Houtt.) Merr.	4.1	8
Ischaemum muticum L.	2.5	8
Axonopus compressus (Swartz.) Beauv.	2.2	7
Paspalum scrobiculatum L.	1.1	4
Cyperus brevifolius (Rottb.) Hassk.	0.5	4
Imperata cylindrica (L.) Beauv.	0.6	3
Chrysopogon aciculatus (Retz.) Trin.	0.4	3
Eragrostis sp.	0.6	2
Elephantopus scaber L.	0.1	1
Sacciolepis indica (L.) Chase	0.1	1
Total cover	12.2	-
Bare ground	87.8	-

Table 4. Composition of an *Imperata cylindrica* infested grass plot by the MacRitchie Reservoir forest.

Species	Basal cover (%)	"B" value
Imperata cylindrica (L.) Beauv.	6.7	8
Ischaemum muticum L.	2.7	6
Zoysia matrella (L.) Merr.	1.3	3
Paspalum scrobiculatum L.	0.5	3
Ischaemum indicum (Houtt.) Merr.	1.0	2
Axonopus compressus (Swartz.) Beauv.	0.9	2
Chrysopogon aciculatus (Retz.) Trin	0.1	1
Digitaria didactyla Willd.	0.1	1
Elephantopus scaber L.	0.1	1
Clitorea laurifolia Poir.	0.1	1
Total cover	13.5	-
Bare ground	86.5	-

Table 5. List of grasses and their weeds found within the grass plot at the upper quadrangle of the Institute of Education campus.

Species	Family
Ageratum conyzoides L.	*Compositae*
Alternanthera triandra Steud.	*Amarantaceae*
Axonopus affinis Chase	*Gramineae*
Axonopus compressus (Swartz.) Beauv.	*Gramineae*
Borreria sp.	*Rubiaceae*
Borreria alata (Aubl.)	*Rubiaceae*
Borreria laevicaulis Ridley	*Rubiaceae*
Borreria setidens (Miq.) Bold	*Rubiaceae*
Caladium. sp.	*Araceae*
Centella asiatica Urbs.	*Umbelliferae*
Chrysopogon aciculatus (Retz.) Trin	*Gramineae*
**Cinnamomum iners* Reinw. ex Bl.	*Lauraceae*
Cleome rutidosperma DC.	*Capparidaceae*
**Cordia cylindristachya* Roem. & Schutt.	*Boraginaceae*
Cynodon dactylon (L.) Pers.	*Gramineae*
Cyperus aromaticus (Ridley) Mattf. & Kukenth.	*Cyperaceae*
Cyperus brevifolius (Rottb.) Hassk.	*Cyperaceae*
Cyperus compressus L.	*Cyperaceae*
Cyperus cyperinus (Retz.) Valck Sur.	*Cyperaceae*
Cyperus kyllingia Endl.	*Cyperaceae*
Cyperus polystachyos Rottb.	*Cyperaceae*
Desmodium heterophyllum (Willd.) DC.	*Leguminosae*
Desmodium triflorum (L.) DC.	*Leguminosae*
Digitaria ciliaris (Retz.) Pers.	*Gramineae*
Digitaria longiflora (Retz.) Pers.	*Gramineae*
Elephantopus scaber L.	*Compositae*
Eleusine indica (L.) Gaertn.	*Gramineae*
Emilia sonchifolia (L.) DC ex Wight	*Compositae*
Eragrostis elongata (Willd.) Jacq.	*Gramineae*
Eragrostis unioides (Retz.) Nees ex Steud.	*Gramineae*
**Eugenia grandis* Wight	*Myrtaceae*
**Eugenia jambos* L.	*Myrtaceae*
**Eugenia longiflora* F.-Villar	*Mrytaceae*
Euphorbia hirta L.	*Euphorbiaceae*
Euphorbia thymifolia L.	*Euphorbiaceae*
**Fagraea fragrans* Roxb.	*Loginaceae*
Fimbristylis acuminata Vahl	*Cyperaceae*
Fimbristylis capilliculmis Ohwi	*Cyperaceae*
Fimbristylis globulosa (Retz.) Kunth	*Cyperaceae*
Fimbristylis miliacea (L.) Vahl	*Cyperaceae*
Fimbristylis ovata (Burm.f.) Kern	*Cyperaceae*
Hedyotis biflora (L.) Lamk	*Rubiaceae*
Hedyotis corymbosa (L.) Lamk	*Rubiaceae*
Hedyotis diffusa Willd.	*Rubiaceae*
Imperata cylindrica (L.) Beauv.	*Gramineae*
Ischaemum indicum (Houtt.) Merr.	*Gramineae*
Ischaemum muticum L.	*Gramineae*
Ischaemum timorense Kunth	*Gramineae*
Lindernia crustacea (L.) F.Y.M.	*Scrophulariaceae*
Lindernia sessiliflora (Bth.) Wettst.	*Scrophulariaceae*
**Melastoma malabathricum* L.	*Melastomaceae*
Mimosa pudica L.	*Leguminosae*
**Muntingia calabura* L.	*Tiliaceae*
Oxalis barrelieri L.	*Oxalidaceae*
Oxalis corniculata L.	*Oxalidaceae*
Panicum repens L.	*Gramineae*
Paspalum conjugatum Berg.	*Gramineae*
Paspalum scrobiculatum L.	*Gramineae*
Peperomia pellucida (L.) H.B.&K.	*Piperaceae*
Phyllanthus niruri L.	*Euphorbiaceae*
Phyllanthus urinaria L.	*Euphorbiaceae*
Sacciolepis indica (L.) Chase	*Gramineae*
Sporobolus diander (Retz.) Beauv.	*Gramineae*
Sporobolus fertilis (Steud.) W. D. Clayton	*Gramineae*
Torenia polygonoides Bth.	*Scrophulariaceae*
Typhonium trilobatum (L.) Schott	*Araceae*
Vernonia cinerea (L.) Less.	*Compositae*
Zoysia matrella (L.) Merr.	*Gramineae*

* Seedling/sapling

Table 5 lists the 68 species of plants that were found within the grassy plot at the campus while Table 6 gives the 46 species recorded from the plot bordering the forest. An analysis of the composition of the plants from these two plots is given in

Table 6. List of grasses and their weeds found within the grass plot by the edge of the MacRitchie Reservoir area.

Species	Family
**Acacia auriculiformis* A. Cunn. ex Bth.	*Leguminosae*
**Adinandra dumosa* Jack	*Theaceae*
Axonopus compressus (Swartz.) Beauv.	*Gramineae*
Blechnum orientale L.	*Dennstaedtaceae*
Chrysopogon aciculatus (Retz.) Trin	*Gramineae*
**Cinnamomum iners* Reinw. ex Bl.	*Lauraceae*
Clidemia hirta D. Don	*Melastomaceae*
Clitorea laurifolia Poir	*Leguminosae*
**Cordia cylindristachya* Roem. & Schutt.	*Boraginaceae*
Cyperus brevifolius (Rottb.) Hassk.	*Cyperaceae*
Dianella ensifolia (L.) DC.	*Liliaceae*
Digitaria didactyla Willd.	*Gramineae*
**Dillenia suffruticosa* (Griff.) Martelli	*Dilleniaceae*
Elephantopus scaber L.	*Compositae*
Eragrostis sp.	*Gramineae*
**Eugenia grandis* Wight	*Myrtaceae*

**Eugenia longiflora* F.-Villar	*Mrytaceae*
**Fagraea fragrans* Roxb.	*Loginaceae*
**Ficus* sp.	*Moraceae*
**Ficus grossularioides* Burm f.	*Moraceae*
Hibiscus rosa-sinensis L.	*Malvaceae*
Imperata cylindrica (L.) Beauv.	*Gramineae*
Ischaemum indicum (Houtt.) Merr.	*Gramineae*
Ischaemum muticum L.	*Gramineae*
**Lantana camara* L.	*Verbenaceae*
Lycopodium cernuum L.	*Lycopodiaceae*
Lygodium scandens (L.) Sw.	*Schizaeaceae*
**Macaranga javanica* (BL.) M.A.	*Euphorbiaceae*
**Macaranga triloba* (Reinw. ex Bl.) M.A.	*Euphorbiaceae*
**Melastoma malabathricum* L.	*Melastomaceae*
Mikania micrantha H.B.C.	*Compositae*
**Nephelium lappaceum* L.	*Sapindaceae*
Nepenthes rafflesiana Jack	*Nephenthaceae*
Paspalum scrobiculatum L.	*Gramineae*
Passiflora foetida L.	*Passifloraceae*
**Pithecellobium clyperia* (Jack) Bth.	*Leguminosae*
**Rhodamnia cinerea* Jack	*Myrtaceae*
Sacciolepis indica (L.) Chase	*Gramineae*
Scleria ciliaris Nees	*Cyperaceae*
Scleria levis Retz.	*Cyperaceae*
**Spathodea campanulata* Beauv.	*Bignoniaceae*
Stachytarpheta indica (L.) Vahl	*Verbenaceae*
Taenitis blechnoides (Willd.) Sw.	*Adiantaceae*
Tetracera scandens (L.) Merr.	*Dilleniaceae*
**Vitex pubescens* Vahl	*Verbenaceae*
Zoysia matrella (L.) Merr.	*Gramineae*

*Seedling/sapling

Table 7. Analysis of plants found in the grass plots at the Institute of Education (IE) campus and at MacRitchie Reservoir.

Groups	Number of species	
	IE campus	MacRitchie
Monocotyledons		
Grasses	20	10
Sedges	11	3
Others	2	1
Dicotyledons	35	28
Pteridophytes	0	4
Total no. of species	68	46
Total no. families	19	24

Table 7. The composition of the weeds is distinctly different in the two locations. There were more shrub and tree species in the plot by the forest: 20 as compared to eight from the urban area. Of the woody species found in the plot by the forest, it is interesting to note that *Adinandra dumosa, Dillenia suffruticosa, Fagraea fragrans, Macaranga javanica, Melastoma malabathricum* and *Rhodamnia cinerea* are members of the *Adinandra* belukar community. On the other hand, *Cinnamomum iners, Eugenia grandis* and *E. longiflora* are typically of the *Rhodamnia/Champereia* belukar. *Nephelium lappaceum, Acacia auriculiformis, Cordia cylindristachya* and *Spathodea campanulata* can be considered as human casuals as the first species is the local fruit tree, the rambutan, while the rest are common wayside trees and shrubs.

Of the herbaceous species, more grass and sedge species were found in the plot at the campus than by the forest: 20 and 11 versus 10 and three respectively. Also, the plot at the campus was invaded by more species of weeds but belonging to a lesser number of families while that by the forest experienced less number of weeds but coming from more families.

DISCUSSIOIN

The finest lawns in Singapore are made up of *Zoysia matrella* (Siglap Grass) and *Digitaria didactyla* (Serangoon Grass), or even *Cynadon dactylon* (Bermuda Grass). For coarser lawns, *Axonopus compressus* and *A. affinis* (Carpet Grass) are planted. The usual method of starting a lawn is to transplant tufts of such grasses from a well-grown plot and allow these to overgrow the new area. Invariably, other less desirable species of grass like *Ischaemum indicum, I. muticum, Chrysopogon aciculatus, Eragrostis elongata, Digitaria longiflora* and *Paspalum scrobiculatum* are present and continue to coexist with the dominant grass species. Under what conditions the casual grass species dominate the chosen species are yet unknown. Studies on the succession of grass plots would provide information on these problems. Seeding of lawns would ensure a pure stand, however, this is not popular because of economic reasons.

The regular mowing of lawns is necessary for their maintenance. This is in some way similar to grazing and it results in changes in the composition of the vegetation. If mowing is not done, the species would undergo a major change with the invasion and subsequent establishment of shrub and tree species (Wee, 1984). These plants would ultimately shade out the grasses and herbs, resulting in the formation of belukars. The composition of these belukars would obviously vary with the locality. Wayside species like *A. auriculiformis, F. fragrans, E. grandis* and *Muntingia calabura* will dominate in urban areas where these plants are commonly grown and their seeds easily brought in by birds. Within the vicinity of the forest, the belukar species that develop from abandoned grass plots would naturally be dominated by forest species. Mowing lawns removes these species and results in the dominance of those species that can rapidly recover by the adoption of a spreading habit and reproduce by runners or rhizomes. Small creeping herbs like *Lindernia crustacea, D. heterophyllum, D. triflorum, Borreria setidens, B. laevicaulis, Hedyotis biflora, Torrenia polygonoides* and *Centella asiatica* usually coexist with the grass species as their growing points are close to the surface of the ground where they are not damaged by the frequent mowing.

Herbaceous species with erect habit are similarly removed as a result of mowing. Those plants that have basal clumps of leaves producing only erect reproductive structures like *Elephantopus scaber,* survive if mowing is less regular. They are able to reproduce the species and the seeds are able to establish and in turn bear seeds as they become reproductive within 6-15 weeks. Species of grasses like *Sporobolus fertilis* and *Eleusine indica,* with their basal clumps of leaves, also escape eradication with less frequent mowing.

More weed species survive along the periphery of lawns as these areas are less meticulously mowed. Also, where there is constant trampling by people moving about, the chances of weeds surviving is less.

Invasion by *I. cylindrica* can be seen in the grass area at MacRitchie. This grass spreads aggressively with the aid of its underground rhizome. Given the chance, it easily dominates the vegetation, shading off the other herbaceous species. Once this grass finds a foothold in an area, it will slowly dominate the area, maintaining its dominance especially with the aid of fire (Gilliland, 1971). During dry periods the grass is liable to catch fire easily. This kills off the other plants but not this grass, as its underground rhizome is stimulated by fire to produce new aerial vegetative well as flowering shoots, resulting in the grass having a firmer hold on the area. *I. cylindrica* is in fact a fire sub-climax and short of removing every piece of its extensive network of underground rhizome, a very laborious and elaborate task indeed, or using suitable herbicides which means killing all other plants including the desirable grasses, complete eradication is not possible. The importance of not allowing this grass to gain a foothold in lawns need not be over emphasised.

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AC 252,925 : A NEW HERBICIDE FOR USE IN RUBBER PLANTATIONS

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ABSTRACT

Field experiments were conducted in Malaysia and Thailand to evaluate the performance of AC 252,925 herbicide for control of *Imperata cylindrica* (L.) Beauv and other common herbaceous weeds in rubber plantations.

AC 252,925 was evaluated at rates ranging from 0.5 to 1.0 *kg* ae/*ha* for control of *I. cylindrica* and from 0.25 to 0.5 *kg* ae/*ha* for control of herbaceous weeds.

Single applications of AC 252,925 at 1.0 *kg* ae/*ha* consistently gave acceptable to excellent control of *I. cylindrica* for up to 180 days. Split applications at half the single dosage did not provide any advantage over single applications.

The results of experiments on herbaceous weeds also indicate that applications of AC 252,925 at 0.250 to 0.375 ae/*ha* can be recommended for sustained control of these weeds, with a good margin of safety to rubber trees which are at least 2 years old. When AC 252,925 is applied at the recommended rates, the frequency of sequential sprays can be reduced by at least half when compared with the standard treatments.

Extensive crop tolerance studies are currently in progress in Malaysia, Thailand and Indonesia.

INTRODUCTION

AC 252,925 is a new broad–spectrum herbicide developed by American Cyanamid Company for industrial weed control and for use in conifer forests and in plantation crops. The compound is the isopropylamine salt of 2–(4–isopropyl–4–methy–5–oxo–2–imidazolin–2–yl) nicotinic acid (common name–imazapyr).

AC 252,925 was first evaluated for *Imperata cylindrica* control in rubber plantation in Malaysia in 1981. Extensive trials on *I. cylindrica* and other herbaceous weeds began in 1982. Trials were extended to Thailand in 1984.

This paper summarises results obtained from a series of field trials on *I cylindrica* and other herbaceous weeds in rubber plantations in Malaysia from 1982 to 1984 and in Thailand in 1984. The sites selected reflect typical plantation conditions in terms of weed composition and density, soil types and rainfall patterns.

MATERIALS AND METHODS

In the *I. cylindrica* trials, weeds ranged in height from 80 to 150 *cm* and were growing in both open and shaded conditions. Application was made during both the dry and wet seasons. AC 252,925 at rates ranging from 0.375 to 1.0 *kg* ae/*ha* was evaluated either as a single or split treatment. Treatments were applied post-directed, using spray volumes of 250 to 625 *litres/ha.*

Single treatments of glyphosate at 1.90 to 4.32 *kg* ae/*ha* and split treatments of dalapon at 10.625 followed by 10.625 *kg* ai/*ha* were used as standards for comparison.

Herbaceous weed control trials were conducted in established rubber plantations with trees ranging from 6 months to 8 years old. AC 252,925 at 0.25 to 0.5 *kg* ae/*ha* was evaluated. The standard herbicides paraquat, paraquat combinations, glyphosate and glyphosate plus picloram were used for comparison. Treatments were applied broadcast close to the base of the rubber trees, using spray volumes of 250 to 350 *litres/ha.*

The experiments were designed as randomized complete blocks, replicated 3 to 4 times. Experimental plots measured 4 × 4 *m,* 4 × 6 *m,* and 5 × 6 *m* in the *Imperata* trials. Plot size in the herbaceous weed trials varied from 3-to 15-tree rectangles, with tree rows situated in the centre of the plot. In simple non-replicated block trials, there were 5 to 15 trees per plot.

Spray equipment was either pneumatic knapsack sprayer or CO_2-operated precision plot sprayer equipped with either flat fan (5/64″) or Tee-Jet (8003) nozzles.

RESULTS AND DISCUSSIONS

Imperata cylindrica

AC 252,925 killed *Imperata* slowly. Chlorotic effects were not visible until about 15 to 30 days after treatment (DAT). Necrosis progressed slowly and maximum control was achieved between 90 to 120 DAT.

AC 252,925 at 0.5 to 1.0 *kg* ae/*ha* consistently produced a longer duration of control than dalapon at 10.625 followed by 10.625 *kg* ai/*ha* (Tables 1 and 2) and glyphosate at 2.16 or 4.32 *kg* ae/*ha* (Table 3). Split application of AC 252,925 at 0.5 followed by 0.5 *kg* ae/*ha* at a 40-day interval gave equally good to excellent control, comparable to a single application of AC 252,925 at 0.75 *kg* ae/*ha* (Table 1).

In a study conducted by the Rubber Research Centre in Thailand (Boonsrirat, 1985), inter-rows in the treated plots were accidently ploughed in around 227 DAT. It was observed that at 298 DAT, all plots treated with AC 252,925 had less than 7% *Imperata* regrowth compared with the standard treatments (Table 2). It is apparent that AC 252,925 has a greater potential to suppress regrowth from the *Imperata* rhizomes than the standard herbicides.

Table 1. Effect of AC 252,925 on *I. cylindrica* in field studies conducted in Tone Nga Chang, Thailand, in 1984

Treatment	Rate[1] (*kg* ae/*ha*)	% *Imperata* control (DAT)[2] 34	62	102	161	207	% *Imperata* regrowth 305 DAT
AC 252,925	0.5	20	58	78	83	91	< 15
	0.375 fb* 0.375	20	70	81	93	94	< 10
	0.5 fb 0.5	20	65	84	85	93	< 10
	0.75	30	60	84	84	94	< 10
Glyphosate	2.56	64	93	93	89	88	40
Dalapon	10.625 fb 10.625	21	90	95	92	87	35
Untreated	—	0	0	0	0	0	100

[1]Rates for dalapon expressed in *kg* ai/*ha*. For AC 252,925, single application and first split application were made on June 15, 1984; second split application was made 40 days thereafter
[2]Mean of 4 replicates. DAT = days after treatment.
*fb = followed by.

Table 2. Effect of AC 252,925 on *I. cylindrica* in field studies conducted in Kao Chai Son, Thailand, by the Rubber Research Centre in 1984[1]

Treatment	Rate[2] (*kg* ae/*ha*)	% *Imperata* control (DAT)[3] 30	60	84	114	175	% *Imperata* regrowth 298 DAT
AC 252,925	0.5	20	55	85	95	95	< 7
	0.75	30	60	85	95	95	< 5
	1.0	30	75	95	100	97	< 5
Glyphosate	1.90	60	85	75	75	30	> 60
	2.56	65	95	90	90	85	> 40
Dalapon	10.625 fb* 10.625	25	90	90	90	90	30
Untreated	—	0	0	0	0	0	> 80

[1]Non-replicated block trial. Each plot measured 8 × 10 *m*.
[2]Rates for dalapon expressed in *kg* ai/*ha*. Single application was made on June 2, 1984
[3]DAT = days after treatment.
*fb = followed by

Table 3 depicts the comparative performance of AC 252,925 and glyphosate under prolonged drought-stress and wet season situations. AC 252,925 showed acceptable *Imperata* control, comparable to glyphosate under very dry conditions, but under wet season conditions, more effective control was sustained by AC 252,925 for up to 240 DAT, while glyphosate at 4.32 *kg* ae/*ha* provided acceptable control for only 120 days.

Table 3. Effect of AC 252,925 on *I. cylindrica* in field studies conducted in Malaysia in 1983/84

Treatment	Rate (*kg* ae/*ha*)	% *Imperata* control (DAT)[1] 45	90	120	180	240
	Under prolonged-drought-stress conditions[2]					
AC 252,925	0.75	60	89	89	75	72
	1.0	64	86	90	75	65
Glyphosate	2.16	96	95	91	75	55
	4.32	99	96	92	78	75
	Under wet season conditions[3]					
AC 252,925	0.75	52	84	91	94	94
	1.0	45	79	89	94	85
	1.25	56	82	93	99	-
Glyphosate	2.16	72	73	69	53	35
	4.32	87	90	86	77	-

[1]DAT = days after treatment
[2]Mean of 3 trials
[3]Mean of 6 trials.

Herbaceous weeds

Tables 4 to 6 depict the comparative performance of AC 252,925, paraquat, paraquat + diuron, paraquat + 2, 4-D amine, glyphosate and glyphosate + picloram.

In trials in Thailand, paraquat and paraquat combinations showed relatively poorer and shorter duration of herbaceous weed control than that obtained with AC 252,925 (Tables 4 and 5). Reinfestation of the plots treated with paraquat and paraquat combinations was fast and reached 50% within 45 to 60 DAT.

Table 4. Effect of AC 252,925 on annual herbaceous weeds in field studies conducted at the Rubber Research Centre, Hatyai, Thailand, in 1984

Treatment	Rate[1] (*kg* ae/*ha*)	% Weed control (DAT)[2] 7	15	27	41	49	62	99
AC 252,925	0.25	0	0	22	37	53	65	58
	0.375	0	0	33	48	60	85	73
	0.50	0	0	25	43	53	73	50
Paraquat	0.69	50	37	23	17	17	23	18
	1.04	50	58	23	58	52	53	35
Paraquat + diuron	0.69 + 0.5	50	60	45	47	38	30	18
	1.04 + 0.75	50	65	35	67	52	53	43
Glyphosate	1.28	13	42	40	56	48	50	40
Untreated	—	0	0	0	0	0	0	0

Rates for paraquat and paraquat + diuron expressed in *kg* ai/*ha*
Mean of 3 replicates . DAT = days after treatment
Major weeds present : Legumes, *Paspalum conjugatum* and *Borreria latifolia*

The trials in Thailand also showed that one application of glyphosate at 1.28 *kg* ae/*ha* and glyphosate + picloram at 0.68 + 0.08 *kg* ae/*ha* initially gave good control of the weed cover for about 60 days, but by 90 DAT, reinfestation had reached such a level that retreatment was necessary (Table 5).

Table 5. Effect of AC 252,925 on annual herbaceous weeds in field studies conducted in Ban Ta Chang, Thailand in 1981[1]

Treatment	Rate[2] (*kg* ae/*ha*)	% Weed Control (DAT)[3] 30	60	90
AC 252,925	0.25	30	95	70
	0.375	40	95	70
	0.50	45	95	75
Paraquat	0.69	50	30	15
	1.04	60	55	30
Paraquat + 2, 4-D amine	0.52 + 0.94	85	55	30
Paraquat + diuron	0.52 + 0.75	80	70	40
	1.04 + 0.75	80	65	40
Glyphosate	1.28	95	85	60
Glyphosate + picloram	0.55 + 0.06	90	80	45
	0.68 + 0.08	95	85	50
Hand-weeded	—	95	65	40

[1]Non-replicated block trial. Each plot measured 2 × 20 *m*.
[2]Rates for paraquat and paraquat combinations expressed in *kg* ai/*ha*
[3]DAT = days after treatment
Major weeds present : *Paspalum conjugatum, Digitaria* spp., *Borreria latifolia* and *Cleome* spp.

One single application of AC 252,925 at 0.25 to 0.375 *kg* ae/*ha* demonstrated good to excellent control of herbaceous weeds, principally *Paspalum conjugatum* and *Ottochloa nodosa,* and encroaching leguminous cover crops in rubber strips under 10 to 50% shade. This control lasted for about 90 to 120 days (Table 6). Other broadleaved weeds, such as *Cleome rutidosperma, Borreria latifolia* and *Asystasia* sp., began to recolonise from seeds by about 90 days when present in the plot. AC 252,925 at 0.375 *kg* ae/*ha* effectively prevented encroachment of the leguminous cover crops for about 60 days. Subsequent encroachment became relatively less rapid. *Desmodium* spp. was less susceptible and regenerated around 90 DAT.

Table 6. Effect of AC 252,925 on annual herbaceous weeds in field studies conducted in rubber plantations in Malaysia in 1982/84

Treatment	Age of trees (years)	% Est. Shade	% Weed Control (DAT)[1]				
			30	45	60	90	120
AC 252,925	6 months	10	75	-	-	90	40
at 0.375 *kg* ae/*ha*	1 1/4	20	-	83	-	92	-
	1 3/4	40	65	75	82	59	-
	2	50	-	70	-	-	85
	2 1/4	50	-	65	-	90	20
	3	50	40	-	85	91	87
MEAN			60	73	84	84	58
Paraquat + 2, 4-D amine	6 months	10	80	-	10	-	-
at 1.4 *litre/ha*	1 1/4	20	-	8	-	-	-
	1 3/4	40	40	30	-	-	-
	2	50	-	50	-	-	-
	2 1/4	50	-	20	-	-	-
	3	50	75	-	55	40	33
MEAN			65	27	33	40	33

[1]Mean of 3 to 4 replicates. DAT = Days after treatment
Major weeds present : Legumes, *Paspalum conjugatum* and *Ottochloa nodosa*

Selectivity to rubber trees

In crop selectivity field trials in Malaysia, AC 252,925 at 0.125 to 2.0 *kg* ae/*ha* was selective to 2- to 4½-year-old trees.

Two-year-old rubber trees showed tolerance to 6 applications of AC 252,925 at 0.75 to 1.5 *kg* ae/*ha* made at 90-day intervals (Figure 1). Mean girth measurements taken at 97, 182, 477 and 619 days after the last herbicide treatment were comparable to trees treated with paraquat + 2, 4-D amine and the untreated trees.

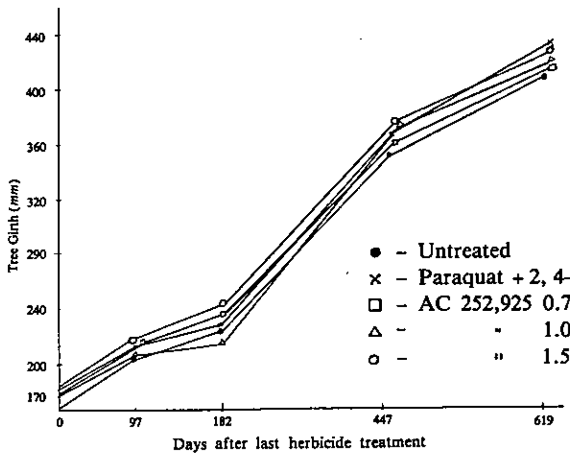

Figure 1. Effect of AC 252,925 on tree girth of 2-year-old rubber trees (PB 260) after 6 applications at 90-days intervals. Malaysia, 1983. Mean of 3 replicates.

AC 252,925 was also selective in 4½-year-old rubber trees when rates ranging from 0.75 to 2.0 *kg* ae/*ha* were applied as required for a total of 6 treatments (Figure 2). Mean girth measurements taken at 607 days after the last herbicide treatment were 411 and 457 *mm*. This was comparable to 407 *mm* for trees in the paraquat + diuron treatment and 395 *mm* for trees in the untreated plot.

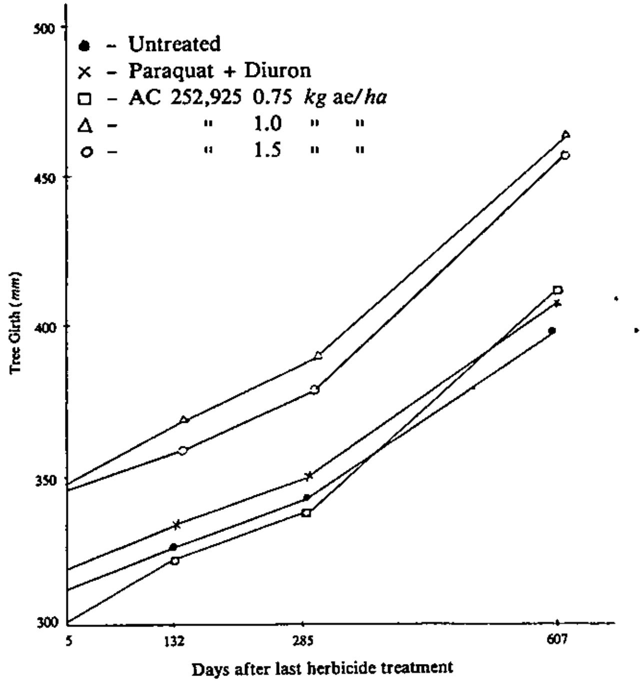

Figure 2. Effect of AC 252,925 on tree girth of 4½-year-old rubber trees (RRIM 600) after 6 applications. Malaysia, 1983. Mean of 3 replicates.

In bio-efficacy trials conducted in Thailand, all AC 252,925 rates (0.375 to 1.0 *kg* ae/*ha*) were selective to trees ranging from 9 months to 4 years of age. Elongated leaf laminae were noted on some young leaves in a few 9-month-old trees. Subsequent new flushes resumed normal growth.

Several crop selectivity field studies in rubber trees of different ages and under different conditions are currently in progress in Malaysia, Thailand and Indonesia.

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BAS 514 .. H - QUINCHLORAC* FIELD EXPERIENCE TO CONTROL *Echinochloa crus-galli* IN RICE

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ABSTRACT

BAS 514 . . H (3, 7-dichloro-8-quinolinecarboxylic acid) was tested intensively under different water management regimes in seeded and transplanted rice. Rice showed high tolerance to BAS 514 . . H when BAS 514 . . H was applied after the 2-3 leaf stage of seeded rice, respectively after transplanting.

BAS 514 . . H can be applied into shallow water or on water-saturated soil and also under upland rice conditions with subsequent irrigation. The active material is mainly taken up via the root system. Best efficacy is obtained with water levels of 2-5 *cm.*

BAS 514 . . H provides consistent control of *Echinochloa* spp. when applied from germination up to tillering. The rate ($>$ 95% control) will be between 0.15-1.0 *kg/ha a.i.* depending on the system of rice cultivation, climatic environment and growth stage of *Echinochloa* spp. . Besides of the consistent control of *Echinochloa* spp. the following weeds in rice fields are sensitive to BAS 514 . . H: *Aeschynomene* spp., *Cassia* spp., *Sesbania* spp., *Ipomoea* spp. . *Monochoria vaginalis* and *Oenanthe javanica* can be suppressed with rates necessary for *Echinochloa* control.

Because of its consistent *Echinochloa* efficacy, BAS 514 . . H can be combined with many other rice herbicides in order to add *Echinochloa* activity or to extend application time.

Toxicological studies with the active material are in progress.

INTRODUCTION

BAS 514 . . H is a new experimental herbicide of BASF Aktiengesellschaft, Federal Republic of Germany; it is being developed as a specific herbicide for the control of *Echinochloa* spp. in different rice growing systems. BAS 514 . . H acts mainly via the soil on germinating and emerged *Echinochloa* plants; it can be applied postemergently to direct seeded as well as in trans-planted rice. Due to its specific and long-lasting effect this herbicide complements other important post-emergence herbicides in rice which are not or only insufficiently effective against *Echinochloa* species. BAS 514 . . H is effective even on already tillering *Echinochloa* thus permitting a wide choice of application times; at the same time it is excellently tolerated by the crop.

Beside *Echinochloa,* the following rice weeds are susceptible to BAS 514 . . H: *Monochoria vaginalis, Oenanthe javanica, Aeschynomene* spp., *Sesbania* spp., *Ipomoea* spp. Furthermore it controls *Aethusa, Bifora, Euphorbia, Galium,*

*Proposed common name

Hibiscus, Urtica and *Veronica* species in other crops than rice. Beside in rice, BAS 514 . . H is at present being tested also in cereals, cruciferous crops and soyabeans. BAS 514 . . H has been tested in rice up to now in Japan, South Korea, Taiwan, Indonesia, the Philippines, India, Egypt, South Africa, Italy, Spain, Portugal, U.S.A., Colombia, Peru, Brazil, Argentina and Thailand.

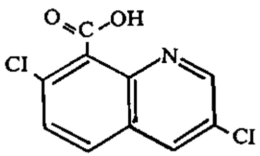
MATERIALS AND METHODS

Chemical, physical and toxicological data

Common name: Quinclorac

Chemical name: 3,7-dichloro-8-quinolinecarboxylic acid

Structure:



Water Solubility: 62 *mg/l.* 20°C

Formulations: BAS 514 00 H 50 % WP
BAS 514 06 H 1 % Granular

Fish toxicity (technical active ingredient):
LC value rainbow trout oral, 96 hours >100 *mg/l*
Further details cf: Wuerzer et al., 1985

The trials were carried out in small field plots, size up to 25 m^2, with 3-4 replications. The values were statistically measured by Duncan Test.

RESULTS

Selectivity
As with almost all herbicides, the degree of tolerance or resistance highly depends on the rate of application, the time of application, the soil, water and climatical conditions. Thus germinating rice up to the 2-leaf stage has a lower tolerance than taller stages (table 1).

Table 1: Selectivity study (Japan)
application timings: 3, 4, 5 and 6-leaf stage (LS) of rice
dosage: 0.5, 1.0 and 1.5 *kg a.i./ha*
no leaching, 3 *cm* water
Crop injury in % at 55 DAA

kg a.i./ha Developmental stage	BAS 514 06 H			MCPB
	0.5	1.0	1.5	0.33
3 LS	0	2	10	
4 LS	0	0	0	20
5 LS	0	0	0	
6 LS	0	0	0	

Sensitivity of rice to BAS 514 06 H decreases with advanced growth stages of rice. BAS 514 06 H is considerably safer than MCPB used at the registered application rate. Crop injury symptoms are similar to that of hormones.

Symptoms of crop damage do not occur under usual water management and transplanting practice, although both factors can influence the selectivity of BAS 514 . . H. Overdoses of the herbicide, for instance, are tolerated when BAS 514 . . H was applied into water of 7 cm depth (table 2). The transplanting depth of the seedlings has obviously a stronger influence. Placing the seedlings on the soil surface caused crop damage. However, when transplanting the seedlings in proper depth even overdoses showed no adverse effect (table 3). All Japanese results from 3 trial years taken together show that the incidence of crop injury is very low, because symptoms occur sporadically only (table 4).

Table 2: Selectivity study (Japan)
water depth: 1, 4 and 7 *cm*
dosage: 0.5, 1.0 and 1.5 *kg a.i./ha*
application timing: 4-leaf stage of rice, no leaching
Crop injury in % at 52 DAA

	BAS 514 06 H		
a.i. kg/ha	0.5	1.0	1.5
1 *cm*	0	7	17
4 *cm*	0	0	3
7 cm	0	0	0

Table 3: Selectivity study (Japan)
planting depth: 0, 1 and 3 *cm*
dosage: 0.5, 1.0 and 1.5 *kg a.i./ha*
application timing: 4-leaf stage, no leaching, 3 *cm* water
Crop injury in % at 42 DAA

	BAS 514 06 H		
a.i. kg/ha	0.5	1.0	1.5
0 *cm*	0	13	30
1 *cm*	0	2	7
3 *cm*	0	0	0

Table 4: Incidence of crop injury of different rates of BAS 514 .. H in transplanted rice (Japan) 1983-85

	BAS 514 .. H			
kg a.i./ha	0.15	0.2	0.25	0.5
% of treatments without damage	100 (47)	98 (45)	100 (61)	91 (39)

( ) = number of samples

Different temperature regimes and leaching did not show a significant influence on the occasional occurrence of crop injury. No significant differences have been observed either on 17 rice varieties of *japonica, indica* and *indica* x *japonica* origin as well as 2 GA-deficient varieties that have been examined so far. The conclusion can be drawn that BAS 514 . . H stands out for good selectivity in seeded and transplanted rice. This is confirmed by the yield results available up to now. As examples, results from Taiwan (table 5) are enclosed.

Table 5: Influence of BAS 514 00 H and its combinations on yields in transplanted rice, spray-application (Taiwan)

	kg a.i./ ha	yield rel. in %	yield *dt/ha*	sign 95% (Duncan-Test)
BAS 514 00 H	0.1	134	52.7	b
	0.15	140	54.9	bc
	0.2	166	65.2	de
	0.5	155	60.9	cd
BAS 514 00 H +Bentazon	0.1 +1.5	185	72.7	e
	0.15 +1.5	179	70.2	e
	0.2 +1.5	178	69.9	e
	0.5 +1.5	174	68.2	de
Bentazon	1.5	137	53.7	bc
Butachlor	1.5	177	69.3	e
Propanil +Bentazon	3.1 +1.5	166	65.1	de
Untreated		100	39.2	a

BAS 514 . . H in combination with insecticides (carbamates and phosphoric esters) does not cause any plant injury on rice.

Efficacy

BAS 514 . . H shows an outstanding efficacy on the most different *Echinochloa* species, varieties, and ecotypes, among them: *Echinochloa crus-galli* var. *crus-galli, Echinochloa crus-galli* var. *caudata, Echinochloa crus-galli* var. *formosensis, Echinochloa crus-galli* var. *hispidula, Echinochloa oryzicola, Echinochloa crus-pavonsis, Echinochloa colona, Echinochloa glabrescens.*

There are nearly no differences between the species and varieties mentioned; young plants are more sensitive than older ones. The symptoms begin with chlorotic discolourations on the youngest leaves with subsequent wilting and dying. To achieve the full effect, high soil moisture is necessary. This can be best obtained by flooding. BAS 514 . . H can be applied into the water or onto watersaturated soil, when applied onto dry or wet soil flooding or irrigation should be done at least until 6 days after treatment. Due to its relative mobility in the soil, the active ingredient is transported to the roots of *Echinochloa,* which are the main place of uptake for the active ingredient.

Table 6 shows the effect of BAS 514 . . H in dependence on the rate of application and the developmental growth stage of *Echinochloa crus-galli.* With 250 *g a.i./ha,* applied at the 2-leaf stage of *Echinochloa,* more than 90% control is obtained. With 0.5 *kg a.i./ha* in all growth stages shown (until shortly before the beginning of tillering) far more than 90% effect is attained. Equally good values have been achieved in Taiwan (table 7). This figure shows that *e.g. a* 95% effect on *Echinochloa crus -galli* has been achieved in 100% of all treatments at the 2-3-leaf stage, when 200 *g a.i./ha* of BAS 514 . . H had been applied.

Table 6: Effect of BAS 514 .. H in relation to growth stage of *Echinochloa crus-galli* (Japan, 5 trials)

		Growth stage			
Products	*kg a.i./ha*	12	13	14	15
BAS 514 .. H	0.12	77	70	57	50
	0.25	90	87	88	70
	0.5	97	93	93	92
	1.0	99	98	99	98
Benthiocarb	4.0	77	75	75	70

Table 7: Influence of the time of application (leaf stage *Echinochloa crus-galli*) on the frequency of the 95% efficacy of BAS 514 .. H in transplanted rice (Taiwan)

		Growth stage		
product	*kg a.i./ha*	11-12	12-13	13-14
BAS 514 .. H	0.15	80* (10)	73 (22)	73 (15)
	0.2	93 (19)	100 (19)	85 (13)
	0.25	95 (19)	100 (23)	81 (16)

( ) = number of samples
* = % of treatments with over 95% control of *Echinochloa*

Combination

On account of its outstandings properties on *Echinochloa* plants, BAS 514 . . H is suitable as combination partner for benthiocarb, propanil, triazines, sulfonyl urea herbicides, bentazon and other products. The effect on Echinochloa can be added or improved and also the time of application can be prolonged. This is demonstrated by the example of Brazil for propanil (table 8) and by the example of Japan for benthiocarb, SL-49 and S-47 (tables 9 and 10). In all cases BAS 514 . . H proved to be a good combination partner for prolonging the time of application and furthermore BAS 514 . . H provides the possibility of a targetted weed control by one treatment only. In most countries the recommended rates of BAS 514 . . H with partner compounds will be between 0, 2-0, 3 *kg/ha a.i.* of BAS 514 . . H

Table 8: Improvement of the *Echinochloa crus-galli* activity of propanil and prolongation of the time of application by adding BAS 514 ... H in seeded rice (Brazil, 2 trials)

Products	kg a.i./ha	Growth stage 12-13	13-21	21-30
BAS 514 .. H	0.25	81	92	70
	0.5	95	99	97
Propanil	2.9	79	86	27
BAS 514 ... H + Propanil	0.25+2.9	100	99	78

Table 9: Activity of BAS 514 .. H and BAS 514 .. H combined with SL-49 and S-47 in transplanted rice (Japan) 3rd evaluation.

kg a.i./ha	Growth stage	BAS 514 .. H	SL-49	S-47	BAS 514 .. H +SL-49 +S-47
		0.3	3.0	1.5	0.3+2.1+1.5
Echinochloa crus-galli	1-2	99	78	53	99
Monochoria vaginalis	1-2	85	99	100	100
Cyperus difformis	1-2	15	100	100	99
Rotala indica	B	5	98	96	100
Sagittaria pygmea	1-2	0	100	0	99
Scirpus juncoides	1-2	0	99	100	100
Cyperus serotinus	1-3	22	89	47	89
Potamogeton distinctus	1-3	0	99	0	98

Table 10: Activity of BAS 514 ... H and of the combination BAS 514 ... H + propanil, resp. benthiocarb on *Echinochloa crus-galli* at different growth stages in seeded rice (Japan)

Products	kg a.i./ha	Growth stage 12-13	13-21	21-30
BAS 514 .. H	0.25	90	88	91
Propanil	3.0	83	80	83
BAS 514 ... H + Propanil	0.2+2.0	98	98	98
Benthiocarb	4.0	57	63	57
BAS 514 ... H + Benthiocarb	0.25+3.0	97	98	98

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DPX-F5384 HERBICIDE APPLICATION FLEXIBILITY FOR BROADLEAF WEED CONTROL IN DIRECT SEEDED RICE - THAILAND

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ABSTRACT

DPX-F5384 herbicide, Methyl 2-[[[[[(4,6-dimethoxypyrimidin-2-yl) amino]carbonyl]amino]sulfony]methyl] benzoate, is a sulfonylurea compound for the control of most annual and perenial broadleaf weeds and sedges in paddy rice. The compound was discovered and is being developed by E I Du Pont De N emours & Co Inc., for use at preemergence and early postemergence to weeds in both direct seeded rice and transplanted rice. DPX-F5384 shows remarkable safety to Indica type rice varieties.

Experiments were conducted in Thailand during 1983 - 1985 to study various application techniques of DPX-F5384 for the control of broadleaf weeds in rice *(Oryza sativa L).* Results showed that seed treatment, spot application, spray and granule broadcast applications of DPX-F5384 at the rates of 30 and 40 *gm ai/ha* gave excellent control of *Sphenoclea zeylanica* Gaertn., *Cyperus difformis* L., *Marsilea crenata* Presl and *Fimbristylis miliacea* (L.) Vahl for up to 45 days. No phytotoxicity was noted from any application technique of DPX-F5384.

INTRODUCTION

Weeds are a most severe and widespread biological constraint to rice production in all rice growing countries. It is necessary to invest in control practices to reduce yield losses caused by weed competition with the rice plant (Gonzalez et. al. 1981). Weed control, which will always be a major input in rice production, is sometimes achieved through indirect methods such as land preparation, water control, planting method and even fertility management. However, farmers in most countries in Asia employ some direct weed control methods including hand weeding, mechanical weeding and herbicides. Recent advances in chemical control combined with other cultural practices and indirect methods of weed control provide excellent alternatives to hand weeding alone (De Datta and R Herdt 1981). However, most herbicides require strict adherence to narrow application timing windows and can be applied only as a spray or broadcast granule to achieve both good weed control and crop safety.

In Thailand, it was observed during field trials and large scale tests, that DPX-F5384 10 WP and G disperses quite readily and retains its effectiveness even when applied as a concentrated spot treatment into flooded paddy with at least 3 *cm* of water depth. After this initial observation replicated trials were conducted and it was found that uniform broadcasting of DPX-F5384 at equivalent rates *(ai/ha)* gave performance equal to DPX-F5384 when applied in concentrated spots ranging from 0.5 *metre* to 2 *metres* apart. This ease of dispersion in water allows for several innovative application alternatives. However, todate we have not recommended a spot application technique because it seems to contradict a normal good agricultural practice which requires uniform product distribution. In this paper we discuss the results of trials on two innovative application techniques, seed treatment and shaker bottle.

MATERIALS AND METHODS

Four formulations of DPX-F5384, 10%WP, 0.24% G, 0.25% G and 0.32% G, were used for testing. Field tests were conducted in the central area of Thailand in direct seeded rice in 1983-85. Experimental details are presented for each of these trials in Table 1. In Exp 1 - 5, a randomized complete block design with 3 replications was used. Plot size was 100 *sq m*. In experiments 6 - 8, a split plot design with 3 replications was used. Plots size was 15 *sq m*. In all experiments assessment for weed control was done visually at 2 week intervals after herbicide application 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 for experiments 1 - 5 was taken from the whole plot and threshing was done with a small thresher. Yield data is presented with standardized moisturte content of 14%.

Experiment 1 - 3:

These trials were designed to evaluate weed control and crop safety of DPX-F5384 G (.25%) at 40 *gm ai/ha* when applied in concentrated spots at spacing intervals of 0.5, 1.0, 1.5 and 2.0 metres apart (Lad Lum Keow and Bang Sai) as well as DPX-F5384 WP (10%) as a seed treatment (Bang Lane). The DPX-F5384 treated dry seed was also placed into the paddy in concentrated spots at the same spacing interval used in the G formulation trials. DPX-F5384 as a uniform broadcast application was the standard treatment. All treatments were applied 36 hours before seeding. Pregerminated RD23 seed was soaked for 1 day and incubated for 2 days and then sown. Water management followed the local practice.

Experiment 4 - 5 :

These trials were designed to evaluate weed control and crop safety of 30 *gm ai/ha* of DPX-F5384 WP (10%) in a spray using 500 lt carrier/*ha*, with 30 *gm ai/ha* of DPX-F5384 WP (10%) seed treatment uniformly distributed. These application techniques were compared to a broadcast application of piperophos - dimethametryne 3% G. The DPX-F5384 treated dry seed was broadcast by hand 2 - 3 days before the paddy was sown while the spray was applied 10 days after sowing. A uniform DPX-F5384 G application was also applied 10 days after sowing plus the standard piperophos - dimethametryne 3% treatment.

Experiment 6 - 8:

These trials were designed to evaluate weed control and crop safety of DPX-F5384 G (.24%) and WP (10%) at 30 and 40 *gm ai/ha* when applied as broadcast, spray (500*lt water/ha*), shaker bottle (6.25*lt water/ha*) and seed treatment. Piperophos - 2, 4-D 500 EC at 800 *gm ai/ha*, piperophos-dimethametryne 3.3% G at 750 *gm ai/ha*,

Table 1 : Experimental details of DPX-F 5384 trials in Thailand

EXPERIMENT	1	2	3	4	5	6	7	8
LOCATIONS	Lad Lum Keow	Bang Sai	Bang Lane	Bang Nam Prieo	Bang Lane	Donjedi	Sriprachan	Donjedi
SEEDING DATE	May 30, 83	Jun 3, 83	Jun 16, 83	Dec 27, 83 (dry seed) Dec 30, 83 (pre-germinated seed)	Jan 25, 84 (dry seed) Jan 27, 84 (pre-germinated seed)	Feb 21, 85 (dry seed) Feb 23, 85 (pre-germinated seed)	Mar 6, 85 (dry seed) Mar 8, 85 (pre-germinated seed)	Mar 8, 85 (dry seed) Mar 10, 85 (pre-germinated seed)
APPLICATION DATE	May 29, 83	Jun 2, 83	Jun 15, 83 (seed treatment)	Dec 27, 83 (seed treatment) Jan 9, 84 (broadcast & spray)	Jan 25, 84 (seed treatment) Feb 6, 84 (broadcast & spray)	Feb 21, 85 (seed treatment) Mar 2, 85 (broadcast, spray & liquid granule)	Mar 6, 85 (seed treatment) Mar 15, 85 (broadcast, spray & liquid granule)	Mar 8, 85 (seed treatment) Mar 17, 85 (broadcast, spray & liquid granule)
PLOT SIZE	100 m^2	100 m^2	100 m^2	100 m^2	100 m^2	15 m^2	15 m^2	15 m^2.
RICE VARIETY	RD23	RD23	RD23	RD23	RD1	RD23	RD7	RD23
SOIL TYPE	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay
SOIL pH	4	4.5	5	4.9	5.2	5.8	5.9	6.5
% O.M.	2.67	2.69	1.82	0.91	5.7	1.31	2.55	0.93
PRODUCT USED	0.25% G	0.25% G	10% WP	0.32% G 10% WP	0.32% G 10% WP	0.24% G 10% WP	0.24% G 10% WP	0.24% G 10% WP
% WEED COVER IN UNTREATED	40%	100%	100%	80%	70%	100%	100%	.100%
HARVESTING DATE	Aug 31, 83	Sep 2, 83	Oct 1, 83	Apr 17, 84	May 23, 84	—	—	—

oxadiazon-2, 4-D 16.6% EC at 800 *gm ai/ha* and 2, 4-D 80% WP at 1,500 *gm ai/ha* mixed with fertilizer were used at the recommended application timings as standard treatments related to the DPX-F5384 application method concerned. Herbicide treatments were used as main plots. Application methods were used as sub-plots. The dry seed treated with DPX-F5384 was seeded 2 days before other application methods.

RESULTS AND DISCUSSION

Experiment 1 - 3:

A summary of test results obtained for the control of *Sphenoclea zeylanica, Cyperus difformis, Marsilea crenata* and *Fimbristylis miliacea* at test sites in Lad Lum Keow, Bang Sai and Bang Lane are shown in Table 2. At Lad Kum Keow and Bang Sai DPX-F5384 at 40 *gm ai/ha* both granule and wettable powder formulations provided excellent control of those mentioned weeds when applied at 36 hours before seeding at 0.5, 1.0, 1.5 and 2.0 metres apart compared to the standard broadcast method. At Bang Lane the rice seed treated with DPX-F5384 at 40 *gm ai/ha* did germinate and showed no phytotoxicity. Average yield obtained from the 3 locations is significantly different from the untreated.

Experiment 4 - 5:

The results reported in Tables 3 and 4 show that DPX-F5384 both 0.32% G and 10% WP at 30 *gm ai/ha*, when applied as broadcast granule, spray and seed treatment, caused no crop injury and gave effective control of *Sphenoclea zeylanica, Cyperus difformis, Marsilea crenata* and *Limnocharis flava* equal to piperophos-dimethametryne at 562.5 *gm ai/ha*. There were insignificant differences in weed control among the application methods. For yield evaluation, there were no significant differences among herbicide treatments. DPX-F5384 treatments, except the seed treatment at Bang Nam Prieo, was significantly different from the untreated.

Experiment 6-8 :

A summary of test results is reported in Table 5. DPX-F5384 at 30 and 40 *gm ai/ha* at any application method gave excellent control of *Sphenoclea zeylanica, Monochoria vaginalis* and *Cyperus difformis* which were superior to the standard treatments. No phytotoxicity was noted from DPX-F5384 treatments.

Table 2 : Effect of DPX-F5384 applied pre-emergence as spot treatment in direct seeded rice. average from 3 locations.

TREATMENT	DISTANCE BETWEEN APPLICATION POINTS	CROP* INJURY AT 2 WAA**	% WEED CONTROL AT 6 WAA				YIELD[1] TONS/HA
			Sphenoclea zeylanica	*Cyperus difformis*	*Marsilea crenata*	*Fimbristylis miliacea*	
DPX-F5384 40 *gm ai/ha*	0.5 *metre*	0	100	100	100	100	4.64 a
	1.0 *metre*	0	100	100	95	100	4.65 a
	1.5 *metre*	0	100	100	100	100	4.85 a
	2.0 *metre*	0	99	99	100	97	4.99 a
	Broadcast	0	100	100	100	100	5.04 a
Untreated Check		0	0	0	0	0	2.65 b

Application timing : 36 hours before seeding
* 0 - 10 crop injury rating system : 0 = no injury, less than or equal to 3 = acceptable crop injury
4 - 6 = moderate, 7 - 9 = heavy, 10 = complete kill
** WAA = weeks after application
1 - in a column, means followed by the same letter are not significantly different at P = 0.01 by DMRT.

Table 3 : Effect of DPX-F5384 applied as various application methods in direct seeded rice at Bang Nam Prieo

TREATMENTS	APPLICATION* METHODS	*GM A.I./HA*	CROP INJURY AT 2 WAA	%WEED CONTROL AT 6 WAA			YIELD[1] *TONS/HA*
				Sphenoclea zylanica	*Cyperus difformis*	*Marsilea crnata*	
DPX-F5384 0.32% G	Broadcast	30	0	90	90	78	4.13 a
DPX-F5384 10% WP	Spray	30	0	86	95	73	4.17 a
DPX-F5384 10% WP	Seed Treatment	30	0	90	88	83	3.58 a b
Piperophos-dime thametryne 3% G	Broadcast	562.5	0	87	85	85	3.57 a b
Untreated Check	—	—	0	0	0	0	3.07 b

* The treated dry seed with DPX-F5384, seed treatment method, was seeded at 3 days earlier than the other treatments which pre-germinated seed was used. The application as broadcasting or spraying was done at 10 DAS.

1 - In a column, means followed by the same letter are not significantly different at P = 0.01 by DMRT.

Table 4 : Effect of DPX-F5384 applied as various application methods in direct seeded rice at Bang Lane

TREATMENTS	APPLICATION* METHODS	*GM A.I./HA*	CROP INJURY AT 2 WAA	%WEED CONTROL AT 6 WAA *Sphenoclea zylanica*	*Cyperus difformis*	*Limnocharis flava*	YIELD[1] *TONS/HA*
DPX-F5384 0.32% G	Broadcast	30	0	100	100	100	5.51 a
DPX-F5384 10% WP	Spray	30	0	100	100	100	5.52 a
DPX-F5384 10% WP	Seed Treatment	30	0	98	100	100	5.45 a
Piperophos-dime thametryne 3% G	Broadcast	562.5	0	100	100	82	5.24 a
Untreated Check	—	—	0	0	0	0	4.87 b

* The treated dry seed with DPX-F5384, seed treatment method, was seeded at 2 days earlier than the other treatments which pre-germinated seed was used. The application as broadcasting or spraying was done at 10 DAS.

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

Table 5 : Effect of DPX-F5384 as various application methods in direct seeded rice at 5-6 WAA (average from 3 locations).

APPLICATION*	% WEED CONTROL AT 5 - 6 WAA																	
	DPX-F 5384			DPX-F 5384			STANDARD TREATMENTS											
METHODS	30 *GM.A.I./HA*			40 *GM.A.I./HA*			PIPEROPHOS-DIME-THAME-TRYNE 3.3% G 750 *GM.A.I./HA*			PIPEROPHOS-2, 4-D 50% EC 800 *GM.A.I./HA*			OXADIAZON-2, 4-D 16.6% EC 800 *GM.A.I./HA*			2,4-D 80% WP MIXED WITH FERTILIZER 1,500 *GM.A.I./HA*		
	SZ	MV	CD	SZ	MV	CD	SZ	MV	CD	SZ	MV	CD	SZ	MV	CD	SZ	MV	CD
Broadcast	99	100	100	100	100	100	65	60	67	-	-	-	-	-	-	-	-	-
Spray	100	100	100	100	100	100	-	-	-	78	78	83	-	-	-	-	-	-
Liquid granule	99	100	100	100	100	100	-	-	-	-	-	-	98	85	95	-	-	-
Seed treatment	100	100	100	99	100	100	-	-	-	-	-	-	-	-	-	29	18	33
Crop injury at 2 WAA		0			0			0			0.11			1.8			0.22	

* The dry seed treated with DPX-F5384,seed treatment method, was seeded at 2 days earlier than the other treatments in which pre-germinated seed was used.-

Application timing : DPX-F 5384 as seed treatment = 2 DBS
DPX-F 5384 as broadcast, spray, liquid granule = 7 DAS
Piperophos - 2, 4-D = 10 DAS
Piperophos - dimethametryne and oxadiazon-2,4-D = 13 DAS
2,4-D mixed with fertilizer = 21 DAS

SZ = Sphenoclea zeylanica, MV = Monochoria vaginalis, CD = Cyperus difformis

CONCLUSION

The results of these trials shows the outstanding crop safety and excellent control of the most important broadleaf weeds in direct seeded rice by DPX-F5384. The application flexibility seen in these trials could be a meaningful tool to rice growers to help reduce the time spent applying the compound.

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EFFECT OF TIME OF SEED-INCUBATION ON THE SELECTIVITY OF SOFIT IN DIRECT WET-SEEDED RICE

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ABSTRACT

Field and greenhouse experiments were carried out to determine the effect of incubation time on the selectivity of Sofit® (mixture of pretilachlor and safening agent CGA 123'407) in direct wet seeded rice. IR-36 seeds were soaked for 24 hours and incubated for 24, 36, 48 and 60 hours. In the untreated check the number of surviving seedlings dropped significantly after 36 hours of incubation. Short incubation periods (24-36 hours) resulted in a clearly better crop stand than 48 and 60 hours. Application of Sofit® did not reduce the number of surviving seedlings and a similar or better crop stand than in untreated check was achieved.

INTRODUCTION

Wet sown rice is becoming increasingly important in a number of countries in South East Asia as method of growing rice due to increases in production costs and shortages of labour for transplanting.

A major constraint to the wider adoption of wet sown rice is weed control (Chiang 80). Herbicides are often recommended for weed control in wet-sown rice because of the difficulties encountered with handweeding. However, selectivity is often marginal due to the same stage of development of rice and weeds. According to Moody (1984) the herbicide selectivity can be improved by manipulating several agronomic factors such as adjusting the application time, applying crop safeners and reducing the rate of herbicide applied.

Many herbicides may cause phytotoxicity to wet-sown rice if they are applied before the development of the second leaf (Moody and Madrif, 1983). The time taken to reach this stage will depend on the cultivar grown and the length of incubation of the seeds before sowing.

Trials conducted over several seasons suggested that the crop tolerance of herbicides varies depending on the length of incubation period.

In order to issue a safe recommendation for the use of Sofit® (pretilachlor + CGA 123'407) in wet-sown rice, a detailed study was conducted comparing the different length of incubation periods.

MATERIALS AND METHODS

Two field experiments were established at the CIBA-GEIGY Research and Development Station, Cikampek West Java, Indonesia in 1984 and 1985. Soil type was clay with a pH of 4.7; CEC 14.1*ml*/100 *gr*; total N 0. 167%and organic carbon 1.63%. Soil preparation was done manually and puddled twice before levelling. Rice cultivar, IR-36 was incubated for the different length of incubation periods i.e. 24, 36, 48 and 60 hours. Seed rate used was 80 *kg/ha*. Urea, triple superphosphate and KCL were applied at the rate of 200, 100 and 90 *kg/ha*, respectively. One third of the total nitrogen rate was applied before the final puddling to facilitate incorporation into the soil.

Sofit® and Rifit® at the rate of 600 *gr ai/ha* were applied at 0 DBS (days before sowing) and 1 DAS (days after sowing) with a special boom sprayer equipped with T-jet nozzle 8002 which delivered a spray volume of 500 *ltr/ha*. The plot size was 20 *sqm* and all treatments were replicated 3 times.

Assessments were done visually at 10, 30 and 60 days after sowing using a % rating scale where 0% = no effect and 100% = complete kill. Data obtained from these two field experiments were pooled together for analysis.

RESULTS

The toxicity of pretilachlor to rice seedlings increased when the length of the incubation period was prolonged from 24 to 60 *hrs* (table 1 and figure 1). Much higher phytotoxicity was observed at the longer periods of incubation i.e. 48 and 60 hours. The results further indicate that the percentage of phytotoxicity also increases when pretilachlor is applied at 1 DAS as compared to 0 DBS. Similar results were also obtained with pretilachlor + CGA 123'407, however the degree of phytotoxicity was far lower than with pretilachlor alone. Application time did not signigicantly influence the toxicity of pretilachlor + CGA 123'407 to rice seedlings.

Table 1. Influence of incubation period and application time on phytotoxicity of pretilachlor and pretilachlor + CGA 123,407 at 0,6 *kg ai/ha*. expressed as %stand reduction.
(Visual assessment at 15 DAS)

a) Value in parentheses are for pretilachlor + CGA 123'407

Application time \ Incubation period (hours)	24	36	48	80	Average
0 DBS	38.3 (9.3)a)	54.3 (13.7)	68.3 (14.0)	63.3 (20.0)	56.1 (14.3)
1 DAS	84.3 (13.3)	86.0 (12.6)	88.0 (20.7)	85.6 (16.0)	86.0 (15.7)
Average	61.3 (11.3)	70.2 (13.2)	78.2 (17.4)	74.5 (18.0)	

In one of the two trials a detailed counting of seedling density was carried out. The respective data are presented in figure 1.

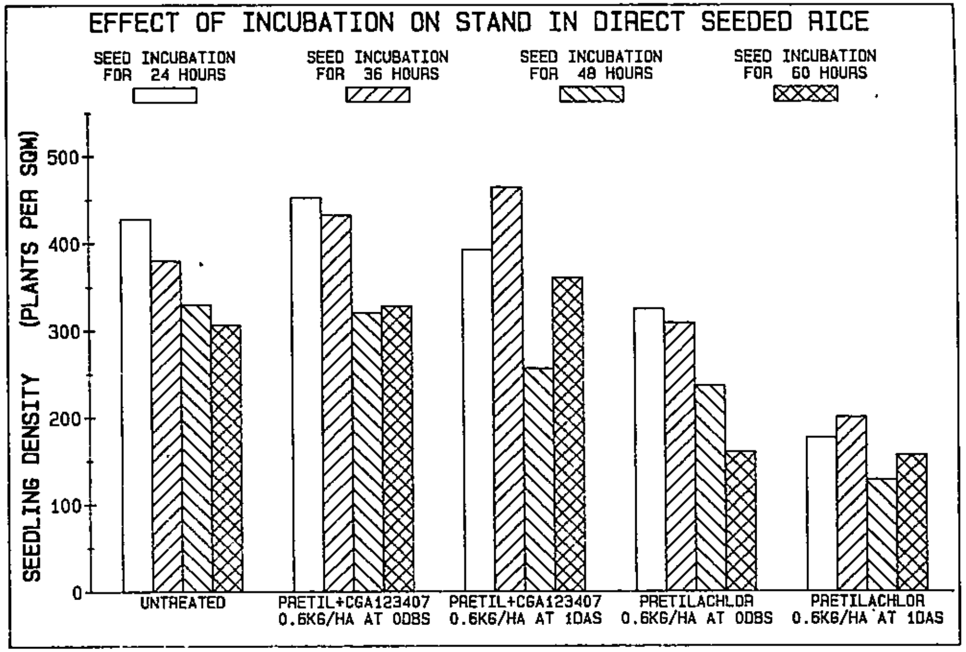

Figure 1. Effect of time of seed–incubation on the selectivity of Sofit in direct wet–seeded rice

These data show a clear reduction of the number of surviving seeds for the longer incubation periods. The values for check and for pretilachlor + safener were very similar whereas pretilachlor alone reduced the crop stand significantly and with both timings.

Weed coverage was not influenced either by length of incubation period or application time. Comparing the activity of Rifit® and Sofit®, good weed control was obtained with Sofit® at both application timings (table 2 and 3).

Table 2. Weed coverage (%plot cover) for check, pretilachlor and pretilachlor + CGA 123407 evaluated at 30 DAS

Application time \ Herbicide treatment	Check	Preti lach lor	Pretilachlor + CGA 123407
0 DBS	46	9	9
1 DAS	42	5	5
Average	44	7	7

Table 3. Weed coverage (%plot cover) for check, pretilachlor and pretilachlor + CGA 123407 evaluated at 60 DAS

Herbicide treatment / Application time	Check	Pretilachlor	Pretilachlor + CGA 123407
0 DBS	61	22	18
1 DAS	51	11	11
Average	56	22	15

DISCUSSIONS

Based on the results obtained it can be concluded that shorter periods of incubation i.e. 24 or 36 hours are more suitable than longer ones.

With shorter incubation intervals the total number of surviving seeds in general was considerably higher not only in the herbicide treated plots but also in the untreated checkplots. More developed seeds certainly suffer more mechanical damage during the seeding operation.

However in case of heavy rains shortly after planting longer incubation periods might be preferred since the more developed radicles will penetrate quicker in to the mud and hence reduce the risk of seeds being washed off. Experience from many trials has shown that in general a grain stage with radicles just emerging up to a length of less than 2-3 *mm* will be the most suitable stage for broadcasting. To reach this specific growth stage it takes the variety IR-36 about 26-40 hours under our Indonesian conditions but this period can vary considerably for different varieties and therefore needs variety specific adjustment.

Since meanwhile the overall best application timing for pretilachlor + CGA 123'407 has been established at around 4 DAS the development stage of the seed at planting time has little or no effect on its crop tolerance.

The experiments conducted have however confirmed that if for some reasons pretilachlor + CGA 123'407 is applied at 0 or at 1 DAS its crop tolerance will not, or only slightly, be affected by the seed development stage.

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EVALUATION OF SOIL RESIDUAL ACTIVITY OF GLYPHOSATE

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ABSTRACT

Glasshouse studies were conducted to evaluate the herbicidal activity of glyphosate from soil applications on three New Zealand soils varying widely in their texture and organic matter content. Soil-applied glyphosate caused no measurable effects on annual ryegrass *(Lolium multiflorum* cv. 'Tama') plants at 2 *kg/ha*, a rate often used for controlling many weed species. Some minor detrimental effects were noted on a peat soil at a rate of 4 *kg/ha*, but no effects could be measured on the two mineral soils at rates of up to 10 *kg/ha*, which is several times higher than normal use rates. On silica sand, the damage symptoms were observed at rates as low as 0.25 *kg/ha*. Glyphosate applied to the soil surface caused less injury to ryegrass when seeds were planted 0.5 *cm* deep than when surface-sown. The residual activity from a rate of 10 *kg/ha* on the peat soil reduced the growth of ryegrass planted 28 days after application. Inorganic phosphorus added to soil at rates much higher than fertiliser rates, did not enhance the activity of soil-applied glyphosate on the three soils tested.

INTRODUCTION

Glyphosate is registered for a variety of use situations in New Zealand. An effective systemic foliage-applied herbicide, it is used selectively for spot treatments or directed applications away from the crop, or wiper applications that reduce exposure to established crop plants. It is also useful for controlling weeds prior to planting or emergence of the crop. These uses, however, depend on a lack of activity from the soil-applied glyphosate.

Glyphosate was generally shown to be inactive when applied to soils at normal use rates (Baird *et al.* 1971, Egley and Williams 1978, Hensley *et al.* 1978); glyphosate rates as high as 56 *kg/ha* were inactivated by clay or muck soils (Sprankle *et al.* 1975). However, several other studies showed that glyphosate caused plant injury when applied to soils (Brewster and Appleby 1972, Campbell 1974, 1976, Boldt and Putnam 1978). Recently Salazar and Appleby (1982) demonstrated that glyphosate caused substantial dry weight reduction of browntop *(Agrostis capillaris)*, lucerne and red clover when applied to moist soils at normal use rates.

Adsorption of glyphosate is largely related to the phosphonic acid moiety in glyphosate (Hance 1976, Nomura and Hilton 1977). Conceivably inorganic phosphorus may compete with glyphosate for adsorption sites and result in increased herbicidal activity from soil-applied glyphosate. Many New Zealand soils have a high phosphate sorption capacity and high rates of phosphate fertilisers are commonly applied. The effect of added phosphate on the soil activity of glyphosate was, therefore, investigated in this study.

Because of the widespread use of glyphosate, and these recent studies that demonstrate activity of glyphosate from soil uptake, our objective was to evaluate the potential for glyphosate activity from several New Zealand soils when crops are planted into treated soils.

MATERIALS AND METHODS

Soil for the glasshouse experiments were collected from the top 10 *cm* of the three soil types listed in Table 1. The soil properties were determined by the standard procedures described by Rahman (1977). "Tama" annual ryegrass was used as the assay species after preliminary trials which also considered oats, radish and white clover. Ryegrass was among the most sensitive of the species tested. Each experiment was repeated once or twice, usually at different times of the year.

Table 1. Some physical and chemical properties of the soils used.

Soil Property	Soil Type: Rukuhia peat	Horotiu sandy loam	Hamilton clay loam
Organic carbon *(%)*	33.5	10.2	4.0
Sand *(%)*	28.1	55.9	31.9
Silt *(%)*	21.4	18.2	28.5
Clay *(%)*	16.2	10.1	33.1
Cation exchange capacity *(me/100 g)*	35.7	27.9	20.0
Exchangeable cations *(me/100 g)*			
Ca	3.0	3.5	6.1
Mg	0.73	0.64	0.85
K	0.22	0.29	1.46
Na	0.18	0.16	0.16
Available nutrients *(ppm)*			
Ca	1	3	5
Mg	1	4	21
K	4	9	14
P	105	21	27
P retention *(%)*	84	92	47
pH	4.3	5.0	5.1
Water holding capacity *(%)*	60.7	42.4	40.1
Bulk density *(g/cc)*	0.38	0.64	0.73

Glyphosate was applied at rates ranging from 1 to 16 *kg/ha* to the three soils in 10 *cm* diameter pots by a single nozzle glasshouse sprayer. The application was made to a moist soil surface in 545 *litres* of water/*ha*. About 50 ryegrass seeds (assessed by weight) were either sown on the surface (and pressed lightly for uniform contact with the moist soil surface) 5 hours after glyphosate application or sown 0.5 *cm* deep 3 days prior to application. Rates of 0.25, 0.5, 1.0, 2.0 and 4.0 *kg/ha* were also applied to water-washed silica sand using the same procedure as above. As the surface-sown ryegrass seeds did not appear to imbibe water, a glass plate was used to cover each pot for 4 days to permit seed germination. After the first week, pots were sub-irrigated every second day if required with 50 *ml* of Ruakura nutrient solution (Smith et al. 1983). The treatments were arranged in a randomised block design with four replications.

For experiments on residual activity of glyphosate, peat soil in pots was treated with glyphosate at 10 *kg/ha*. Ryegrass was surface-sown at 0 (5 hours), 4, 7, 14, 28 and 42 days after glyphosate application, providing four replicates each of treated and untreated soil for each sowing date.

To study the effects of P additions, P was applied as $Ca(H_2PO_4)_2.H_2O$ at 0, 100, 200 and 400 parts per million by weight of oven-dry soil *(ppmw)* P to Rukuhia peat, at 0, 200, 400 and 800 *ppmw* P to Hamilton clay loam and at 0, 200, 400, 800 and 1600 *ppmw* P to Horotiu sandy loam and thoroughly mixed. KNO_3 at 0.2 g per 10 *cm* diameter pot was also mixed with each soil. Glyphosate was applied at 0, 3, 6 and 12 *kg/ha* and about 62 ryegrass seeds (measured by weight) were surface-sown 5 hours after glyphosate treatment. The treatments were arranged as a factorial with four replications in a randomised complete block.

Soils were sub-irrigated every 2 days (2 hours for mineral soils, 5 hours for peat and ½ hour for silica sand) and overhead sprinkling was applied every 2 days equivalent to 1.5 *mm* of water. This watering regime maintained the soil at about field capacity throughout the experiment. Since the glyphosate effect was often expressed by stunted plants, the number of plants less than 10 *cm* tall relative to the total number of plants per pot was counted. Plants were harvested 21 to 24 days after sowing by clipping at soil level and oven-dried.

RESULTS AND DISCUSSION

Ryegrass symptoms resulting from soil applied glyphosate ranged from severe leaf chlorosis and bleaching, as well as morphological abnormalities often observed with foliar-applied glyphosate, to stunted plants with symptomless foliar parts. While lacking foliar symptoms these plants were associated with severe root inhibition and slightly swollen root tips and were therefore distinguishhable from healthy plants. Stunted plants were generally less than 10 *cm* tall while visually unaffected plants in the same pot were 10 to 25 *cm* tall.

On the three soils tested, soil-applied glyphosate caused no measurable effects at 2 *kg/ha*, a rate normally used for control of many weed species (Table 2). Effects on ryegrass were observed at rates as low as 4 *kg/ha* on the peat soil (Table 2), but generally not until 12 or 16 *kg/ha* on the mineral soils (data not presented). At 4 *kg/ha* in the peat soil, there were significantly more stunted plants than the control, even through no dry weight differences were detected until the 10 *kg/ha* rate. Presumably the stunted plants allowed the apparently unaffected plants in the same pot to produce more growth.

Injury to ryegrass was generally more severe when surface-sown on the glyphosate-treated peat or sand than when seeded 0.5 *cm* deep (Table 2). More stunted plants and dry weight reductions resulted from seeded plants, when more overhead watering was applied in another experiment. Greater injury to surface-sown ryegrass was probably related to the closer proximity of the absorbing organs to sufficiently high concentrations of glyphosate available for absorption.

Table 2. Effect of soil-applied glyphosate on annual ryegrass as influenced by glyphosate rates and seeding method (surface-sown versus seeded 0.5 cm deep).

Soil type	Seeding method	Avg no. ryegrass per pot	Glyphosate rate (*kg/ha*) 0	0.25	0.5	1.0	2.0	4.0	6.0	8.0	10.0
			Ryegrass dry weight/pot (*mg*)*								
Rukuhia peat	surface		302				345	282	254	263	120**
	seeded		359				351	355	303	353	354
Horotiu sandy loam	surface		304				256	417	382	368	263
	seeded		338				341	419	326	414	294
Hamilton clay loam	surface		425				375	353	426	426	343
	seeded		460				287	401	395	349	415
Silica sand	surface		302	212**	97**	56**	12**	5**			
	seeded		271	239	184**	83**	46**	19**			
			Ryegrass per pot less than 10 *cm* tall (number)*								
Rukuhia peat	surface	17.0	0.5				0	3.3**	4.3**	5.3**	8.8**
	seeded	18.1	0.5				1.0	0.8	0.8	2.3**	3.5**
Horotiu sandy loam	surface	13.8	0				0	0	0	0.5	0.5
	seeded	12.8	0.5				0	0.5	0.5	0.8	0.8
Hamilton clay loam	surface	13.1	0.3				0.8	0	0.5	0.5	1.8
	seeded	12.1	0.8				0.5	1.0	0.3	0.3	1.0

* Analysis of variance was of square root transformed data.
** Significantly different from the control by the LSD, $P < 0.01$.

The magnitude of soil-applied glyphosate activity reported here is considerably less than reported by Salazar and Appleby (1982), but in closer agreement with earlier published reports (Egley and Williams 1978, Hensley *et al.* 1978). It is not clear why Salazar and Appleby (1982) obtained the extent of soil-applied glyphosate activity that they did.

In order to test the appropriateness of the technique used, glyphosate was also applied to water-washed silica sand. In this case, the glyphosate effect was observed at rates as low as 0.25 *kg/ha* when ryegrass was surface sown and 0.50 *kg/ha* when seeded 0.5 *cm* deep (Table 2). Ryegrass growth virtually ceased at 2 *kg/ha* when it was surface sown.

This large difference in activity between silica sand and the natural soils is likely related to the amount of adsorption and consequent availability of glyphosate for absorption by ryegrass. Similarly, the difference in activity between the peat soil and the mineral soils might also be attributed to adsorption differences. The activity of glyphosate was greater in the peat soil which had much higher level of organic matter than the mineral soils. Hance (1976) also showed that there was no relationship with organic carbon content and glyphosate adsorption. Thus higher glyphosate activity from the peat may be related to other factors, such as the high moisture holding capacity of this soil.

Although fairly high rates of soil-applied glyphosate were required to cause moderate ryegrass injury, the effects were found to persist for several weeks. On the peat soil 41% of plants were stunted and dry matter was reduced by 36% when ryegrass was planted directly after the application of 10 *kg/ha* glyphosate (Table 3).

Table 3. Residual activity of glyphosate in peat soil treated with 10 *kg/ha*

Days after treatment	*Ryegrass plants/pot* $<$*10 cm* tall		Ryegrass dry weight/pot (*mg*)	
	control	treated	control	treated
0	0.5	7.0*	285	182*
4	0.8	5.5*	278	182
7	0.5	4.5*	385	356
14	0.8	3.5*	344	361
28	0.8	4.8*	349	300
42	1.3	1.5	305	283
Average no. plants/pot	20.1	17.1		

* Significantly different from the control, $p < 0.05$.

Although no significant reduction in dry weight occurred when ryegrass was planted at any time after the date of spraying, a significant number of stunted plants were present even when ryegrass was planted 28 days after glyphosate application. No effects were observed at 42 days after planting. Thus once glyphosate soil-residual effects are observed, a moderate waiting period may be required prior to planting.

Glyphosate adsorption to soils has been attributed to the phosphonic acid moiety in glyphosate (Hance 1976, Nomura and Hilton 1977). Furthermore, Hance (1976) showed that adsorption was slightly better related to unoccupied P sorption than to total P sorption capacity. In our experiments on the effect of added inorganic P, no significant changes in number of stunted plants or dry matter production of ryegrass were observed at any rate of glyphosate (data not presented). This implies that the quantities of inorganic P applied as fertilisers are insufficient to cause much enhancement of glyphosate activity from the soil.

In conclusion, our studies show that some damage to susceptible plants from soil-applied glyphosate is possible on soils of very low adsorption such as pumice or silica sand. Some injury is also possible at high rates of application on the peat soils. However, plant damage due to soil-applied glyphosate is not likely on most New Zealand soils at the normal use rates.

ACKNOWLEDGEMENTS

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HERBICIDAL PROPERTIES OF DIMEPIPERATE

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ABSTRACT

Dimepiperate [S–1–methyl–1–phenylethyl piperidine–1–carbothioate] is a new thiolcarbamate–type herbicide discovered by Mitsubishi Petrochemical Co., Ltd. It has a herbicidal activity against barnyardgrass *(Echinochloa crus–galli)* on rice plant fields at pre– to early post–emergence.

Since 1979 dimepiperate has been tested on direct seeding and transplanting paddy fields in Japan and other rice areas such as the Far East, Southern Europe and Latin America. As a result dimepiperate proved completely safe in the germ and seedling of rice, and efficient against barnyardgrass.

Herbicidal properties of dimepiperate are as follows.

1) Dimepiperate is classified as a growth inhibition type herbicide and kills weeds primarily by inhibiting formation and elongation of their stems and leaves.

2) Dimepiperate exhibits higher activity on barnyardgrass than on other weeds such as broadleaves and sedges under flooded condition.

3) Dimepiperate has excellent inter–genus selectivity between rice and barnyardgrass and efficiently controls barnyardgrass at up to the 2–leaf stage without giving adverse effects to rice plants. It can be used for all types of rice cultivation.

4) Dimepiperate is absorbed actively from the root, leaf and stem of the plant and translocated mostly in the upward direction. Both absorption and translocation are more active in barnyardgrass than in rice.

5) Dimepiperate has moderate persistance in soil and inhibits emergence of weeds for approximately 20 days. The movement of dimepiperate into the soil is up to 3 *cm* from the surface.

6) Dimepiperate shows good control under a wide range of soil, flooded depth and temperature conditions.

INTRODUCTION

Dimepiperate (S–1–methyl–1–phenylethyl piperidine–1–carbothioate) is a new selective pre– to early post–emergence herbicide for use in rice plants. It has a good herbicidal activity against barnyardgrass. Since 1979 dimepiperate has been tested on direct seeding and transplanting paddy fields in Japan and other rice areas such as the Far East, Southern Europe and Latin America. This paper presents basic information on herbicidal activity and rice plants selectivity of dimepiperate under greenhouse and field conditions.

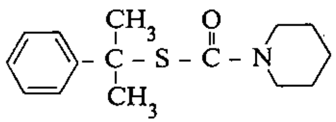
MATERIALS AND METHODS

1. Test compounds

Dimepiperate was prepared as described in our previous reports[1]. Chemical and physical properties of dimepiperate are shown in Table 1.

Table 1. Chemical and Physical Properties of dimepiperate

Trade name : Yukamate[R]
Common name : dimepiperate (proposed to ISO)
Code number : MuW - 1193, MY - 93
Chemical name : S-1-methyl-1-phenylethyl piperidine-1-carbothioate
Chemical structure :



Empirical formula : $C_{15}N_{21}NOS$
Molecular weight : 263.4
Appearance : wax-like solid
Melting point : 38.8 - 39.3 °*C*
Boiling point : 164 - 168 °*C*/0.75 *mm* Hg
Vapor pressure : 4×10^{-6} *mm* Hg/30 °*C*

Solubility :		
	Water	0.02 *g/l*
(at 25 °*C*)	n-Hexane	2.0 *kg/l*
	Xylene	3.1 *kg/l*
	Ethanol	4.1 *kg/l*
	Acetone	6.2 *kg/l*
	Chloroform	5.8 *kg/l*
	Cyclohexanone	4.9 *kg/l*

Stability :
1) Temperature stable for a minimum of 1 year at 30 °*C*
2) Acids and Alkalis stable in the aquaous solutions of 1/10 N NCl and 1/10 N NaOH
3) Light stable under dry conditions

(Formulation : 7 percent granule,
50 percent emulsifiable concentrate)

2. Biological tests

The biological tests of dimepiperate were conducted mostly with 10% wettable powder. All biological tests were replicated two times for each application.

2-1. Pre- and post-emergence herbicidal activity and crop selectivity

a) Pots each having an inside diameter of 15 *cm* were filled with paddy soil and seeded with eight species of weeds shown in Table 2. The pots were submerged to a depth of 3 *cm* and kept in a greenhouse at about 25 °*C*. At the stage of pre-emergence of barnyardgrass and at 10 days after seeding (post-emergence treatment), a water-diluted wettable powder of dimepiperate was applied to each pot at a rate of 3 *kg* a.i./*ha*. The herbicidal activity was visually evaluated by a 0 to 5 rating system at 20 days after treatment (0 : no effect, 5 : complete killing).

b) On the other hand, various varieties of rice plants in Table 3 were treated with dimepiperate at a rate of 6 *kg* a.i./*ha*. At the time of treatment, rice plants were at germination stage (pre-) and 1.5 leaf-stage (post-). Treated pots were kept in a greenhouse for 30 days, and then rice plants phytotoxicity was evaluated in the manner described above.

Table 2. Herbicidal spectrum

	Treatment	Pre-emergence	Post-emergence
Plant spp.	Dose a.i. *kg/ha*	3	3
Echinochloa crus-galli L		5	5
Monochoria vaginalis Persl.		1.5	0
Rotala indica Koehne		0	.
Cyperus difformis L.		3	1.5
Scirpus juncoides ROXB.		1.5	0
Alisma canaliculatum A. Br. et		1.5	0
Sagitaria pygmaea Miq.		0	0
Cyperus serotinus Rottb.		1.5	0

(0 : no effect, 5 : complete killing)

Table 3. Crop selectivity in various varieties of rice plants

	Treatment	Pre-emergence	Post-emergence
Variety	Dose a.i. *kg/ha*	6	6
Nihonbare		0	0
IR-8		0.5	0
Blue-bell		0.5	0
Blue-bonnet		0	0
Balilla		0	0

(0 : no effect, 5 : complete killing)

2-2. Selectivity between barnyardgrass and rice plants

The difference in sensitivity between barnyardgrass and rice plants was determined by a greenhouse pot test. Dimepiperate was applied with various rates at germination, 1.0, 2.0 and 3.0-leaf stage of barnyardgrass and at germination and 2.0 leaf-stage of rice plants.

At four weeks after treatment, aerial parts of test plants were cut off and their fresh weight was measured. Growth inhibition of rice plants and barnyardgrass was evaluated on the basis of percentage of the fresh weight of remaining aerial parts relative to that of the untreated control.

2-3. Factors influencing herbicidal efficacy and phytotoxicity

In order to compare dimepiperate with conventional herbicides such as molinate and benthiocarb, pot tests were conducted on several conditions described below. a) effect of soil kinds, b) water depth, c) temperature conditions. Those test methods were essentially the same as aforementioned.

2-4. Movement in soil

The soil was filled into a plastic column (10 *cm* in diameter, 10 *cm* deep) and test chemicals were treated on the soil surface at a rate of 3 *kg ai/ha*. Each 10 *mm/hr* of artificial rainfall was applied one and two days after treatment and soil column was divided horizontally into ten equal depth. The each soil was transferred into a petri dish and seeds of barnyardgrass were sown. Growth inhibition of the above-ground shoot length of barnyardgrass was evualated after two weeks growing in a phytotron.

2-5. Residual activity

The soil was filled into plastic pots (15 *cm* in diameter) to a depth of 3 *cm*, and then test chemicals were treated on the soil surface at a rate of 4 *kg ai/ha* at five-day intervals from 35 days to the appointed day before sowing of barnyardgrass. Growth inhibition of the aboveground shoot length of barnyardgrass was evaluated after three weeks growing in a greenhouse.

2-6. Absorption, translocation and metabolism

Studies were conducted using autoradiographic and direct counting technique. ^{14}C-dimepiperate labeled at the -position of the benzyl group and 2, 6-position of the piperidine ring were used.

The germinated seeds were planted in moist soil and grown in a greenhouse. At the 1 to 3 leaf-stage, the seedling were transferred to water culture in Kasugai's nutrient solution and treated with ^{14}C-dimepiperate from the roots. Translocation in and from the leaf was investigated by applying ^{14}C-dimepiperate at the stem or the center of the blade at 3 - 4 leaf-stage. The plants were harvested after growing by water culture for two or five days.

The plants were homogenized in 80% acetone and the filtrate was extracted with dichloromethane. They were fractionated into 80% acetone extractable, water soluble and tissue debris fractions, dimepiperate was measured after separating by silica gel plates.

2-7. Field test

The field test was conducted in a similar manner to the pot test. The field was located at Ami, Ibaraki in Japan and plot size was 1.5 m^2. Seeds of barnyardgrass were sown in each plot and each plot was submerged to a depth of 2 - 3 *cm*. At the time of 1.5, 2.0, 2.5 and 3.5 leaf-stage of barnyardgrass, 7% granules of test chemicals were applied at a rate of 2.1 *kg ai/ha*. The herbicidal activity was determined by weighting fresh aerial parts at 30 days after treatment.

RESULTS AND DISCUSSION.

Dimepiperate is classified as growth inhibition type herbicide and kills weeds primarily by inhibiting formation and elongation of their stem and leaves, and its herbicidal symptoms were very similar to that of benthiocarb and molinate.

1) Pre- and post-emergence herbicidal activity and crop selectivity

Dimepiperate showed higher activity on barnyardgrass than on other weeds such as broad leaves and sedges (Table 2). Except for barnyardgrass, it showed a little weaker post-emergence activity compared with pre-emergence activity. Its herbicidal symptoms against barnyardgrass were more clearly shown in their shoot elongation than in their root elongation. Their shoots were completely inhibited and then resulted in killing off.

On the other hand, dimepiperate did not inhibit the germination of rice plants, even at 6 *kg ai/ha* as shown in Table 3, and it exhibited high selectivity in several species of rice plants.

Consequently, dimepiperate has excellent safety and it can be used even at the stage of the germination of rice plants, and it showed potent herbicidal activity against barnyardgrass.

2) Selectivity between barnyardgrass and rice plants

Growth inhibition of barnyardgrass and rice plants by dimepiperate was shown in Fig. 1.

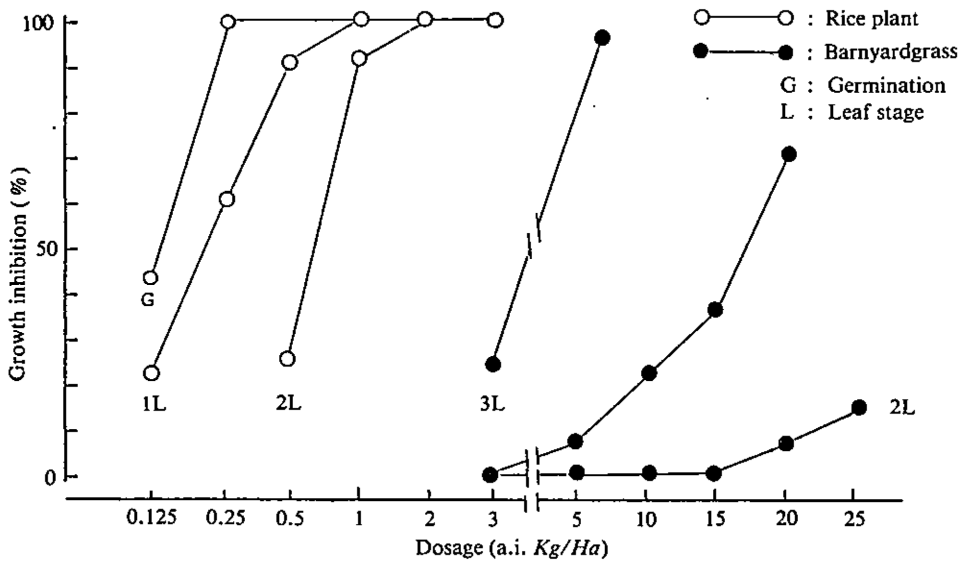


Fig. 1 Growth inhibition of rice plant and barnyardgrass by dimepiperate

Dimepiperate showed a higher activity against barnyardgrass at 2 leaf-stage but at 3 leaf-stage it had a lower activity. Phytotoxicity on rice plants was not observed when it was applied at 2 leaf-stage even at 15 *kg ai/ha*, and at germination stage less than 10% of the growth inhibition was observed at 5 *kg ai/ha*.

Consequently dimepiperate has excellent inter-genus selectivity between rice plants and barnyardgrass and efficiently controls barnyardgrass at up to 2 leaf-stage without giving adverse effects to rice plants at the rate of 3 *kg ai/ha*. Comparison of dimepiperate with conventional herbicides on the sefety to rice plants was shown in table 4.

Table 4. Selectivity in rice plants under various application time (3 a.i. *kg/ha*)

treatment	-3					+0				
Common name / var.	Nihon-bare	IR-8	Blue-bell	Blue-bonnet	Ba-liila	Nihon-bare	IR-8	Blue-bell	Blue-bonnet	Ba-lilla
Dimepiperate	0	0	0	0	0	0	0	0	0	0
Molinate	0	0.5	0	0	0	0	1	0.5	0	0
Benthiocarb	0.5	1	1	0	0	2	4	3	2	2

treatment	+7					+10				
Common name / var.	Nihon-bare	IR-8	Blue-bell	Blue-bonnet	Ba-lilla	Nihon-bare	IR-8	Blue-bell	Blue-bonnet	Ba-lilla
Dimepiperate	0	0	0	0	0	0	0	0	0	0
Molinate	0	0.5	0	0	0	0	0.5	0	0	0
Benthiocarb	0.5	2	1	0.5	0.5	0	1	0	0	0

Dimepiperate has excellent safety and it can be used even at the stage of germination of rice plants. The safety of dimepiperate can be ranked in comparison with other herbicides as follows, dimepiperat molinate benthiocarb. It can be used for all types of rice cultivation such as direct seeded rice, transplanted rice under flooded and irrigated conditions.

3) Factors influencing herbicidal efficacy and phytotoxicity

a) Effect of soil kinds

Using four kinds of soils, the herbicidal efficacy and phytotoxicity of dimepiperate were determined by the method described previously and the results were shown in Table 5. The herbicidal efficacy and phytotoxicity of dimepiperate was not influenced by soil kinds.

Table 5. Growth inhibition of rice plant (Nihonbare) by using 4 kinds of soils.

Soil kind		TOYAMA	TOCHIGI	ATSUGI	IBARAKI
		alluvial soil	diluvial soil	alluvial soil	diluvial soil
H.C.*		2.7%	12	30	12
pH		5.7	6.2	6.5	6.5
Rice phytotoxicity**	3 *kg/ha*	115	110	117	113
	6 *kg/ha*	109	103	108	110
Residual barnyardgrass weight (%)	3 *kg/ha*	0.3	0.1	0.1	0
	6 *kg/ha*	0	0	0	0

** : aerial part weight (%)

* : humus concentrate

b) Effect of water depth

Changing the depth of water, the herbicidal efficacy of dimepiperate was compared with benthiocarb, and the results were shown in Fig. 2. Herbicidal efficacy of dimepiperate was less influenced than that of benthiocarb. The difference in herbicidal efficacy between the two herbicides became more remarkable in a water depth of 0.5 - 1.0 *cm*.

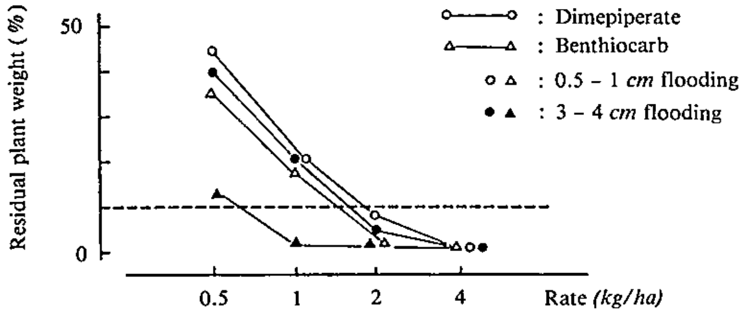


Fig. 2 Herbicidal efficacy by chainging water depth

c) Effect of temperature

Changing temperature conditions, such as the low temperature (10 - 12°*C*), the medium temperature (25 - 27°*C*) and the high temperature (32 - 34°*C*), the herbicidal efficacy and phytotoxicity of dimepiperate were determined by pot test in a phytotron. As shown in Table 6, all test temperature conditions showed no effect on the herbicidal efficacy and phytotoxicity even at the high dosage.

Table 6. Effect of temperature

Temperature condition		Low (10-20°*C*)	medium (25-27°*C*)	high (32-33°*C*)
Residual barnyardgrass weight (%)	1 *kg/ha*	0.3	0.1	0.2
	3 *kg/ha*	0	0	0
Rice aerial part weight (%)	3 *kg/ha*	110	113	110
	6 *kg/ha*	112	108	109

illuminatioin intensity 15,000 *Lux*. 12 *hr/day* humidity 60 - 75%

Consequently, dimepiperate shows stable efficacy and low phytotoxicity under a wide range of soil, water depth and temperature conditions.

4) Movement in soil

Relative mobility of dimepiperate in soil was determined by biosassay as shown in Fig. 3.

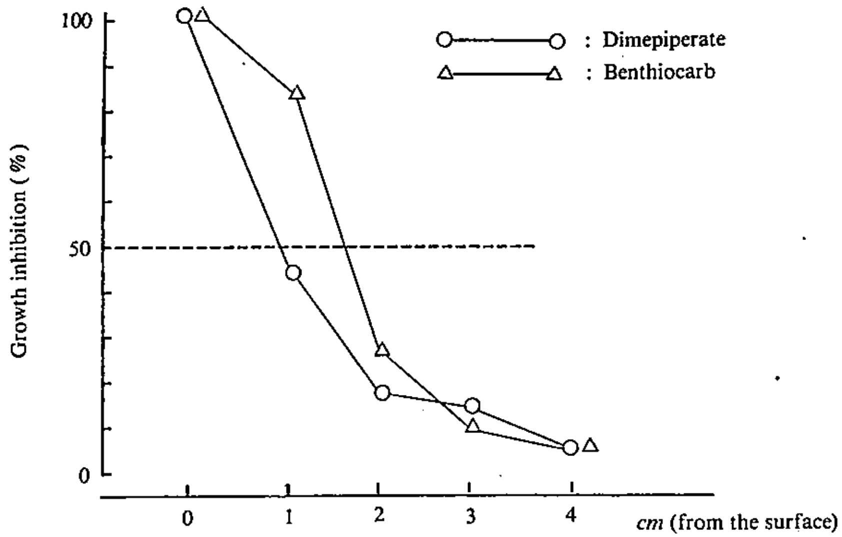


Fig. 3 Movement in soil

According to inhibitory activity on barnyardgrass, the movement of dimepiperate into the soil was the same as that of benthiocarb up to 3 *cm* from the surface.

5) Residual activity

Residual activity of dimepiperate was determined in comparison with molinate (Fig. 4).

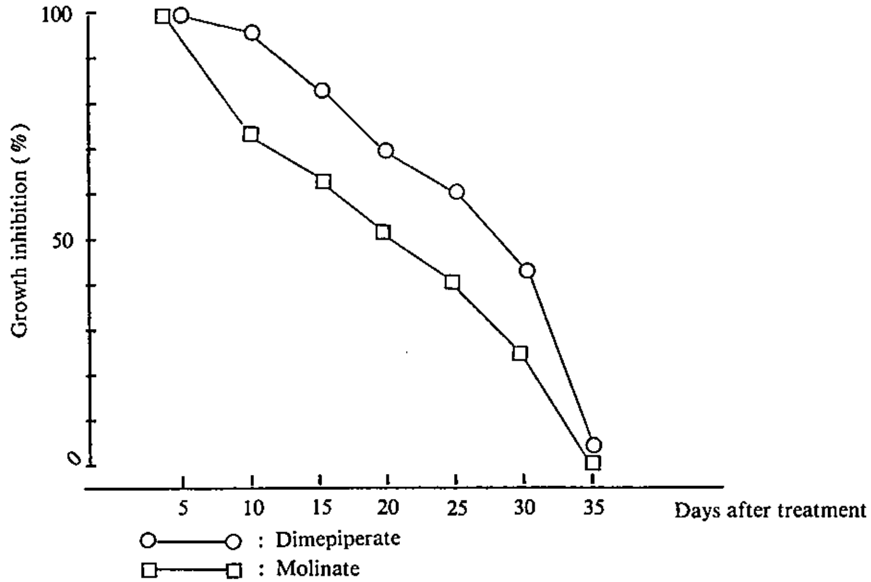


Fig. 4 Residual activity

Dimepiperate showed moderate persistance in soil and inhibited emergence of barnyardgrass for approximately 20 days. The result showed a little longer residual effect compared with that of molinate.

6) Absorption, translocation and metabolism

As shown in Fig. 5, root–applied ^{14}C–dimepiperate was readily absorbed by 3 leaf–stage plants and rapidly translocated into the aerial part of both rice plants and barnyardgrass.

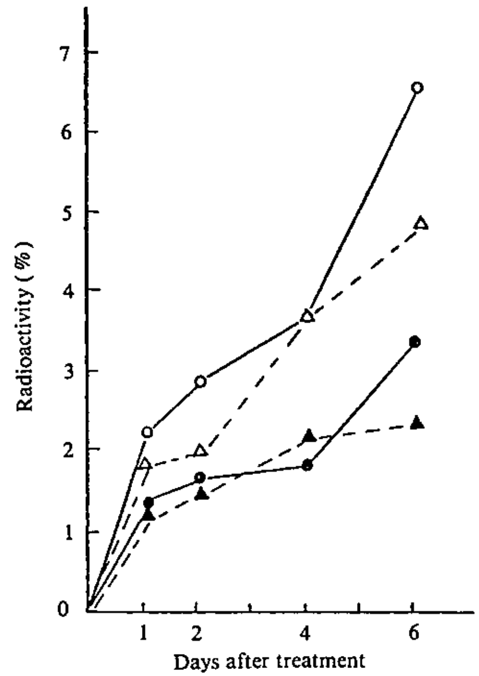


Fig. 5 Uptake and translocation of ^{14}C label in rice plant and barnyardgrass grown in nutrient solution containing (B – ^{14}C) dimepiperate (0.56 *ppm*) Data are shown as % of applied ^{14}C for two plants (3*L*).

	Whole plant	Shoot
Rice plant	○——○	●——●
Barnyardgrass	△– – –△	▲– – –▲

Autoradiograms showed a pattern of radiolabel distribution indicating the plants translocated the radioactivity into the shoot acropetally. Tanslocated dimepiperate was spread apoplastically in the whole plant body. The uptake from leaf and the successive translocation were examined by means of autoradiography. The radioactivity remained mostly in the treated leaf, and only a small amount was detected in the stem and root indicating dimepiperate is able to move downward. There was no translocation into other leaves.

^{14}C–dimepiperate absorbed from the stem similarly moved largely to the upper parts of the plants and a little to the roots. No differences in translocation between rice plants and barnyardgrass were obserbed in this study. Dimepiperate seems to be mainly absorbed through the stems as well as through the roots.

Therefore, as shown in Fig. 6, dimepiperate was more rapidly absorbed in barnyardgrass than in rice plants in the cases of 1 to 1.5 leaf-stage used and dimepiperate was also metabolised rapidly to the organic, water soluble and tissuebound metabolites. Amounts of 80% acetone extractable fraction reached to the maximum 1 or 2 days after treatment and rapidly decreased to the same level of rice plants fraction. It seems that the selectivity of the herbicidal activity between rice plants and barnyardgrass is probably due to the rapid absorption of barnyardgrass as compared with rice plants.

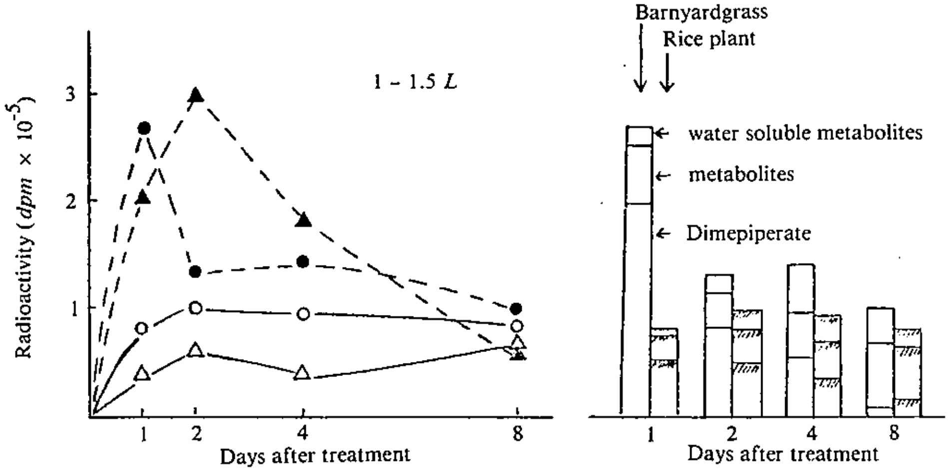


Fig. 6 Time course of 80% acetone extractable ^{14}C label in rice and barnyardgrass treated with (B – ^{14}C) MY – 93

	Shoot	Root
Rice plant	○——○	△——△
Barnyardgrass	●– – –●	▲– – –▲

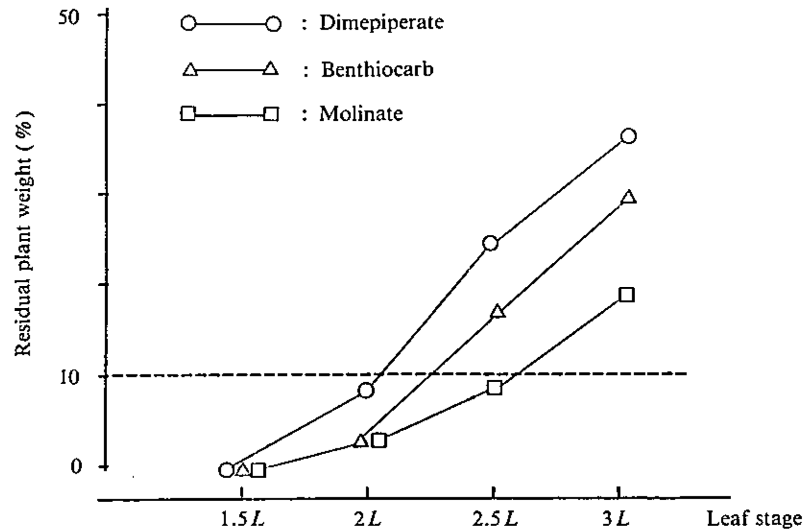


Fig. 7 Herbicidal activity against barnyardgrass in field test

7) Field test

Herbicidal activity against barnyardgrass was determined by the field test, and expressed as the ED_{90} value (the leaf-stage of 90% reduction of the fresh weight of residual weeds). The results were shown in Fig. 7. The dimepiperate exhibited a strong activity against barnyardgrass at up to 2 leaf-stage under flooded field test. The usable period of molinate and benthiocarb were 2.5 and 2.2 leaf-stage respectively, which were wider than that of dimepiperate.

SUMMARY

As a result dimepiperate proved good safety in the germ and seedling of rice, and efficient against barnyardgrass. Herbicidal properties of dimepiperate are as follows.

1. Dimepiperate is classified as a growth inhibition type herbicide and kills weeds primarily by inhibiting formation and elongation of their stems and leaves.
2. Dimepiperate exhibits higher activity on barnyardgrass than on other weeds such as broadleaves and sedges under flooded condition.
3. Dimepiperate has excellent inter-genus selectivity between rice and barnyardgrass and efficiently controls barnyardgrass at up to 2 leaf-stage without giving adverse effect to rice plants. It can be used for all types of rice cultivation.
4. Dimepiperate is absorbed mainly from the root, leaf and stem of the plant and translocated mostly in the upward direction. Absorption is more active in barnyardgrass than in rice.
5. Dimepiperate has moderate persistance in soil and inhibits emergence of weeds for approximately 20 days. The movement of dimepiperate into the soil is up to 3 *cm* from the surface.
6. Dimepiperate shows good control of barnyardgrass under a wide range of soil, water depth and temperature conditions.

HOE 33171 (FENOXAPROP-ETHYL) – A NEW PRODUCT FOR POSTEMERGENCE GRASS WEED CONTROL IN BROADLEAVED CROPS, ESPECIALLY IN VEGETABLES

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ABSTRACT

Hoe 33171 (fenoxaprop-ethyl) was tested for grass weed control in tobacco and a number of vegetable crops in Germany, Japan, Brazil, the Philippines and South Africa.

A large number of annual grass weeds, including *Rottboellia exaltata* and *Digitaria adscendens* are controlled by rates between 120 and 240 *g* a.i./*ha* More developed growth stages require higher rates than younger grasses.

Vegetable crops found to be tolerant to 270 *g/ha* a.i. or to higher rates include: broccoli, chinese cabbage, cauliflower, white and red cabbage, Brussel's sprouts, savoy cabbage, dwarf French bean, azuki bean, peas, faba beans (broad beans), soya, peanut, radish, carrot, tomato, egg plant, pepper, leeks, onion, garlic, lettuce, water melon, pumpkin, and furthermore tobacco. At this rate, damage may occur on mung beans and on cucumbers.

In yield trials conducted with different vegetable crops it could be demonstrated that yields were not reduced by normal and double use rates of Hoe 33171.

INTRODUCTION

Hoe 33171, proposed common name: fenoxaprop-ethyl, chemical designation: ethyl-2-(4 (6-chloro-2-benzoxazolyl-oxy-)-phenoxy)-propanoate, is a new herbicide for postemergence grass weed control and was first published by Bieringer et al (1982) and Schumacher et al (1982). This product has been developed initially for Johnsongrass and annual grass weed control in soya beans in North and South America (Strachan & Kinney, 1983; Olson & Hanson, 1983; Kinney, 1983), for annual grass weed control in rape seed, potatoes and sugar beets in Europe, and for annual grass weed control in direct seeded rice in North and South America (Todd, 1984; Thomas, 1984). In Argentina, the product has been commercially introduced under the trade name of ®Furore.

Parallel to this development, fenoxaprop-ethyl was tested for tolerance of various broadleaved crops, especially vegetable crops in Germany, Japan, Brazil, the Philippines and South Africa. The following report deals with this experimentation.

®Furore = registered trade mark of Hoechst AG

MATERIALS AND METHODS

Two formulations of Hoe 33171 were used in these trials, a 90 *g/l* EC (other code: Hoe 00664) and a 120 *g/l* EC (other code: Hoe 00581). Standard products used were alloxydim Na (75% WP) or fluazifop-butyl (250 *g/l* EC), the latter with an addition of oil or a surfactant.

Most trials were field trials using a randomized block design. Plot sizes for efficacy and tolerance trials — no yield determination — varied between 4 and 10 m^2 with 2 or 3 replicates. The crop tolerance trials with yield determination had plot sizes of 10 to 30 m^2, in one case even 55 m^2, and each treatment was replicated 4 times. In these trials the control plots were kept weed free unless otherwise indicated; if necessary, the whole trial area was sprayed with an appropriate herbicide for broadleaf weed control. Variance analysis has been used for computing the yield results. In table 1 the letters indicate differences in the mean yields according to Duncan's multiple range test: Treatments with the same letter had no significant differences at the 95% level. Applications were made postemergence (crop and weed) with van der Weij precision plot sprayers at a pressure of 2. 5 bar, using flat fan nozzles. Average water volume was 300 (200–400) *l/ha*; in the Japanese trials 1000 *l/ha* were used.

The 1983 crop tolerance tests in Japan were done as pot trials in an open vinyl house using 2 to 3 pots per treatment with uniform plant numbers and plant size.

Applications were made when annual grasses were between the 2 to 4 leaf or tillering stage, or the crop plants had developed 2 to 4 true leaves; details are given in the tables. Treatments were evaluated using a scoring system of 0 to 100 for herbicidal efficacy and phytotoxicity.

RESULTS

1. Crop tolerance trials

In a trial series conducted in Germany 1984, no damages could be observed in peas, dwarf french beans, broad field beans, carrots, onions and transplanted red and white cabbage after application of the very high rate of 450 *g* a.i./*ha*. In all crops the yields of the treated plots were practically equal to those of the handweeded check (table 1). Further trials conducted by the official plant protection service confirmed the good crop tolerance in white and red cabbage, cauliflower, savoy, Brussel's sprout, chinese cabbage and leeks; the rate used in these trials was 270 *g* a.i./*ha* (Schumacher, personal communication).

In South Africa fenoxaprop-ethyl was found to be tolerant to transplanted and seeded white cabbage (5 and 1 trials, resp.), transplanted tomato (2 trials), and tobacco (2 trials) at rates of 180 and 360 *g* a.i./*ha*; alloxydim Na at 937.5 and 1875 *g* a.i./*ha* was also tolerated. Assessments were made up to 4 weeks after application.

In Brazil, some trials in dwarf french beans in the 1981/82 and 1982/83 seasons indicated that even 240 *g* a.i./*ha* with the addition of 2 *l/ha* oil did not damage the crop. In the 1984/85 season a further trial in beans (table 1) showed no

Table 1. Fenoxyprop-ethyl: Relative yields of vegetables in 3 countries: formulations: in Germany EC 90, in the other countries EC 120.

country, year crop (stage at applic.)	check	fenoxaprop-ethyl g a.i./ha		fenoxaprop-ethyl + oil g a.i./ha		fluazifop-butyl g a.i./ha	
		x	2x	x	2x	x	2x
1. Germany 1984:	hand-weeded	225	450	-	-	375 (+ 0, 025 % wetting agent)	
pea (pre-flower)	100 A	95 A	97 A			96 A	
dwarf bean (pre-fl.)	100 A	96 A	94 A			102 A	
broad bean (2 1)	100 A	95 A	97 A			100 A	
carrot (6 1)	100 A	96 A	98 A			95 A	
onion (6 1)	100 A	90 A	96 A			95 A	
red cabbage (8 1)*	100 A	97 A	97 A			95 A	
white cabbage (8 1)*	100 A	99 A	102 A			97 A	
2. Brazil 1984/85:	un-weeded	180	360	180 (1. 5 l/ha oil)	360	375 (+ 2. 0% adjuv.)	750
dwarf bean (1st trif. leaf)	100 A	89 A	103 A	103 A	94 A	101 A	94 A
cucumber (2 1)	100 B	132 AB	97 B	-	-	145 AB	154 A
3. Philippines 1985:	hand-weeded	-	-	120 (+ 2 l/ha oil)	240	150 (+ 2 l/ha oil)	300
cabbage (5-9 1)*	100 AB			108 A	97 AB	94 B	100 AB
chinese cabbage (3-8 1)*	100 A			100 A	103 A	105 A	96 A
mungbeans (2-5 1)	100 A			97 AB	102 A	100 A	90 B
tomato	100 A			115 A	98 A	107 A	112 A

* transplanted

significant yield differences in plots treated with 180 or 360 *g* a.i./*ha* as compared to the untreated check. Even the addition of oil to fenoxapropethyl did not cause any damage. The same applies for fluazifop-butyl at 375 and 750 *g* a.i./*ha*. *Eleusine indica* at tillering stage was completely controlled. — In cucumbers, the high rates of fenoxaprop-ethyl and of fluazifopbutyl were completely tolerated by the crop, however, the yields varied to a certain degree; they were higher in the fluazifop-butyl plots than in those treated with fenoxaprop-ethyl. *Digitaria sanguinalis* (stage: beginning of tillering) was completely controlled by both products. New emergence of this weed occured in this trial, more in the Hoe 33171 than in the fluazifop-butyl treated plots.

In the Philippines, from 1982 - 1984 crop tolerance tests were conducted with fenoxaprop-ethyl. The following crops were found to tolerate 360 *g* a.i./*ha* of the product: cabbage, tobacco, pepper, soya bean, bush bean, onion; 480 *g* a.i./*ha* were tolerated by tomato, egg plant, peanut, cucumber, water melon and garlic. The only vegetable crop to react with leaf distortion and twisting was mungbean; these symptoms occured at lower rates (180 to 240 *g* a.i./*ha*). However, in a yield trial (see table 1) no yield reduction could be found at the highest rate 240 *g* a.i./*ha* (+ oil). The same applies for the other crops tested in this series: cabbage, chinese cabbage, and tomato.

Further crop tolerance tests have been made in Japan from 1980 to 1983 with both formulations. Only azuki bean and in one trial pumpkin reacted to the application of fenoxaprop-ethyl at higher rates (540-720 *g* a.i./*ha*), and cucumbers were sensitive even to lower rates (240 *g* a.i./*ha*).

Crops found to be tolerant were: Chinese cabbage, broccoli, white cabbage, cauliflower, lettuce (all tolerant to 720 *g* a.i./*ha*), Japanese radish, tomato, egg plant, carrot, dwarf French bean, green soya bean (all tolerant to 540 *g* a.i./*ha*) and peanut (tolerant to 225 *g* a.i./*ha*).

A general survey on the results of tolerance trials is given in table 2.

Table 2. Fenoxaprop-ethyl: survey on crop tolerance and yield trials in 5 countries. 1980 - 1984/85

species	countries*	rate**	species	countries*	rate**
dwarf french bean	1, 2, 4, 5	C 540 Y 450 Y 360***	cabbage (white and red)	1, 2, 4, 5	C 720 Y 240*** Y 450
mung bean	4	C 180 (240) Y 240***	cauliflower	1, 5	C 720
			savoy	1	C 270
braod bean	1	Y 450	broccoli	5	C 720
azuki bean	5	C 360 (540)	chinese cabbage	1, 5 4	C 720 Y 240***
pea	1	Y 450	Brussel's sprouts	1	C 720
soya bean	4, 5	C 540			
peanut	4, 5	C 480	Japanese radish	5	C 540
cucumber	3, 4 5	C 480 (240) Y 360	tomato	2, 4, 5	C 540 Y 240***
			egg plant	4, 5	C 540
water melon	4	C 480	pepper	4	C 360
			tobacco	2, 4	C 360
pumpkin	5	C 360 (540)	onion	1, 4	C 360 Y 450
carrot	1, 5	C 540 Y 450	leeks	1	C 270
			garlic	4	C 480
lettuce	5	C 720			

* 1 - Germany, 2 - South Africa, 3 - Brazil, 4 - Philippines, 5 - Japan
** highest rate tolerated in *g* a.i./*ha* : C = crop tolerance, Y = in yield trials; figures in brackets ( ) indicate rates with visual symptoms
*** with addition of oil

2. Grass weed control trials

Parallel to the crop tolerance tests, a number of efficacy trials were conducted. A few are mentioned here.

In the Philippines, Hoe 33171, was tested for *Rottboellia exaltata* control. Trials were done in the wet season with dosage rates between 60 and 180 *g* a.i./*ha*. Applications were done at different stages of weed growth. Trials at different growth stages were laid down side by side for comparison. The first stage was 1 to 4 leaves and 3-13 *cm* plant height; the later stage was 4 to 5 leaves to beginning of tillering and 10-30 *cm* plant height of *R. exaltata*. At the early stage, 90 *g/ha* and at the later stage trial 180 *g/ha* Hoe 33171 were necessary to achieve at least 90% control. The corresponding rates of fluazifop-butyl (+ oil) were 150 and 250 *g/ha*. — Other trials indicate, however, that under very dry conditions the effect of fenoxaprop-ethyl was weaker than under wet conditions.

In trials conducted with Hoe 33171 in Japan, *Digitaria adscendens* was the main target weed. In a typical trial, the efficacy at 3 different growth stages could be compared side by side: At application before tillering, 60 *g* a.i./*ha* were necessary for *Digitaria* control, at beginning of tillering 90-120 and at 4-5 tillers 180 *g/ha* were required. The corresponding rates of alloxydim Na were 750 *g/ha* or above for the control of the youngest, and 1500 *g/ha* or slightly less for the control of the bigger plants.

DISCUSSION

Hoe 33171, fenoxaprop-ethyl, has been tested intensively for some years and has been found to control grassy weeds very well. Principal data has been published on rates required for annual as well as for perennial grass weed control. It indicates that generally 100 to 220 *g* a.i./*ha* are necessary to achieve a good control of annual grasses (Schumacher et al, 1982, Bieringer et al, 1982; Kinney, 1983; Strachan & Kinney, 1983; Olson & Hanson, 1983; Product Information Furore, 1984). Olson and Hanson pointed out, however, that in semi arid areas the use rate should be 280 *g* a.i./*ha* (0, 25 *lbs/acre*). This corresponds with the experience that under very dry conditions the efficacy of fenoxaprop-ethyl is not as good as under good growing conditions. The efficacy data presented in this paper is generally in agreement with that published earlier. This applies even for the specific sensitivity of different growth stages: Lower rates are needed for the control of younger growth stages.

Generally it can be assumed that 180 to 240 *g* a.i./*ha* is sufficient to control a broad spectrum of annual grass weeds in more advanced growth stages and of *Sorghum halepense*. For the control of younger growth stages (at least 2 leaves) under good growing conditions the rates may be reduced to 100 or 120 *g/ha*.

In all yield trials reported in this paper normal ("normal in this connection means: according to local experience and requirements) and double use rates of fenoxaprop-ethyl were applied to various vegetable crops. No trials showed a significant yield reduction. This applies to those trials which were kept weed free mechanically. However, grass weeds occured in the trials conducted in Brazil. The dwarf bean trial showed no influence of treatments on yields, as the infestation of *Eleusine indica* was relatively low. The situation in the cucumber trial was different. Here, after complete control of all *Digitaria* plants by the herbicides, a second flush germinated (influenced of irrigation). The better yields obtained in the fluazifop-butyl plots may be owing to the longer preemergence effect of this material as compared with fenoxaprop-ethyl. The only crop tested in yield trials to show some phytotoxicity symptoms was mungbean *(Phaseolus aureus)*. The symptoms grew out later and no yield reduction could be determined even for fenoxaprop-ethyl + oil treatments.

In other orientative crop tolerance trials very high rates were applied in some cases. In Japan azuki bean *(Phaseolus angularis)* and pumpkin *(Cucurbita pepo)* showed some phytotoxicity symptoms to the high rate of 450 *g* a.i./*ha*. These symptoms were leaf spots, leaf necroses or leaf distortion, which all later grew out. However, this rate is so extremely high, that it will not be used. Only cucumbers were more damaged in Japanese trials at lower rates (240 *g/ha*). The reason why cucumbers in the Japanese trials were less tolerant to Hoe 33171 than in Brazil or in the Philippines may be the different sensitivity of the Japanese varieties.

Generally it can be concluded that Hoe 33171 (fenoxaprop-ethyl) is very safe to nearly all vegetable crops.

ACKNOWLEDGEMENT

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INFLUENCE OF RAINFALL AND SOIL MOISTURE ON THE ACTIVITY OF SOME NEWLY DEVELOPED POST-EMERGENCE HERBICIDES

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ABSTRACT

The effect of rainfall and varying soil moisture levels on the activity of several herbicides was studied in glasshouse using maize *(Zea mays)* as the test species. Simulated rainfall (10 *mm* over 20 minutes) half an hour after application of alloxydim sodium, fluazifop-butyl and fenoxaprop-ethyl reduced the activity of these compounds, but on marked effect was noted when one hour lapsed between spraying and the rainfall. the phytotoxicity of Dowco 453 and CGA 82725 was reduced by rainfall up to one hour after application, while sethoxydim and fenthiaprop-ethyl were affected by rain up to two hours after spraying. The effectiveness of non-selective herbicides, viz. glyphosate, glufosinate and SC-0224 was reduced significantly by rainfall within four hours after application. Damage to plants from all herbicides was less in pots which were watered to only 70 or 50% of the field capacity for one week before or after spraying, compared to the pots watered to 100% field capacity. Differences due to both rainfall and soil moisture were higher at the low and middle rate of herbicides, and were more pronounced in the first two weeks after spraying.

INTRODUCTION

During the past few years several new selective herbicides have been developed for control of grass weeds in broadleaf and non-graminaceous crops. This alternative to traditional pre-emergence herbicide treatments allows greater flexibility in establishing broadleaf crops and for use in situations such as no tillage, reduced tillage and narrow-row crop production. Most of these selective post-emergence herbicides have a similar mode of action viz., disruption and decay of meristematic tissues, and appear to translocate to underground plant parts (Velovitch 1982). The major activity is through foliar uptake, but some soil activity has been demonstrated for most of them as pre-emergence treatments, although at much higher rates of application.

The effectiveness of most foliar-applied herbicides is reduced if rain falls soon after application (Muzik 1976). As the new selective herbicides are readily absorbed by the foliage of the plant and travel quickly to the site of action (Velovitch 1982), this should lessen the chance of interference by rainfall with their effectiveness. The activity of the non-selective herbicides such as glyphosate and glufosinate, on the other hand, has been reported to be reduced by rainfall occurring up to six hours after their application (Spurrier 1973, Hoechst 1983).

The growth and development of plants and the effectiveness of herbicides are all affected by the water status of the soil. Glasshouse and field research indicates that phytotoxicity of post-emergence herbicides is reduced under conditions of moisture stress shortly before or after spraying. Such observations have also been made with the selective grass weedkillers (Bieringer et al 1982, Blair et al 1984, Caseley 1984, Peek 1982, Ready 1982) as well as the non-selective herbicides such as glyphosate and glufosinate (Moosavi-Nia and Dore 1979, Hoechst 1983).

The objectives of this research were to study the effect of simulated rainfall at different intervals after spraying and that of various soil moisture levels before and after spraying on the activity of several recently developed herbicides for grass weed control. Two non-selective experimental herbicides along with the closely related and established compound glyphosate were also included in these studies.

MATERIALS AND METHODS

The soil used for all the experiments was a Horotiu sandy loam with 61% *sand, 19%* silt, 12% clay, 9.8% organic carbon, a CEC of 31.6 *m.e./*100 *g,* field capacity of 41.6%, and a pH of 5.6. Maize (*Zea mays* cv. Pioneer 3709) was used as the test species. Six seeds were planted in 15 *cm.* plastic pots and plants were thinned to four plants per pot after emergence. The treatments were replicated six times and pots were arranged in a randomised block design.

To study the effect of rainfall, post-emergence applications of herbicides were made 14 to 16 days after planting, when the plants had reached a height of about 15 *cm.* A single nozzle glasshouse pot sprayer delivering 360 *l/ha* at 210 kPa was used for spraying three rates of each chemical. A whited emulsifiable crop oil was mixed with alloxydim sodium, sethoxydim and Dowco 453 at 1% *v/v* of spray mix. A non-ionic wetting agent at 0.6% *v/v* was added to fluazifop-butyl. Rainfall (10 *mm* over 20 munutes) simulated through an overhead glasshouse irrigation system was applied to the pots at 0.5, 1, 2 or 4 hours after spraying of the herbicide treatments. Humidity in the glasshouse was maintained around 85% during and 8 hours following the rainfall treatments.

For the soil moisture studies, herbicide treatments were applied as above 14 to 16 days after planting of maize. At the start of the experiment the soil moisture was kept close to field capacity (FC) by surface watering. This moisture level was either maintained throughout the experiment or dropped to 50 ± 3% FC or 70 ± 5% FC for one week before or after the spraying of herbicides.

The glasshouse was maintained between 22 and 30 $^{\circ}C$ temperature and no artificial light was provided. Pots were kept close to field capacity throughout the duration of the experiments by regular surface watering except in the case of soil moisture studies as above. All experiments were repeated three times over a two year period. Herbicide response was evaluated by regular visual damage scores, and by harvesting top growth and recording dry matter weight of surviving plants about five weeks after planting.

RESULTS AND DISCUSSION

The influence of rainfall at different intervals after application of treatments is shown in Table 1. The effect varied considerably with the rate of application, the largest reductions in phytotoxicity being recorded with the low and middle rates which reduced dry matter by 30 to 70%. At the high rate, despite the interference by rainfall, sufficient chemical was probably absorbed by the plant foliage to be phytotoxic to maize seedlings. Reduction in activity due to rainfall at the high rates was often evident in the first two weeks after spraying, but differences became less evident or disappeared with time.

Table 1. Effect of rainfal at different intervals after spraying on the phytotoxicity of various herbicides.

Herbicides	Rate[1] (kg/ha)	Dry shoot weith of maize (% of untreated control)				
		No rainfall	Rain hours after spraying			
			0.5	1	2	4
Alloxydim sodium	0.35	33	58*	38	31	37
	0.70	9	17	13	14	11
	1.40	0	0	0	0	0
Fluazifop-butyl	0.03	59	67	56	68	62
	0.06	7	39*	21	11	13
	0.12	0	8	7	2	2
Fenoxaprop-ethyl	0.13	33	76*	47	38	31
	0.25	8	37*	16	10	10
	0.50	0	11	9	3	5
Dowco 453	0.03	57	88*	71	62	58
	0.06	34	72*	59*	30	38
	0.12	3	3	9	2	0
CGA-82725	0.13	73	84	79	81	71
	0.25	50	77*	74*	46	41
	0.50	8	41*	48*	17	10
Sethoxydim	0.08	68	102*	97*	66	72
	0.16	27	73*	74*	51*	33
	0.32	3	61*	42*	17	1
Fenthiaprop-ethyl	0.08	77	108*	106*	98*	72
	0.16	16	58*	60*	71*	20
	0.32	0	18	5	3	2
Non Selective Herbicides						
Glyphosate	0.72	7	68*	62*	64*	57*
	0.96	0	43*	49*	31*	8
	0.96[1]	0	0	0	0	0
SC-0224	0.36	47	93*	88*	94*	76*
	0.72	12	67*	64*	57*	39*
	0.96	5	40*	46*	35*	16*
Glufosinate	1.0	63	100*	101*	107*	94*
	2.0	12	81*	84*	77*	71*
	3.0	1	45*	38*	36*	18

* Significantly different ($P < 0.05$) from the no rainfall figures for that rate of herbicide.
[1] Emulsifier X-45 added at 0.5% *v/v*.

Rainfall half an hour after application of alloxydim-sodium, fluazifop-butyl and fenoxaprop-ethyl resulted in significant reduction in the activity of these compounds, but no marked effect was noted when an hour lapsed between spraying and the rainfall. The phytotoxicity of Dowco 453 and CGA 82725 was reduced by rainfall up to one hour after application but not when a two-hour interval had passed. Sethoxydim and fenthiaprop-ethyl showed a reduction in activity when rainfall was recorded up to two hours after spraying. It is not clear why these differences were noted between different selective herbicides, particularly when their modes of uptake and action are similar (Velovitch 1982). Differences in their commercial formulations may have some influence on their rainfastness.

The effectiveness of three non-selective herbicides, viz. glyphosate, SC-0224 and glufosinate was affected considerably more by rainfall when compared to the selective grass herbicides. The reduction in dry matter weights of maize plants due to all three herbicides was significantly less if rain fell within four hours after treatment (Table 1). These results confirm the earlier observations with glyphosate and glufosinate that rainfall up to six hours after their application may reduce the level of activity (Spurrier 1973, Hoechst 1983). Addition of an emulsifier X-45 (tested only with glyphosate) nullified the negative impact of rainfall on the foliar activity of glyphosate. Further work is in progress with different emulsifiers and surfactants at present.

Experiments on the effects of soil moisture status showed that when soil water content dropped from 100% FC to 70 or 50% FC, the activity of all selective grass herbicides was significantly reduced (Table 2). In some instances the reduction in phytotoxicity was not significant, but a trend towards reduction due to lowered soil moisture was apparent in most cases. These results are supported by observations made by other workers for some of these herbicides (Banks and Tripp 1983, Bieringer et al 1982, Velovitch 1982). There is a suggestion from data in Table 2 that moisture deficit after spraying was more consistent in significantly reducing the damage to plants, and that 50% FC possibly had more effect on herbicide activity than the 70% FC moisture level. As with rainfall, differences due to soil moisture were more obvious in the first two weeks after spraying.

Table 2. Effect of different soil moisture levels one week before or after spraying on the phytotoxicity of various herbidides.

Herbicides	Rate[1] (kg/ha)	Dry shoot weight of maize (% of untreated control)				
		Moisture level as 1% of field capacity				
		50	70	100	50	70
		(week before spraying)			(week after spraying)	
Alloxydim sodium	0.35	64*	57*	31	68*	53*
	0.70	22*	7	4	12	10
Fluazifop-butyl	0.03	49	46	35	61*	47
	0.06	34*	22	10	31*	21

Herbicides	Rate[1] (*kg/ha*)	Dry shoot weight of maize (% of untreated control)				
		Moisture level as 1% of field capacity				
		50	70	100	50	70
		(week before spraying)			(week after spraying)	
Fenoxaprop-ethyl	0.13	75*	76*	53	74*	79*
	0.25	42*	33	21	51*	45*
Dowco 453	0.03	81*	76*	52	76*	69
	0.06	22	19	12	39*	25
CGA-82725	0.13	68*	63*	41	64*	68*
	0.25	24*	11	4	36*	21
Sethoxydim	0.08	79*	71	57	90*	78*
	0.16	43*	46*	20	58*	50
Fenthiaprop-ethyl	0.08	54*	45	34	63*	56*
	0.16	21*	12	3	26*	24*
Non Selective Herbicides						
Glyphosate	0.72	66*	62*	31	60*	71*
	0.96	36*	23	9	29*	33*
SC-0224	0.72	70*	63*	42	63*	69*
	0.96	38*	32*	11	32*	37*
Glufosinate	1.0	71*	64	52	75*	72*
	2.0	41*	45*	18*	42*	31

* Significantly different ($P < 0.05$) from the 100% FC figures for that rate of herbicide.
[1] High rates not included in the table, as no significant differences due to soil moisture were recorded.

Low soil moisture levels also depressed the activity of all three non selective herbicides (Table 2). No marked differences were observed between 50 and 70% FC moisture levels or due to whether the moisture content was lowered before or after spraying. Ismael *et al* (1983) reported reduced kill of couch by glyphosate when plants grew under water deficit stress before or after spraying.

CONCLUSIONS

A rainfall of 10 *mm* over 20 minutes would be considered a fairly heavy level of precipitation. The activity of most selective grass herbicides was not seriously affected if such rain fell one or two hours after their application. The rapid absorption of these herbicides by the plant foliage and their relative rainfastness is a very desirable attribute for their use as post-emergence treatments. The three non selective materials were prone to be washed off plant surfaces by rainfall for longer periods after spraying than the selective herbicides. Limited work with glyphosate suggests that addition of an emulsifier may improve its rainfastness markedly. The effectiveness of both selective and non selective herbicides was reduced significantly when the plants were subjected to a moisture stress for one week before or after chemical application. Differences due to both rainfall and soil moisture were more obvious in the first two weeks after spraying.

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MODE OF SELECTIVITY OF LONDAX® HERBICIDE (DPX F5384) IN PADDY RICE

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ABSTRACT

LONDAX® [Methyl 2-[[[[(4,6-dimethoxypyrimidin-2-yl) amino]carbonyl]amino] sulfonyl]benzoate], a member of the unique class of herbicides known as sulfonylureas, is a broad-spectrum herbicide for direct-seeded and transplanted paddy rice. Extensive field tests have demonstrated that the compound is very useful for the control of most key weed species in the paddy field, especially broadleaves and sedges. Rice crop tolerance to "Londax" has also been proven through a number of greenhouse and field trials under various conditions over the last five year. Recent laboratory studies indicate that this high tolerance of rice to "Londax" is related to the ability of rice leaves to rapidly metabolize "Londax" to an inactive compound. Sensitive weeds such as *Alisma trivale* and *Cyperus difformis* show little or no metabolism of "Londax."

INTRODUCTION

Sulfonylurea compounds discovered and developed by E.I. du Pont de Nemours and Company are new herbicide products with high weed control activity and crop safety. Glean® chlorsulfuron and Oust® sulfometuron methyl have been introduced commercially. Under development are Ally® metsulfuron methyl (code name DPX T6376), Classic® (DPX F6025), Harmony® (DPX M6316) and "Londax" (DPX F5284)[(1,2,3,4)]. These sulfonylurea compounds from Du Pont are uniquely selective to certain crops such as cereals, soybeans or rice.

The mode of action of sulfonylurea herbicides has been studied by Ray[(5)]. The primary site of action for these compounds is the inhibition of acetolactate synthase (ALS), an important enzyme in the pathway for branched-chain amino acid biosynthesis.

"Londax" has been extensively tested in a number of countries for various types of rice culture. In our field studies, crop tolerance has been seen with rates up to 800 *g ai/ha* with transplanted Indica-type rice varieties. Weed control activity was clearly observed at rates as low as 25 *g* ai/*ha* with certain annual weed species[(6)]. Here we report on selectivity studies which demonstrate that "Londax" is safe to rice due to rapid metabolic detoxification.

MATERIALS AND METHODS

Experiment 1.

Pre-germinated seeds of rice *(Oryzae sativa* Cv. "Nihonbare"), barnyardgrass *(Echinochloa crus-galli), Monochoria vaginal is* and *Scirpus juncoides* were planted separately into 40 cm^2 pots under simulated paddy conditions with 3 *cm* depth of water at the rate of 10, 20, 30 and 20 seeds per pot, respectively. Two days after planting, "Londax" technical grade material (99.9% purity) dissolved in acetone solution was applied at the rates of 1.6, 3.1, 6.3, 12.5, 25, 50 and 100 g *ai/ha.* Fourteen days after chemical treatments, the above-the-soil parts of each plant were cut and weights were measured after drying at 70°C for 48 *hours.* The experiment was carried out in a growth chamber with temperature condition 25°C by day and 20°C at night, and with 33,000 *lux* light intensity with two replications.

Experiment 2.

"Londax" at the rate of 0.4, 2, 10 and 100 *g ai/ha* was treated on the surface of 2 *cm* soil layer and then thoroughly incorporated into the soil. A portion of treated soil was transferred into plastic containers of 10 *cm* × 20 *cm* and the seeds of rice *(0. sativa* Cv. Nihonbare") and wheat *(Triticum aestirum),* and Chinese cabbage *(Brassica pekinensis)* and spinach *(Spinacia aleracea)* were placed on the soil in a separate container, at the rate of 12 seeds each per plot and 14 seeds each per plot, respectively. Visual rating of the growth retardation was done by 0–10 scale; 0 = no effect, 10 = completely killed, and the fresh weights of above–the–soil parts of each plant were measured 14 days after seeding. The experiment was carried out under dry land conditions in a greenhouse with temperature 27°C by day and 15°C at night and with three replications.

Experiment 3.

"Londax" plant metabolism studies were carried out with rice *(O. sativa* Cv. "Nihonbare"), waterplantain *(Alisma trivale),* arrowhead *(Sagittaria latifolia),* smallflower umbrellaplant *(Cyperus difformis),* barnyardgrass *(Echinochloa crus-galli)* and sprangletop *(Leptochloa dubia)* at 13 to 18, 28 to 34, 10 to 15, 42 to 56, 14 to 19, and 19 days after planting, respectively. The cut end of excised leaves were allowed to take up a nutrient solution containing ^{14}C radiolabeled material of "Londax" for one hour and then transferred to a nutrient solution for 1 to 24 hours. The amount of unmetabolized "Londax" in an acetone extract of the leaves was measured by HPLC and a radioactive flow detector.

RESULTS

Experiment 1.

As shown in Figure 1, remarkable differences in sensitivity to "Londax" was seen between rice and tested paddy weeds; *E. crus-galli, M. vaginalis* and *S. juncoides.* Although marked growth retardation of these weeds was observed with "Londax" rates as low as 1.6 *g ai/ha,* only slight phytotoxicity was observed with rates up to 50 *g ai/ha* on direct water-seeded rice when applied very early postemergence.

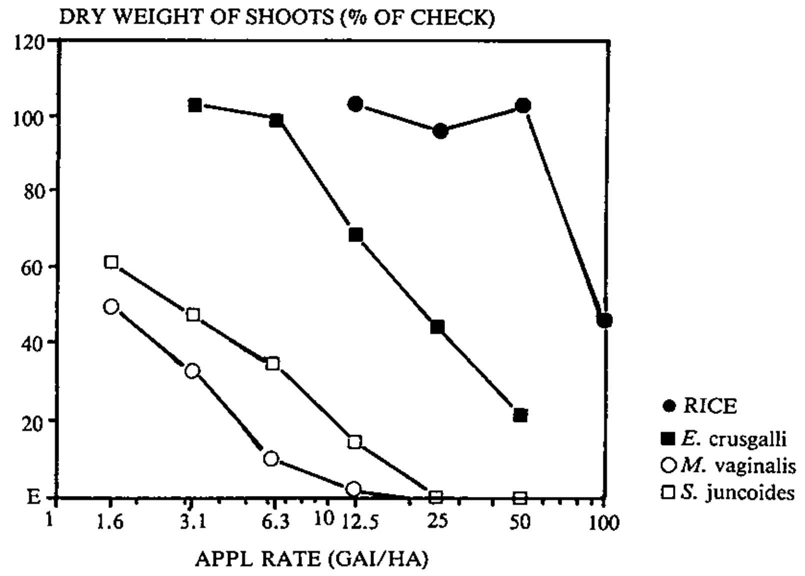

Figure 1. Selectivity of Londax: rice vs. paddy weeds

Experiment 2.

Similar sensitivity differences between gramineous crops and broadleaf crops were seen in this experiments. Under the dry land condition, rice and wheat did not exhibit any visible phytotoxicity symptoms with "Londax" rates up to 10 *g ai/ha.* whereas the growth of Chinese cabbage and spinach was severely retarded with rates as low as 2 *g ai/ha.* Table 1 shows the visual rating and fresh weight percentage of untreated check by each tested crop.

Table 1: Selectivity to "Londax" — Broadleaf Crops vs. Gramineous Crops

		Rice		Wheat		C. Cabbage		Spinach	
Treatment	Dose	V.C.	F.W.	V.C.	F.W.	V.C.	F.W.	V.C.	F.W.
	(g a.i./ha)								
"LONDAX"	100	0	107	0	115	8	22	8	20
	10	0	110	0	105	6	30	6	40
	2	0	105	0	100	4	57	5	67
	0.4	0	102	0	105	1	78	1	105

V.C. : Visual Count ... 0-10 rating scale of phytotoxicity
0=no phyto; 10=completely killed
F.W. : Fresh Weight of Shoot, % of Untreated Check

Experiment 3.

"Londax" metabolism by the rice leaves was very rapid. The metabolism followed pseudo first order kinetics; a plot of the log of unmetabolized herbicide remaining in the leaves vs. time gave a straight line from which a metabolic half-life could be calculated, as shown in Figure 2. In the same way, "Londax" half-lives in *A. trivale, S. latifolia, C. difformis, E. crus-galli* and *L. dubia* have been determined, as shown in Table 2. Weeds sensitive to "Londax" such as *A. trivale, S. latifolia* and *C. difformis* show little or no metabolism of "Londax". Note that in the case of *E. crus-galli,* which shows intermediate sensitivity, we see an intermediate rate of metabolism while the more tolerant *L. dubia* shows rapid metabolism.

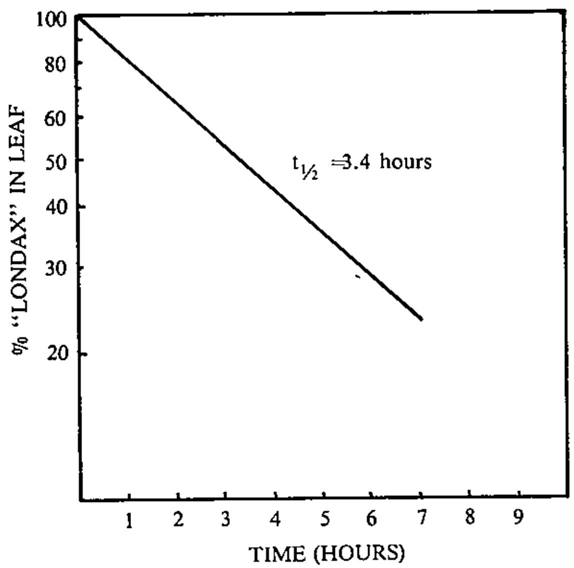

Figure 2. Metabolism of "Londax" by rice leaves

Table 2: Metabolism of "Londax" by rice and weed leaves

Plant Material	Metabolism Half-Life (Hours)
Rice (Cv. "Nihonbare")	2.6-60
Alisma trivale	50
Sagittaria latifolia	50
Cyperus difformis	50
Echinochloa crus-galli	12 - 50
Leptochloa dubia	1.5

The age of the plants: Rice - 13 to 13 days old; A. *trivale* - 28 to 34 days old; *S. latifolia* - 10 to 15 days old; *C. difformis* 6 to 8 weeks old; *E. crus-galli* - 14 to 19 days old; *L. dubia* - 19 days old.

DISCUSSION

In growth chamber and greenhouse studies (Figure 1 and Table 1), there is a clear diffrence in sensitivity to "Londax" for weeds versus crop plants or broadleaf crops vs. gramineous crops at several application rates. This agrees with our field observations for "Londax" in which we see selective control of broadleaves and sedges in paddy rice. These differences in selectivity indicate differences in the way crops and weeds react to "Londax". For chlorsulfuron, it is known that tolerance in wheat is due to metabolism of a compound which does not inhibit acetolactate synthase and is therefore non-herbicidal. The active sulfonylurea ingredient in "Londax" inhibits rice acetolactate synthase, but rice remains tolerant. Rice has the ability to metabolize the active ingredient in "Londex" at a rate much faster than the weeds (Figure 2, Table 2). The metabolite produced in rice is a hydroxylated derivative probably formed by oxidative demethylation (Figure 3). This metabolite does not readily inhibit acetolactate synthase and is not herbicidal. This evidence strongly suggests that metabolism plays a key role in the tolerance of rice to "Londax".

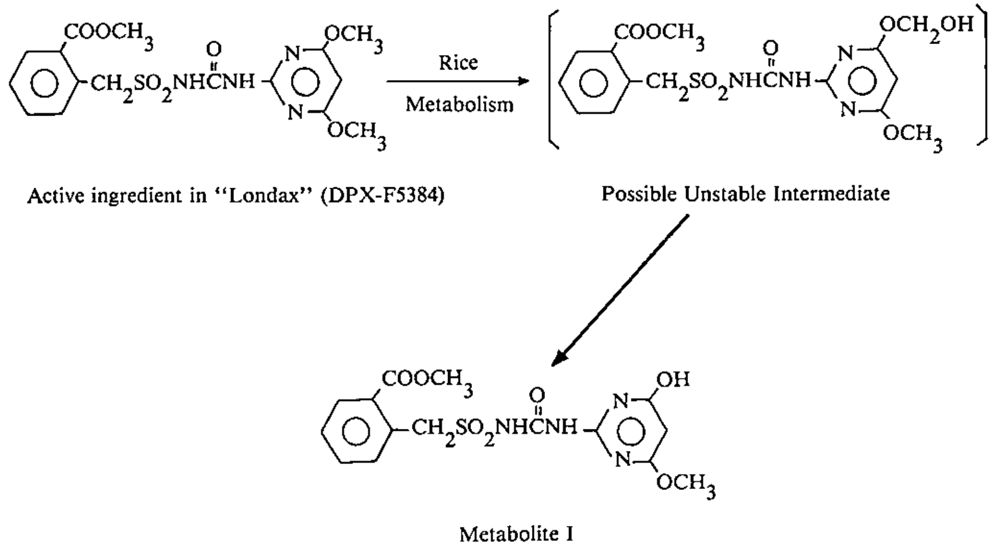

Figure 3. Metabolism of "Londax" by rice leaves

CONCLUSION

The selectivity of "Londax" toward rice is clearly seen in the greenhouse and growth chamber studies using representative paddy weeds (grasses, broadleaves and sedges) and the crop plant, rice. The safety of "Londax" to rice is due to metabolism to a hydroxylated compound which does not readily inhibit rice acetolactate synthase and is non-herbicidal. Our observations in extensive field studies show that "Londax" is a highly-effective and selective weed control tool in paddy rice.

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NC-310, A NEW RICE HERBICIDE IN JAPAN

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ABSTRACT

NC-310 is a new herbicide for paddy rice, which causes chlorosis on many kinds of weeds. NC-310 has a broad herbicide spectrum against paddy weeds including perennial species. The most noticeable characteristic of NC-310 is that it shows excellent efficacy against *Cyperaceae*, especially *Cyperus serotinus*. In a practical using, NC-310 controlled most of paddy weeds at the rate of 1.5 *kg a.i./ha* in Japan.

INTRODUCTION

5-benzyloxy-4-(2,4-dichlorbenzoyl)-l-methyl prazole is a new broad-spectrum herbicide being developed under the code number of NC-310 by NISSAN CHEMICAL IND. for paddy rice *(Oryza sativa.* L).

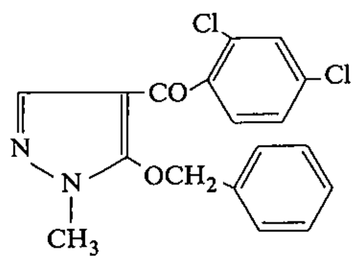
NC-310 was discovered by NISSAN CHEMICAL IND. 1982 and official tests started in 1984 by national and prefectural stations assosiated with the Japan Association for Advancement of Phytoregulators (JAPR). In 1985, NC-310 was evaluated in the formulaton of 5% granule and two kinds of mixed granule.

This paper describes the herbicidal properties of NC-310 in paddy rice in Japan.

Chemical and physical properties of NC-310

chemical name :
5-bezyloxy-4-(2,4-dichlorobenzoyl)-1-methyl pyrazole

structural formula :



molecular formula :	$C_{18}H_{14}O_2N_2Cl_2$
molecular weight :	361.23
physical form :	colorless crystal
melting point :	59° *C*
water solubility :	0.97 *ppm* at 23° *C*

Toxicology

Acute oral LD 50	rat	male 858 *mg/kg*
		female 1266 *mg/kg*
Acute dermal LD 50	rabbit	> 2000 *mg/kg*
Skin irritation	rabbit	nonirritating
TLM 48 hours	carp	1.1 *ppm*
Mutagenicity	negative	

MATERIALS AND METHODS

Field trail

The small scale field test was carried out in Biological and Chemical Research Laboratory of NISSAN CHEMICAL, Saitama, Japan in 1983. A plot size was one square meter and six hills of rice (cv. *Musashikogane)* were transplanted by hand on Jun 7. Weed seeds and tubers were mixed in soil at the paddling time. Leaf stages of barnyardgrass were 0.5-1*L*, 1-1.5*L*, 1.5-2*L* at the application time of three, seven, and ten days after planting, respectively. All plots were replicated three times, and visual assessment was made 42 days after planting.

Greenhouse test

All tests in a greenhouse were made using a/10000 plastic pot with clay loam soil. After paddling, weeds seeds tubers, or rice plant of 2–3 leaf stage were planted. Water level was always kept 4 *cm* in depth during the test period. Herbicides were applied by drop treatment using diluted solution made from wettable powder. Application timing of each test is indicated in each table. Final assessments were made 18–34 days after treatment by measurment of fresh weight or by visual rating.

Dipping test with *Cyperus serotinus* was carried out as the following. Partial or whole plants of *C.serotinus* with 3-6 *cm* shoot were dipped in the diluted solution of NC-310 or pyrazolate with small quantity of ethanol. After 24 hours dipping, plants were washed by tap water and were planted in a/10000 plastic pots.

There were three replications of each treatment.

RESULTS AND DISCUSSION

In the field trial in 1983, NC-310 (5%G) at the rate of 30 *Kg/ha* showed good control of most of paddy weeds except *M. vaginalis* when applied within 7 days after transplanting. No crop injury was observed at any rate nor at any application time (Table-1).

Greenhouse test was conducted to compare the activities of NC-310 to that of pyrazolate which has a similar chemical structure to NC-310. Test results indicated that in most cases, NC-310 was at least three times more effective than pyrazolate. However, there was little difference of the activities against *S. pygmaea* between two herbicides and in the cases of *M. vaginalis* and *A. canliculatim,* the activity of NC-310 was lower than that of pyrazolate (Fig.-1).

Table-1 Efficacy of NC-310 against paddy weeds in the small scale field trial in 1983
- vissual assessment at 42 days after planting

		Gr *(kg/ha)*	ORYSA	ECHCG	SCPJU	MOOVA	broad leaf	SAGPY	CYPSE
NC-310	+3	3	0.3	9.2	9.7	6.2	10	10	10
(5% G)		6	0	10	9.5	9.0	10	10	10
	+7	3	0	9.8	9.7	4.3	10	10	10
	+10	3	0	7.5	9.3	5.0	10	10	6.7
		4.5	0	9.3	9.8	6.0	10	10	8.7
butachlor	+3	3	0	10	9.5	6.7	7.0	1.3	4.7
	+7	3	0.3	10	9.0	1.3	5.3	1.3	5.7

0 = no effect ..10 = completely killed
+3, +7, +10 = applied at 3, 7, 10 days after transplanting

ORYSA	Oryza sativa
ECHEG	Echinochloa crus-galli
MOOVA	Monochoria vaginalis
broad leaf	broadleaf weeds including Rotala indica, Linderia pyxidaria, and Elatine triandra
SAGPY	Sagittaria pygmaea
CYPSE	Cyperus serotinus

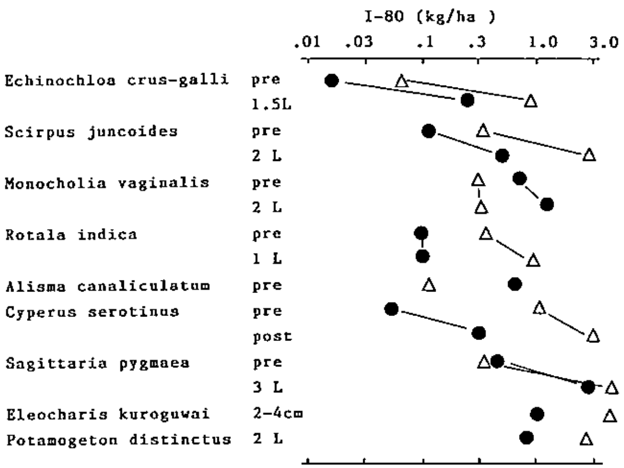


Fig.-1 The dosage to get 80% control of each weed with NC-310 (● - ●) and pyrazolate (△ - △)

A greenhouse test was conducted to see the influence of water depth on the activities against barnyardgrass. In both herbicides, there were little differenceo f the activities between 2 *cm* and 4 *cm* depth of water. However, under the shallow water condition (< 0.5 *cm*), efficacies of both herbicides apparently decreased and the decrement with NC-310 was smaller than with pyrazolate (Table-2).

Table-2 Influence of water depth on the efficacy of NC-310
- applied at 1 leaf stage of barnyardgrass
- fresh weight at 18 DAT

	kg a.i. /ha	*water depth* 0.5 *cm*	2 *cm*	4 *cm*
NC-310	0.1	70%	45%	49%
	0.3	38	13	14
	1.0	19	6	3
pyrazolate	0.3	92	51	63
	1	84	35	24
	3	16	12	16
butachlor	0.03	81	36	20
	0.1	52	1	3
	0.3	11	0	0
untreated	-	100% 19.7 *g*/pot	100% 24.0 *g*/pot	100% 25.0 *g*/pot

A pot test in growth chambers showed that the activity of NC-310 was hardly influenced by temperature conditions while pyrazorate and butachlor decreased their efficacies under low temperature (Table-3).

Table-3 Influence of temperature on the efficacy of NC-310
- pre emergence application
- fresh weight of barnyardgrass at 24 DAT

	kg a.i. /ha	22/15° *C*	22/22° *C*
NC-310	0.03	89 %	94 %
	0.1	44	49
	0.3	19	7
	1	2	0
pyrazolate	0.1	63	90
	0.3	51	19
	1	34	1
	3	11	0
butachlor	0.003	95	76
	0.01	106	73
	0.03	77	13
	0.1	20	2
untreated	-	100 % 9.3 *g*/pot	100 % 27.0 *g*/pot

Both NC-310 and pyrazolate showed less effectiveness against *S.pygmaea* which emerged from deep position in the soil (Table-4).

Table-4 Influence of planting depth on the efficacy of NC-310 against *S.pygmaea*
- Pre emergence application
- visual assessment at 29 DAT

	kg a.i. /ha	planting 1 *cm*	depth 6 *cm*
NC-310	0.03	0.7	1.7
	0.1	2	1.3
	0.3	6	2.7
	1	8.7	8
pyrazolate	0.03	2.3	1
	0.1	3.8	1.3
	0.3	6	3.8
	1	8.3	7.7
untreated	-	0	0

0 = no effect ... 10 = completely killed

Dipping test using *C.serotinus* indicated that NC-310 was about ten times more effective than pyrazolate. And 0.3-1 *ppm* of NC-310 was enough to kill this weed by 24 hours contact (Fig.-2). Another dipping test was conducted to know the part of the plant from which NC-310 is mainly absorbed. The result showed that *C.serotinus* was more susceptible when the shoot was dipped in the solution of NC-310. Therefore, the main part of plant which absorbed NC-310 was considered to be shoot (Fig.-3).

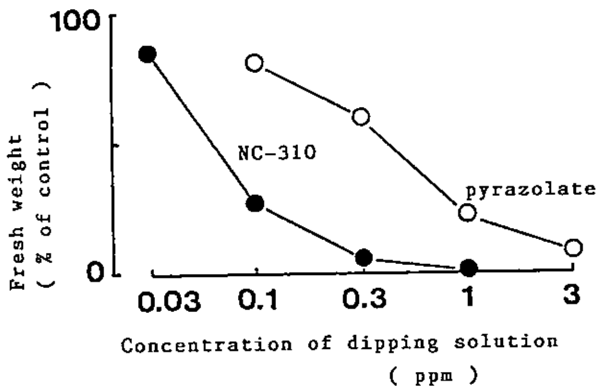


Fig.-2 Effect of NC-310 against *C.serotinus* when whole plants were dipped in the solution for 24 hours

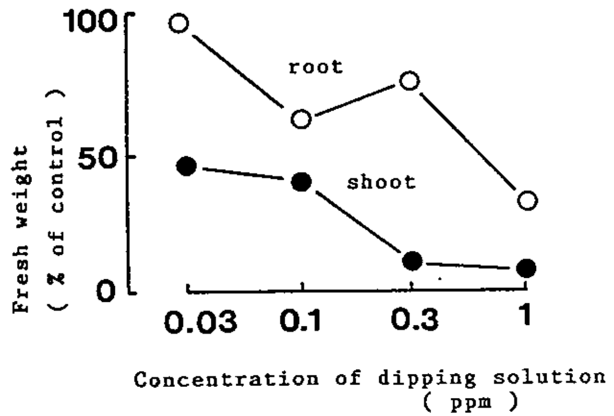


Fig.-3 Response of *C.serotinus* when shoot or root was dipped in the NC-310 solution
1000 500 3 6 24 48 3 6 24 48 imperata paspalum Time (h)

Among many factors which affect crop injury, transplanting depth of rice is thought to be one the most important ones. Crop injury test with varied transplanting depth showed that butachlor caused severe injury on the rice plant when planted in shallow. Similar tendency was found with NC-310 but it caused less injury than butachlor did (Table-5). Additional test of phytotoxicity was carried out on rice varieties of IR series. These varieties also showed a good tolerance to NC-310.

Table-5 Influence of transplanting depth on the crop injury of rice
- applied at the next day of transplanting
- fresh weight of rice at 34 DAT

	kg a.i. /ha	transplanting depth 1 *cm*	4 *cm*
NC-310	0.75	77 %	93 %
	1.5	64	107
	3	26	79
	6	21	60
pyrazolate	0.75	90	107
	1.5	100	93
	3	91	106
	6	91	100
butachlor	3.25	7	94
	7.5	13	97
	15	2	86
	30	2	99
untreated	-	100 % 15.0 g/pot	100 % 14.0 g/pot

SOFIT® 300 EC : PRACTICAL CONSIDERATIONS AND BENEFITS FROM ITS USE IN WET SOWN RICE IN THAILAND

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ABSTRACT

The study was made on SOFIT® 300 EC at a dosage rate of 400 *g.* a.i./*ha* in wet sown rice in Thailand during the season of 1984. The investigation was conducted on high yielding varieties in various provinces of the central plain where *Echinochloa crus galli* and *Leptochloa chinensis* were reported to be major weed problems.

SOFIT® 300 EC was applied on a single 1600 *s.m.* plot in comparison with either a nontreated plot or a plot of the same size treated by a farmer with a local standard. The nontreated and local standard treated plots were adjacent to the SOFIT® 300 EC treated plots. Altogether forty five plots were laid out. Visual assessments were made to record the overall weed cover and individual weed species cover. Within the SOFIT® 300 EC treated plots, a comparison was made between those treated at 1-4 days after sowing (DAS) and those treated 5-6 DAS. A comparison was also made between plots where the water was reintroduced before 10 DAS and after 10 DAS.

It can be concluded from these results that, in every case, plots treated with SOFIT® 300 EC were superior to nontreated and local standard plots in both efficacy of weed control and yield.

Both weed control and yield recorded from plots treated with SOFIT® 300 EC 1-4 DAS were superior to those recorded from plots treated with SOFIT® 300 EC 5-6 DAS.

The reintroduction of water into the SOFIT® 300 EC treated plots within 10 DAS, also resulted in superior efficacy and yield compared to those where the reintroduction of water was later than 10 DAS.

INTRODUCTION

Wet sown, pregerminated, direct seeded rice is becoming increasingly more important in the rice production of many countries in South East Asia. This is certainly the case in Thailand. Quadranti and Ebner (1983) reported that SOFIT® showed an excellent crop selectivity and a very good control of major weeds in pregerminated direct seeded rice in several countries, e.g., Italy, Egypt, Indonesia and Thailand when applied as a preemergent herbicide.

CIBA-GEIGY investigated the efficacy and crop tolerance in this cultural practice using SOFIT® 300 EC at various rates and application timings in 13 multi-plot trials for 3 consecutive seasons. The most economical and effective rate for commercial recommendation was found to be 400 *g.* a.i./*ha* applied 0-4 days after sowing (DAS).

During the wet season 1984 a series of 45 trials was conducted to establish and demonstrate the benefits of SOFIT® 300 EC compared to farmers' standard practices as well as to no treatment.

MATERIALS AND METHODS

SOFIT® 300 EC was applied at 400 *g.* a.i./*ha* to 1600 *s.m.* plots which were adjacent to plots either treated with local standards or were left untreated. Application of SOFIT® 300 EC were made either at 0-4 DAS or at 5-6 DAS, whilst local standards were applied according to the farmers' usual practices.

The reintroduction of water into treated fields had previously been observed to have some influence on the efficacy of SOFIT® 300 EC. Consequently the timing of water reintroduction was noted in these trials.

Visual assessment methods were used to assess weed control efficacy, and recordings were made of percent total weed cover as well as of individual weed species present. Assessments were made in 5 randomly placed quadrats each of 2 × 2 *s.m.*, in each 1600 *s.m.* plot, and were generally made around 45 DAS. Major weeds present were *Echinocloa crus galli, Leptochloa chinensis, Cyperus difformis* and *C. iria, Fimbristylis miliacea, Sphenoclea zeylanica* and *Monochoria vaginalis.*

Yield were measured from 5 randomly placed quadrats of 2 × 2 *s.m.* in each 1600 *s.m.* plot, and were expressed in *m.t./ha* at 14% moisture content.

All recorded data was subjected to the t-test analysis to establish its significance. The cost/benefit of SOFIT® 300 EC application in term of income was also discussed.

RESULTS

1. **SOFIT® 300 EC compared to no treatment**
   - **1.1 Efficacy** : Percent total weed cover in SOFIT® 300 EC treated plots, as seen in Table 1, was significantly lower (P.001) than that in the non-treated plots. All the major weeds were significantly less in the SOFIT® 300 EC plots, especially *Echinocloa crus galli, Cyperus spp.,* and *Monochoria vaginalis.*
   - **1.2 Yield** : The mean yield of 3.32 *m.t./ha* recorded from the SOFIT® 300 EC treated plots, as seen in Figure 1 and Appendix 1 was 19% greater than the mean yield of 2.78 *m.t./ha* recorded from the non-treated plots, although this difference was not significant.
2. **SOFIT® 300 EC compared to local standards**
   - **2.1 Efficacy** : Percent total weed cover in SOFIT® 300 EC treated plots, as seen in Table 2, was significantly lower (P.001) than that in the plots treated with local standards. Except for *Leptochloa chinensis,* all other major weeds were significantly less in the SOFIT® 300 EC treated plots.

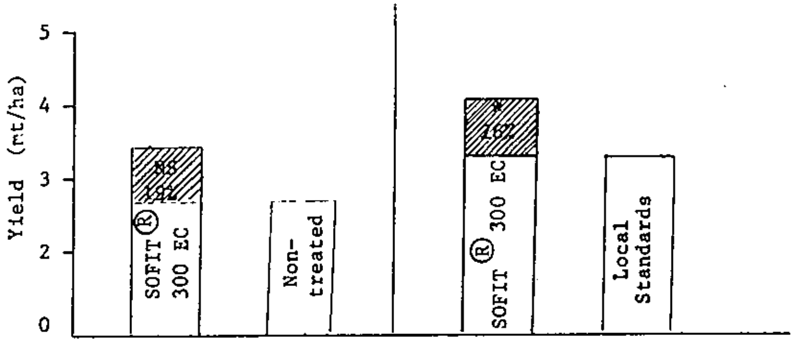
2.2 Yield : The mean yield of 4.06 *m.t./ha* recorded from the SOFIT® 300 EC treated plots, as seen in Figure 1, and Appendix 1 was 26% greater than the mean yield of 3.23 *m.t./ha* recorded from the plots treated with local standards, and this increase was significant (P.05)

Table 1. Percent total weed cover and individual species cover in SOFIT® 300 EC treated and non-treated plots.

		Total Cover	*Cyp.*	*Fim.*	*E.c.g.*	*Lept.*	*Sph.*	*Mono.*
Mean % Cover	SOFIT	9.8	0.4	3.7	1.8	0.3	3.2	0.5
	Non-treated	46.2	9.7	12.4	16.0	16.3	12.4	5.5
t-value	SOFIT Non-treated	***6.35	***5.61	*2.01	***5.21	*3.08	**3.30	***5.38

Note NS - non-sig. diff.
* - sig. diff. at P. 05
** - sig. diff. at P. 01
*** - Sig. diff. at P. 001

Cyp. - *Cyperus difformis/iria*
Fim. - *Fimbristylis miliaceae*
E.c.g. - *Echinocloa crus galli*
Lept. - *Leptochloa chinensis*
Sph. - *Sphenoclea zeylanica*
Mono. - *Monochoria vaginalis*



Note NS - non sig. diff.
** - sig. diff. at P. 05*

Figure 1. Yield data (*mt/ha*) from SOFIT® 300 EC treated plots in comparison with yields from plots that were either non-treated or were treated with local standards (at 14% moisture content)

Appendix 1. Mean yield of SOFIT® 300 EC compared to non-treated and local standards

Treatment	Mean Yield (*mt/ha*)	t-value	sig. diff.	Mean % increase in SOFIT® plots
SOFIT® 300 EC	3.32	1.25	NS	19.4
Non-treated	2.78			
SOFIT® 300 EC	4.06	2.35	P. 05	25.7
Local standards	3.23			

Table 2. Percent total weed cover and individual species cover in SOFIT® 300 EC treated and local standards treated plots.

		Total Cover	*Cyp.*	*Fim.*	*E.c.g.*	*Lept.*	*Sph.*
Mean % Cover	SOFIT	9.4	1.8	1.1	1.1	0.7	4.8
	Standards	40.5	9.8	10.2	5.0	10.8	12.1
t-value	SOFIT Standards	***6.14	**2.86	**3.33	*2.38	NS 2.07	**2.94

3. Application timing of SOFIT® 300 EC at 1-4 DAS compared to 5-6 DAS

3.1 Efficacy : Table 3 shows the percent total weed cover in SOFIT® 300 EC plots treated 1-4 DAS was significantly lower (P. 01) than that in the 5-6 DAS treated plots. There was, in particular, significantly less (P. 05) *Sphenoclea zeylanica.*

Table 3. Percent total weed cover and indivudual species cover in SOFIT® 300 EC treated at 1-4 DAS and 5-6 DAS plots.

		Total Cover	*Cyp.*	*Fim.*	*E.c.g.*	*Lept.*	*Sph.*	*Mono.*
Mean % Cover	1-4 DAS	5.7	0.6	0.9	0.8	0	2.3	0.1
	5-6 DAS	15.7	1.3	3.2	1.0	0.5	5.3	0.6
t-value	1-4 DAS V.S. 5-6 DAS	**3.15	NS 1.19	NS 1.56	NS 0.42	-	*2.25	NS

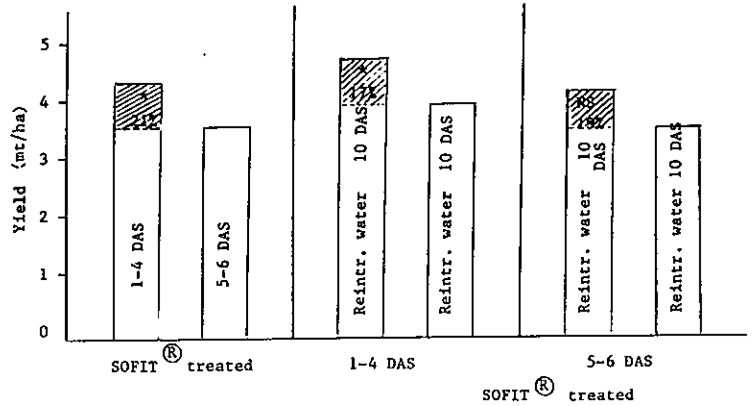
Note NS - non-sig. diff.
* - sig. diff. at P. 05
** - sig. diff. at P. 01
*** - Sig. diff. at P. 001

Cyp. - *Cyperus difformis/iria*
Fim. - *Fimbristylis miliaceae*
E.c.g. - *Echinocloa crus galli*
Lept. - *Leptochloa chinensis*
Sph. - *Sphenoclea zeylanica*
Mono. - *Monochoria vaginalis*

3.2 Yield : The mean yield of 4.23 *m.t./ha* recorded from the 1-4 DAS SOFIT® 300 EC treatment, as seen in Figure 2 and Appendix 2, 3.50 *m.T./ha* from the 5-6 DAS treated plots.

4. Comparison of reintroducing water either before or after 10 DAS to a SOFIT® 300 EC treatment 1-4 DAS

4.1 Efficacy : Percent total weed cover where water reintroduction was before 10 DAS is seen in Table 4. to be less than in plots that did not have water reintroduced until after 10 DAS. Although this difference was not significant, the population of *Echinocloa crus galli* was significantly less (P. 05).



Note NS – non sig. diff.
** – sig. diff. at P. 05*

Figure 2. Yield data (*mt/ha*) SOFIT® 300 EC treated plots at 1-4 DAS and 5-6 DAS (at 14% moisture content)

Appendix 2. Mean yield data of SOFIT® 300 EC applied 1-4 DAS or 5-6 DAS, with water reintroduced before 10 DAS or after 10 DAS.

Treatment			Mean Yield (*mt/ha*)	t-value	sig. diff.	Mean % increase
Appl. Timing of SOFIT®		1-4 DAS	4.23	2.15	P. 05	20.86
		5-6 DAS	3.50			
SOFIT® applied 1-4 DAS	re-intr.	10 DAS	4.48	2.11	P. 05	16.97
	re-intr.	10 DAS	3.83			
SOFIT® applied 5-6 DAS	re-intr.	10 DAS	3.90	1.09	NS	18.90
	re-intr.	10 DAS	3.28			

Table 4. Percent total weed cover and individual species cover with SOFIT® 300 EC treated at 1-4 DAS. The reintroduction of water was before 10 DAS or after 10 DAS.

		Total Cover	*Cyp.*	*Fim.*	*E.c.g.*	*Lept.*	*Sph.*	*Mono.*
Mean % Cover	Before 10 DAS	4	0.7	0.4	0.1	0	1.8	0.2
	After 10 DAS	10	0.8	1.9	1.4	0	3.0	0.1
t-value	Before 10 DAS V.S. After 10 DAS	NS 1.91	NS 0.08	NS 1.09	2.05*	-	NS 0.92	NS 0.13

4.2 Yield : Mean yield recorded from SOFIT® 300 EC treated plots 1-4 DAS, where water was reintroduced before 10 DAS, as seen in Figure 2 and Appendix 2, was 4.48 *m.t/ha.*, which was significantly greater (P. 05) than the mean yield of 3.83 *m.t./ha.* recorded from plots where water was reintroduced after 10 DAS.

5. Comparison of reintroducing water either before or after 10 DAS to a SOFIT® 300 EC treatment 5-6 DAS

5.1 Efficacy : The earlier water reintroduction before 10 DAS, following a SOFIT® 300 EC application at 5-6 DAS, resulted in a slight but non-significant decrease in the percent total weed cover compared to where water reintroduction was after 10 DAS, as seen in Table 5.

Table 5. Percent total weed cover and individual species cover with SOFIT® 300 EC treated at 5-6 DAS. The reintroduction of water was before 10 DAS or after 10 DAS.

		Total Cover	*Cyp.*	*Fim. + Lept.*	*E.c.g.*	*Sph.*	*Mono.*
Mean % Cover	Before 10 DAS	14.7	1.8	1.5	1.0	7.2	0.7
	After 10 DAS	16.3	0.9	4.3	3.0	3.3	0.6
t-value	Before 10 DAS V.S. After 10 DAS	NS 0.24	NS 0.96	NS 0.83	NS 1.75	NS 1.52	NS 0.17

Note NS – non-sig. diff.
* – sig. diff. at P. 05
** – sig. diff. at P. 01
*** – sig. diff. at P. 001

Cyp. – *Cyperus difformis/iria*
Fim. – *Fimbristylis miliaceae*
E.c.g. – *Echinocloa crus galli*
Lept. – *Leptochloa chinensis*
Sph. – *Sphenoclea zeylanica*
Mono. – *Monochoria vaginalis*

5.2 Yield : As seen in Figure 2 and Appendix 2, the mean yield recorded from a 5-6 DAS application of SOFIT® 300 EC where water was reintroduced before 10 DAS was 3.9 *m.t./ha*, compared to 3.28 *m.t./ha.* when the water reintroduction was after 10 DAS, but this difference was not significant.

DISCUSSION AND CONCLUSION

It has been demonstrated that the populations of major weeds occuring in wet sown, pregerminated, direct seeded rice were significantly reduced by an application of 400 *g*.a.i./*ha* SOFIT® 300 EC. It has also been shown that 400 *g*.a.i./*ha* SOFIT® 300 EC was superior to local standard treatments applied according to farmers' practices. Yields recorded from SOFIT® 300 EC treated rice plots were greater than yields recorded from untreated plots and also from plots treated with local standards.

Applications of 400 *G.* a.i./*ha* SOFIT® 300 EC at 1-4 DAS were significantly better than applications at 5-6 DAS in reducing percent total weed cover and especially in controlling *Sphenoclea zeylanica.* This was confirmed by a significantly greater yield in the 1-4 DAS treated plots.

The importance of reintroducing water before 10 DAS, especially where 400 *g.* a.i./*ha* of SOFIT® 300 EC was applied 1-4 DAS. was shown. Control of *Echinocloa crus galli* was increased and resultant yields were greater.

It can be concluded that the greatest reduction in weed populations, and the highest yields, resulted from applications of 400 *g.* a.i./*ha* of SOFIT® 300 EC, applied 1-4 DAS, followed by water reintroduction before 10 DAS.

Cost/benefit of SOFIT® 300 EC application

Table 6a. shows that deducting the cost of herbicide, cost of herbicide application and cost of hand weeding, the application of SOFIT® 300 EC resulted in an increase of Baht 1,651 per *hectare* compared to the non-treated.

Table 6b. shows that after deducting the cost of herbicides and application costs, 400 *g.* a.i./*ha* SOFIT® 300 EC resulted in an increase of Baht 2,125-2,359 per *hectare* over the local standard.

Table 6c. shows that an application of SOFIT® 300 EC at 1-4 DAS was worth Baht 2,190 per *hectare* more than an application at 5-6 DAS.

Table 6d. shows that with a SOFIT® 300 EC treatment at 1-4 DAS, the reintroduction of water before 10 DAS resulted in an additional Baht 1,950 per *hectare* compared to when water was reintroduced after 10 DAS, and with a SOFIT® 300 EC treatment at 5-6 DAS, the reintroduction of water before 10 DAS resulted in an extra Baht 1,860 per *hectare* compared to when water was reintroduced after 10 DAS.

Table 6. Cost/Benefit of SOFIT® 300 EC at 400 g. ai/ha.

a) Compared with non-treated

Treatment	Cost of Herbicide (Bht)	Cost of appl Labour(2) (Bht/ha)	Cost of Hang weeding(3) (Bht/ha)	Yield(1) (mt/ha)	Value (Bht/ha)	After deducted appl. (Bht/ha)	Benefit of using SOFIT® 300 EC (Bht/ha)
						3.32	
SOFIT® 300 EC	444	150	-	3.32	9,960	9,366	1,651
Non-treated	-	-	625	2.78	8,340	7,715	

b) Compared with local standards

Treatment	Cost of Herbicide (Bht)	Cost of appl Labour(2) (Bht/ha)	Cost of Hand weeding (Bht/ha)	Yield(1) (mt/ha)	Value (Bht/ha)	After deducted appl. (Bht/ha)	Benefit of using SOFIT® 300 EC (Bht/ha)
SOFIT® 300 EC	444	150	-				
Local Standards	83-313(4)	150	-				

Note : (1) Price of paddy was *Bht.* 3,000/*mt* (14% moisture content)
(2) Application/*ha* = 2 *man-days* (*Bht.* 75/*person/day*)
(3) Hand weeding minimum one round/*ha* = 12.5 *man-days* (*Bht.* 50/*person/day*)
(4) Cost of local standard herbicides varied from *Bht.* 83-313/*ha*, assuming that 30% of area was treated with post-emergence herbicide and 100% for pre-emergence.

c) Comparison of 1-4 DAS and 5-6 DAS application timing.

Treatment	Timings (DAS)	Yield (*mt/ha*)	Value (*Bht*)	Benefit of using SOFIT® 300 EC
SOFIT® Appl.	1-4	4.23	12,690	2,190
	5-6	3.50	10,500	

d) Comparison of rewintroducing water before or after 10 DAS following a 1-4 DAS SOFIT® 300 EC application.

Treatment	Reintroduction or water (DAS)	Yield (*mt/ha*)	Value (*Bht*)	Benefit of re-introduction of water before 10 DAS (*Bht/ha*)
Appl. time 1-4 DAS	before 10	4.48	13,440	1,950
	after 10	3.83	11,490	

e) Comparison of re-introducing water before or after 10 DAS following a 5-6 DAS SOFIT® 300 EC application.

Treatment	Reintroduction of water (DAS)	Yield (*mt/ha*)	Value (*Bht*)	Benefit of re-introduction of water after 10 DAS (*Bht/ha*)
Appl. time 5-6 DAS	before 10	3.90	11,700	1,860
	after 10	3.28	9,840	

SUBSTITUTED QUINOLINECARBOXILIC ACIDS — NEW ELEMENTS IN HERBICIDE SYSTEMS

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ABSTRACT

New herbicidal quinolinecarboxilic acids are effective against specific important weed species. The information reported here is taken predominantly from greenhouse trials, supported by experiments in the open and the laboratory.

BAS 518 H (7-chloro-3-methyl-8-quinolinecarboxylic acid) is useful for the control of *Galium aparine* (L.) Beauv., and other broadleaf weeds in small grains, oilseed rape, and sugarbeets when applied pre-or postemergence.

Strong emphasis is put on BAS 514 H (3, 7-dichloro-8-quinolinecarboxylic acid) for combatting *Echinochloa* spp. Treatments made postemergence provide the desirable tolerance to the rice crop *(Oryza sativa* L.*)*.

In established plants the uptake takes place predominantly via the roots. Although the mode of action has not as yet been clarified preliminary investigations indicate that the level of auxins in the plants is affected. Due to their characteristic features both BAS 518 H and BAS 514 H at an average rate of 0.3 *kg/ha* active ingredient or less can contribute a decisive part in combination with other herbicides.

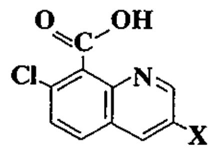
INTRODUCTION

In the patent literature herbicidal and growth regulating properties are disclosed for substituted quinolines, and substituted quinolinecarboxilic acids (DE-A-2 322 143, US-A-2 661 276, US-A-4 009 020, EP-A-0 060 429, EP-A-0 104 389, Wegler, 1977). However, none of these compounds has as yet been documented in standard herbicide publications.

The usefulness of quinolinecarboxilic acids as herbicides varies considerably depending upon the chemical structure of the molecules. Two new and more recent representatives BAS 514 H and BAS 518 H both originating at BASF Aktiengesellschaft are dealt with in this paper. Target weed species are *Echinochloa crusgalli* (L.) Beauv. occurring in rice fields, and *Galium aparine* L., which is troublesome in central and north european crops. In this presentation the greater emphasis is put on BAS 514 H.

MATERIALS AND METHODS

Compounds and characteristics
Structural formula



Code Nr.	X	Chemical name
BAS 514 H	Cl	3, 7-dichloro-8-quinolinecarboxilic acid*
BAS 518 H	CH_3	7-chloro-3-methyl-8-quinolinecarboxilic acid

*Quinclorac (proposed common name)

Chemical and physical properties

	BAS 514 H	BAS 518 H
Molecular formula	$C_{10}H_5Cl_2NO_2$	$C_{11}H_8ClNO_2$
Molecular weight	242.1	221.63
Physical state, colour	colourless crystalline solid, with faint odour	colourless crystalline solid, odourless
Melting point	237° C (decomposition starting)	244° *C*
Vapour pressure mbar at 20° *C*	$< 1.10^{-7}$	$< 1.10^{-7}$

Solubility at 20° C *gr./100 gr.* solvent

Solvents	BAS 514 H	BAS 518 H
Acetone	0.2	0.2
Acetonitrile	< 0.1	0.1
Diethylether	0.1	< 0.1
Dichloromethane	< 0.1	0.2
Ethanol	0.2	0.1
n-Hexane	< 0.1	< 0.1
1-Octanole		4.3×10^{-2}
Olive oil	< 0.1	< 0.1
Water	6.2×10^{-3}	2.1×10^{-3}

Formulations:	50 % WP 1 % Granular 10 % Granular	50 % WP

Toxicological data of the technical active ingredient (BASF, APE/RZ 1985).

BAS 514 H: The toxicity of the technical active ingredient can be regarded as low in the investigations carried out thus far.

The acute oral toxicity tested in the rat resulted in a LD 50 of 2680 *mg/kg*. The dermal LD 50 in the rat was>2000 *mg/kg*. No resorptive symptoms of poisoning or irritations occurred.

The test on skin and eye irritation in rabbits with the undiluted compound showed that there is no skin and eye irritating potential.

Mutagenicity:

The technical active ingredient of BAS 514 H is non mutagenic as determined by the AMES-test. Other test systems are currently under evalution.

Subchronic/Chronic toxicity:

The evalutions of those studies are currently running. Further information can be supplied after having terminated the corresponding studies.

Aquatic animal toxicity

–Rainbow trout LC value oral 96 *hours*>100 *mg/1*. BAS 514 H is not toxic to fish.

BAS 518 H:
The technical active ingredient has only a low toxicity tested in an acute oral study in rats (LD 50>2610 *mg/kg*). The other relevant studies are currently under evalution (BASF APE/RZ, 1985). The compound is not toxic to honey bees (Adolphi, 1984).

Experimental procedures

Greenhouse experiments (Wuerzer, 1983)

Many data were taken from screening type trials. The vessels employed were plastic flower pots having a volume of 300 cm^3. The substrate, if not otherwise mentioned, was a sandy loam with sand 80%, silt 10% clay 10%, organic matter 3.3%, water-holding capacity 32%, pH ($CaCl_2$) 6.5.

In addition a loam was used containing 58% sand, 25% silt, 17% clay, 1.7% *o.m.*, waterholding capacity 55%, pH (KCl) 7.5. The seeds of the test plants were sown shallow, each pot having only one species. Treatments were made pre- and postemergence. Postemergence treatments were applied at various growth stages in order to determine the application window. (This has to be kept in mind when average ratings were interpreted). All doses are given in *kg/ha* of active ingredient. In the greenhouse hotter sections (25° *C* to 40° *C*) were preferred for heatloving species e.g. rice and *Echinochloa*, and 15° *C* to 30° *C* for plants from moderate climates, e.g. sugarbeets. Screening type trials were carried from 3 to 5 weeks. In some trials with rice and *Echinocloa* the soil was kept water logged (paddy condition). Assessments were made on a 0 to 100 scale, 0 denoting no damage or normal emergence and growth, and 100 denoting no emergence or complete destruction of at least the visible plant parts. Carrots (*Daucus carota* L., cultivar "Nantaise") were selected for special bioassays.

Experiments in the open were carried out on small plots. The soil was a light loamy sand with 15%particles (*20 u.* 10%*o.m.*, pH (KCI) 5.2 and 34%waterholding capacity.

In laboratory trials cucumbers (*Cucumis sativus* L., cv. "Robusta") were grown in petridishes. The green algae *Scenedesmus acutus* (mutant Goe 276/3A9) was cultivated in an automatic equipment, 22°*C*, 10,000 *Lux* (manufactured by Kniese Corp.) *Azolla filiculoides* was raised in growth chambers. 22°*C*. 22,000 *Lux* light/dark 16/8 *H*, inorganic nutrient solution with trace elements.

The uptake and translocation studies were conducted using ^{14}C-labeled 3, 7-dichloro -8-quinolinecarboxilic acid and following known laboratory practices.

RESULTS

Weed control

BAS 514 H and BAS 518 H are both active as pre- and postemergence herbicides. However, as measured by ^{14}C labelled BAS 514 H in established plants the uptake took place almost exclusively via the roots with translocation to the shoot (Retzlaff, 1985). However, some foliar uptake cannot be excluded under certain conditions such as wet leaf surfaces. And with BAS 518 H the control of *Galium aparine* was far superior if the plants were transplanted into a soil in which the herbicide was preplant incorporated as compared with foliar applications. In the latter instance the soil was covered by activated charcoal. Sufficient soil moisture and a certain degree of mobility in the soil favour the herbicidal efficacy of the compounds.

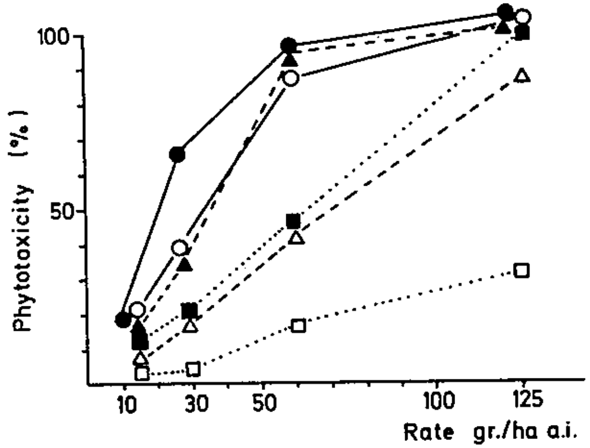


Fig. 1. BAS 514 H and BAS 518 H, phytotoxicity ppi in two soil types — carrot bioassay in the greenhouse

The soil type had some impact on the herbicidal performance (Figure 1). The phytotoxicity of both compounds against carrots was lower in a light sandy loam with 3.9% *o.m.* than in a medium loam with 1.7% *o.m.* BAS 514 H appeared to be less sensitive to the soil type than BAS 518 H, whatever soil characteristics or other factors may have been responsible. (Considerable research is still required). However, in comparison Simazine failed completely in the soil with the higher organic matter contents in spite of its lighter texture.

A number of weed species were controlled similarly by BAS 514 H as well as BAS 518 H. BAS 514 H exerts the broader spectrum and in some instances the higher unit activity (Table 1). A more comprehensive list of weed species controlled and tolerant crops is published elsewhere (BASF, 1985). The essential difference is, BASF 518 H has almost no efficacy against *Echinochloa* spp., whereas BAS 514 H can be considered a speciality herbicide.

Table 1. BAS 514 H and BAS 518 H — differences in weed control and crop tolerance in the greenhouse

Plant species	phytotoxicity or growth inhibition *(%)*			
	Herbicides *kg/ha a.i.* postemergence			
	BAS 514 H		BAS 518 H	
	0.125	0.5	0.125	0.5
Barley	9	17	0	0
Oilseed rape	5	15	0	1
Red clover	62	70	85	100
Rice	2	5	2	3
Soybeans	32	49	10	17
Sugar beets	33	55	10	16
Wheat	6	19	0	0
Cassia tora	63	90	8	21
Echinochloa spp.	67 (74)*	85 (94)*	3	20
Galium aparine	84	92	80	92
Ipomoea spp.	51	63	20	38
Sesbania exaltata	54	81	11	29
Veronica spp.	89	96	88	93

* in ( ) preemergence

In the greenhouse, for the overall control of *Echinochloa* spp., there was a slight difference in favour of the preemergence applications, if all trials available were averaged at a medium scoring date four weeks after the treatments were made. However, in direct comparisons the herbicidal efficacy was somewhat superior when the chemical was applied prior to the weed emergence. Furthermore, a decreased efficacy could be observed if the grass had progressed beyond the second leaf stage (Fig. 2).

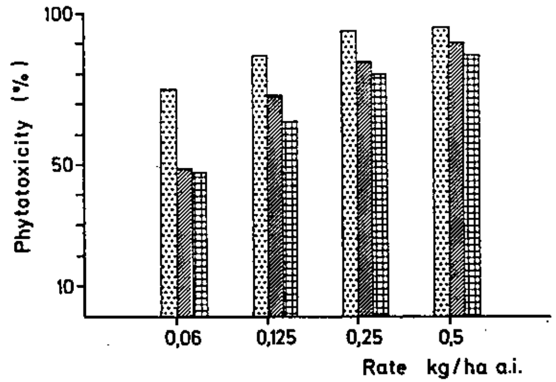


Fig. 2: Bas 514 H control of Echinochloa spp. at various growth stages in the greenhouse

Seeds of *Echinochloa crus-galli* and other *Echinochloa* species were collected from several parts of the world (Japan, Spain, USA) exhibiting a wide variation in type and growth vigour. Provenances from Spain and USA appeared to be somewhat less susceptible to BAS 514 H than those of other origins (Table 2).

Table 2. Response of various provenances of *Echinochloa* spp. to BAS 514 H in the greenhouse

Species	origin	injury % by BAS 514 H applied at rates kg/ha					
		preemergence			postemergence		
		0.125	0.25	0.5	0.125	0.25	0.5
E. crus-galli	Japan	98	99	99	82	93	95
E. crus-galli	Spain	82	98	99	61	80	87
E. crus-galli	USA	71	87	96	61	79	89
E. caudata	Japan	100	100	100	80	90	95
E. oryzicola	Japan	90	92	92	74	85	88

The relatively low scorings, mostly somewhat below 100 are understood by the pattern of how sensitive plants do respond to the chemical: Rapid initial symptoms — particularly in broadleaf plants — but a slow break-down thereafter. In preemergence treatments of cucumber seeds BAS 514 H did not inhibit the germination but later the growth of the roots and the elongation of the shoot were affected (Berghaus und Retzlaff, 1985).

In addition, in spite of low early weed scorings the soil residual activity of BAS 514 H has the potential for weed control during the crop season. Thus BAS 514 H improves the performance of other herbicides by contributing to the efficacy against *Echinochloa* and by extending the period of control.

Crop selectivity

Concerning the tolerance to crops BAS 514 H is primarily targeted for rice. BAS 518 H is in the development stage for upland crops such as small grains, oilseed rape and sugarbeets (Table 1).

In spite of a considerable safety margin, when BAS 514 H is applied postemergence to rice plants incidences of crop injury may occur and be visible as stunting or "onion leaf formation" of individual tillers. Yields were not affected as shown by Menck et al. (1985). Further Research is in progress, and furthermore encouraged to determine the factors which cause the occasional damage. The varietal response of cultivars was also suspected. A collection is printed in Table 3. Others like Labelle, Lemont, Le Bonnet, Star Bonnet, L-202, Cal-Rose (USA), and Mahsuri, NLR-9672, Phalguna and Rasi from India are under current investigation.

Table 3. Response of rice cultivars to BAS 514 H applied post-emergence in the greenhouse

Cultivar	origin	phytotoxicity (%) by BAS 514 H applied at rates of kg/ha		
		0.25	0.5	1.0
Koshihikari	Japan	2	10	10
Nihonbare	Japan	5	5	5
Sasanishiki	Japan	2	2	5
Milyàng	Korea R	2	5	5
Seberany	Malaysia	2	5	5
IR 36	Philippines	5	5	5
Bahia	Spain	2	2	2
New Bonnet	USA	10	12	12

Again some slight injury appeared particularly at rates in excess of those necessary for weed control in the greenhouse. Although a few cultivars such as New Bonnet exhibited a somewhat higher phytotoxicity under the experimental conditions, a clear varietal susceptibility was not established. Regarding this topic the publication of Menck et al. (1985) is also referred to.

Algae and aquatic ferns

In order to broaden the knowledge of BAS 514 H in an aquatic environment the green algae *Scenedesmus acutus (Chlorophyceae)*, and a fern species *Azolloa filiculoides* were exposed to a range of concentrations of BAS 514 H. In Azolla the nitrogenfixing bluegreen algae *Anabaena azolla (Cyanophyceae)* lives in a symbiontic association. Therefore, Azolla can be important as a supplier of green manure (Strasburger et al., 1983). Azolla is also known to suppress a number of weed species which grow in rice fields, with the exception of *Scirpus maritimus* L. and *Echinochloa crus-galli* sp. *hispidula* (Retz.) Honda (Janiya and Moody, 1984). The excessive rate of 1.0 *kg/ha* of BAS 514 H equals a concentration of 8.3×10^{-6} *M* at a water level of 5 *cm*. At the rate of 10^{-5} *M* (highest for Scenedesmus) the growth of *Scenedesmus* and *Azolla* was slightly inhibited. At the concentration of 10^{-6} *M Azolla* was not affected.

Mode of action

In intact plants — except for *Echinochloa* — the visual symptoms of damage remind of phenoxycarboxilic acids, substituted benzoic acids or picolinic acids. 2, 4-D, Dicamba and Picloram induced a similar growth pattern in cucumbers germinated in petridishes. indolyl-3-acetic acid caused significantly weaker inhibitory effects. Additional investigations made in vitro and in vivo indicate that BAS 514 H and BAS 518 H change the auxin levels in plants to various extents (Berghaus and Retzlaff, 1985).

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to those who supplied the seeds of the numerous rice cultivars and Echinochloa of various origins. Thanks to colleagues and in particular to Mrs. Dietlinde Burkhardt and Dr. B. Wortmann for compiling the data and professional and technical support.

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THE MODE OF ACTION OF AC 252,925

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ABSTRACT

AC 252,925 is a member of a new chemical class of herbicides being developed by American Cyanamid. Symptoms and treated plants appear first in the meristematic regions, and then spread to the more mature parts. Measurements of various physiological processes in corn after treatment with AC 252,925 revealed that DNA synthesis is inhibited within 8 hours after initial exposure to the herbicide. There is also a decrease in the level of soluble protein and an increase in the level of the free amino acids. The amount of the individual amino acids was measured in corn suspension culture after exposure to AC 252,925 and the level of most of the amino acids increased except for valine, leucine and isoleucine. The deleterious effects of AC 252,925 on both growth and DNA synthesis in corn could be prevented by exogenously supplying valine, leucine, and isoleucine. AC 252,925 was found to be a potent inhibitor of acetohydroxyacid synthase, the first enzyme in the biosynthetic pathway for valine, leucine and isoleucine. It is proposed that the mechanism of action of AC 252,925 is the inhibition of acetohydroxyacid synthase which prevents the plant from synthesizing valine, leucine, and isoleucine.

INTRODUCTION

AC 252,925 is a member of a new class of herbicidal chemicals discovered by American Cyanamid and is presently in commercial development for use in rubber and oil palm plantations Lapade, et. al. (1983). The first symptoms of AC 252,925 treated plants is a cessation of growth followed by chlorosis and then necrosis of the meristematic regions. Die back occurs slowly from the growing points to the rest of the plant. Mature tissues may appear healthy for a considerable period of time after treatment. Thus, the first site of action appears to be the meristematic tissues. The objective of this research was to determine the physiological responses of a plant to AC 252,925 in order to ascertain the chemical's mode of action. Corn is highly susceptible to AC 252,925 and was used as the test species.

MATERIALS AND METHODS

Plant material

For all but two of the physiological measurements, corn seeds (Pioneer Var. 3541) were surface sterilized and grown in the dark at 28 °C for 3 days in sand culture watered with 0.2 *mm* $CaCl_2$.

Growth response

The growth response of corn to AC 252,925 was determined by growing the corn in sand culture and watering with diluted Hoagland's solution containing various concentrations of the herbicide. Plants were grown in a growth chamber (600 *ue/m^{-2}/sec^{-1}*, 15 h photoperiod, 28/24 *d/n*). Treated plants were harvested at the end of a 14-day period and dry weights determined. The results are expressed as the mean of 3 replicates with 10 plants per replicate.

Sugar content

The level of the total neutral sugars in leaves of 3-week-old greenhouse-grown corn that had been treated with 0.25 *kg/ha* (2 *mM*) of AC 252,925 was determined by the method of Dubois, et.al. (1956).

Respiration

Respiration of 2 *cm* root tips excised from 3-day-old corn was determined with a differential respirometer using the method of Umbreit, et. al. (1972).

Protein, lipid, RNA, and DNA synthesis

Measurements of the effects of AC 252,925 on protein, lipid, RNA, and DNA synthesis was done by determining the incorporation of ^{14}C-labeled precursors into the appropriate metabolic product using a modification of the procedures of Gruenhagen and Moreland (1977). The radiolabeled material consisted of ^{14}C-acetate (Sp. Act, 59 *mCi/mmol*) for lipid synthesis, ^{14}C-leucine and cystine (Sp. Act., 346 and 314 *mCi/mmol,* respectively) for protein synthesis, ^{14}C-uridine (Sp. Act., 552 *mCi/mmol*) for RNA synthesis, and 14 C thymidine (Sp. Act., 50.5 *mCi/mmol*) for DNA synthesis. All measurements were done on 2 *cm* root tips excised from corn grown as described above. The corn roots were treated with AC 252,925 by applying the herbicide as a root drench. Root tips were excised just before they were used to measure incorporation of the radiolabeled precursors into their respective metabolic products. The incubation medium contained 10 *mM* potassium phosphate buffer, pH 6, 1% sucrose, 2 ug streptomycin sulfate and 0.25 *uCi* of radiolabeled precursor per 5 *ml*. The roots were incubated for 1 *h* at 28 $^{\circ}$ *C* with constant shaking. The incorporation of radiolabeled thymidine, uridine and amino acids into DNA, RNA, and proteins, respectively, was measured using the procedures of Rost and Bayer (1976). The root tips were washed 3 times with cold, unlabeled incubation medium and then pulverized in cold (4C) 80%ethanol. The extract was washed successively with 15 *ml* each of 80%ethanol, 5%trichloroacetic acid, ethanol:diethyl ether (1:1 *v:v*) and diethyl ether. The filter was dried and placed in a scintillation vial with 10 *ml* of a scintillation cocktail so that the amount of radiolabeled material on the filter could be determined. The amount of radiolabeled material in the initial filtrate was also determined in order to determine the total amount of radiolabeled precursor that was absorbed by the excised root tips.

To measure the amount of radiolabeled acetate that was incorporated into the lipid fraction, the washed root tips after incubation were pulverized in 3 *ml* of 0.35 *mM* H_2SO_4 and 50 *mM* acetic acid. To this extract was added 4 *ml* of methanol:chloroform (1:2 *v:v*). The resulting mixture was centrifuged and the aqueous layer removed. The chloroform layer was washed 3 times with water. The amount of radioactivity in the aqueous and chloroform fraction was determined.

Soluble proteins and amino acids levels

The level of soluble proteins in corn root tips was determined by extracting the 100 *mg* of tissue in 6 *ml* of 10 *mM* potassium phosphate buffer (pH 6.0). The extract was centrifuged at 20,000 *g* for 15 *min.* and the level of the soluble protein in the supernatant was determined by the method of Bradford (1976). Total free amino-acid levels were determined by grinding 100 *mg* of root tips in 6 *ml* of 5% trichloroacetic acid, centrifuging the extract at 20,000 *g* for 15 *min.* and measuring the level of the amino acids in the supernatant fraction by a ninhydrin reaction (1957).

Amino acid studies

In the reversal studies with valine, leucine, and isoleucine, corn grown in sand culture was watered daily with dilute Hoagland's solution containing 15 *uM* AC 252,925 with or without 1 *mM* of each of the three amino acids. Fourteen days after beginning the treatments, the plants were harvested and dry weights determined. To determine the effects of these amino acids on the inhibition of DNA synthesis, 3-day-old etiolated corn seedlings were treated with 15 *uM* AC 252,925 applied as a root drench. Seedlings were retreated with 15 *uM* AC 252,925 or 15 *uM* AC 252,925 plus 1 *mM* each of valine, leucine and isoleucine, applied as a root drench. Root tips were harvested at 0.25, 2, 4, 6, and 24 hours after the second treatment and DNA synthesis was measured as described above. Results are expressed as the mean of 3 replicates with 10 plants per replicate.

RESULTS

One day after treating corn with AC 252,925 several responses were observed. Respiration in corn root tips treated with 150 *uM* of AC 252,925 decreased 25%, but there was no apparent effect on the ability of root tips to synthesize lipids based on the incorporation of acetate into lipids (Figure 1). Protein synthesis, measured by leucine incorporation, and RNA synthesis, measured by uridine incorporation, were only slightly inhibited by 150 *uM* of AC 252,925. The most dramatic effect observed was the 70% inhibition of thymidine incorporation into DNA. Further examination of the inhibition of thymidine incorporation by AC 252,925 showed that inhibition did not begin until 6 hours after introduction of the herbicide (Figure 2). This decrease in thymidine incorporation was associated with a decrease in the rate of growth of the intact roots. Examination of mitosis showed that there was a decrease in the number of cells in mitosis, although there were no abnormalities observed in any of the mitotic stages. Instead there was a large increase in the number of cells in interphase (Data not presented).

In an attempt to determine what effects AC 252,925 was having on cellular functions, changes in various metabolic pools in the tissue were examined. There was a 140% increase in the level of neutral sugars in green leaf tissue 24 hours after treatment with 250 *g/ha* of AC 252,925 (Figure 3). Also, a 40% decrease in the level of soluble proteins and a 40% increase in the levels of free amino acids in corn root tips 24 hours after treatment with 150 *uM* of AC 252,925 was found. To examine this phenomenon more closely the effect of AC 252,925 on the levels

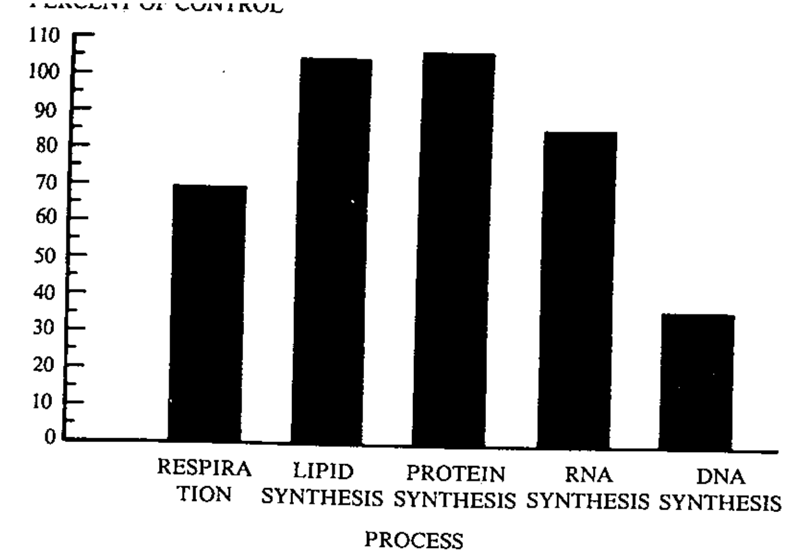

Figure 1. Physiological response of corn seedlings to AC 252,925 treatment.

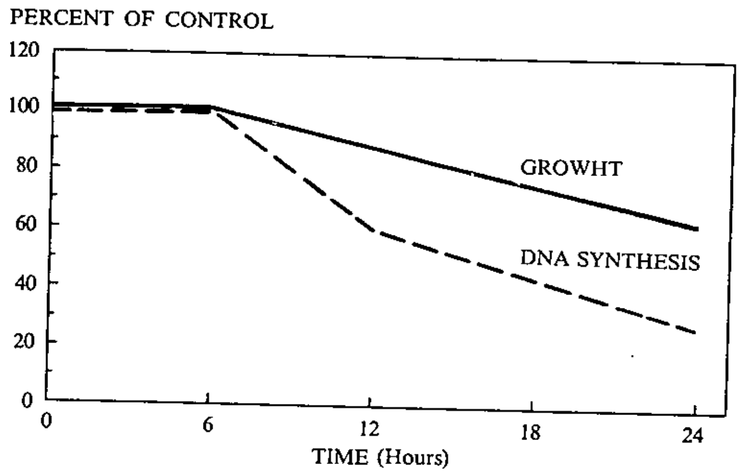

Figure 2. Effects of 150 *uM* AC 252,925 on growth and DNA synthesis in 3-day-old corn roots.

of each of the amino acids in corn suspension cultures treated with the herbicide was determined. This experiment revealed that there were dramatic increases in the levels of some of the amino acids, but there was a 70 to 90% decrease in the levels of valine, leucine, and isoleucine, suggesting that these amino acids may be limiting the growth of treated tissue (Table 1). When these three amino acids were exogenously supplied to corn seedlings treated with AC 252,925, the inhibitory effects of AC 252,925 on growth over a 14-day period and on DNA synthesis after 24 hours could be prevented (Figure 4). All 3 amino acids were necessary for maximum protection, although some protection was provided by supplying isoleucine with either valine or leucine. The inhibitory effects of AC 252,925 on DNA synthesis could be reversed. DNA synthesis of corn root tips that had been pretreated for 24 hours with 150 *uM* of ARSENAL and then retreated with more ARSENAL plus the three amino acids began to recover within 2 hours after supplying the amino acids (Figure 5). Maximum recovery was reached by 6 hours after supplying the amino acids. There are 4 enzymes that are shared in the biosynthetic pathways for valine, leucine, and isoleucine. AC 252,925 was found to be a potent inhibitor of acetohydroxyacid synthase (AHAS, acetolactate synthase), the first enzyme in the branched chain amino acid pathway (Figure 6).

Table 1. Effect of AC 252,925 on free amino acid levels in corn suspension cultures.

Amino Acid	Level (% of Control)
Methionine	794
Cysteine	2417
Serine	307
Valine	12
Leucine	8
Isoleucine	31

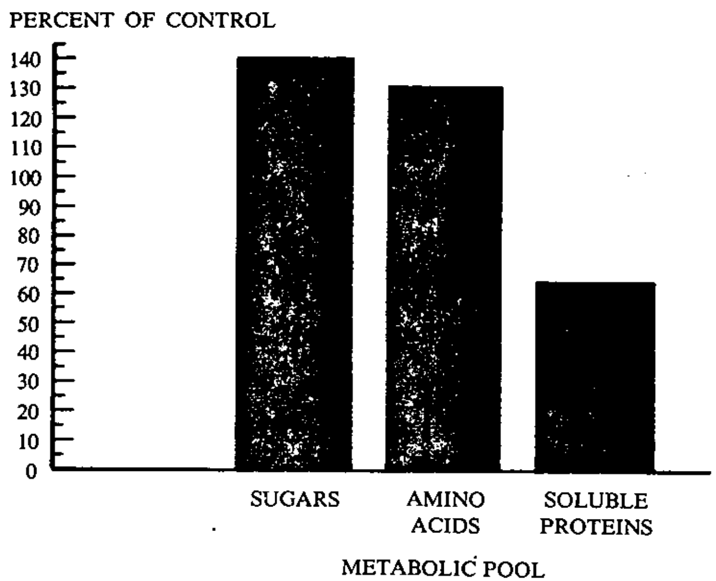

Figure 3. Effects of 150 *uM* AC 252,925 on free amino acid levels and soluble protein levels of 2-*cm* root tips for 3-day-old corn.

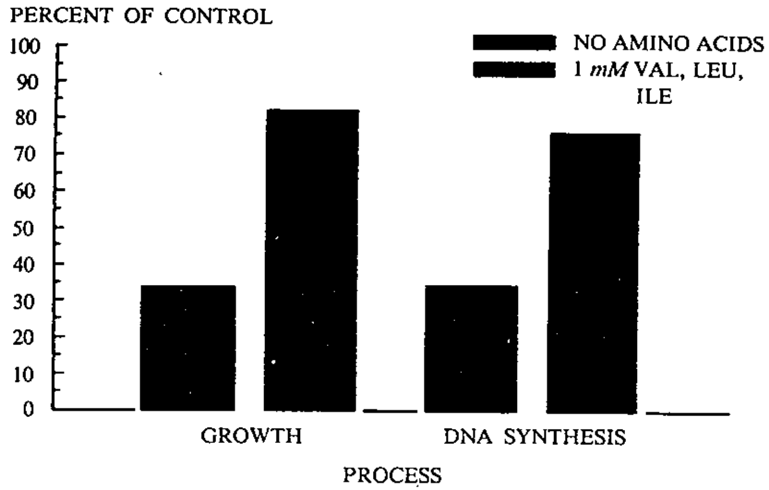

Figure 4. Reversal of the phytotoxic effects of 15 *uM* AC 252,925 on growth and DNA synthesis in corn by valine, leucine and isoleucine.

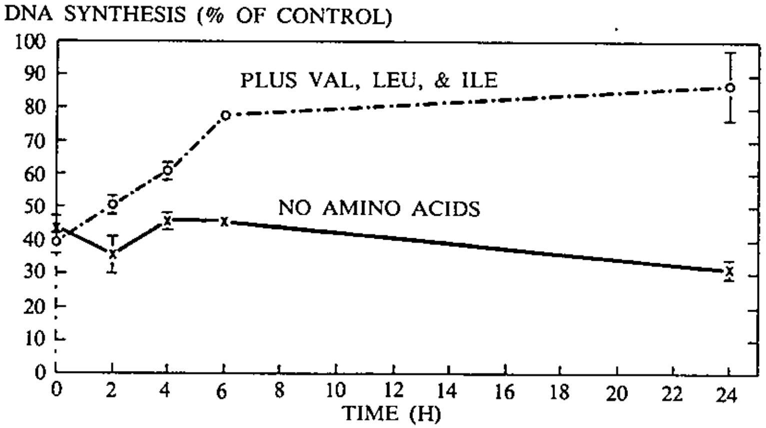

Figure 5. Reversal of the inhibitory effect of 150*uM* AC 252,925 on DNA synthesis in corn by valine, leucine and isoleucine.

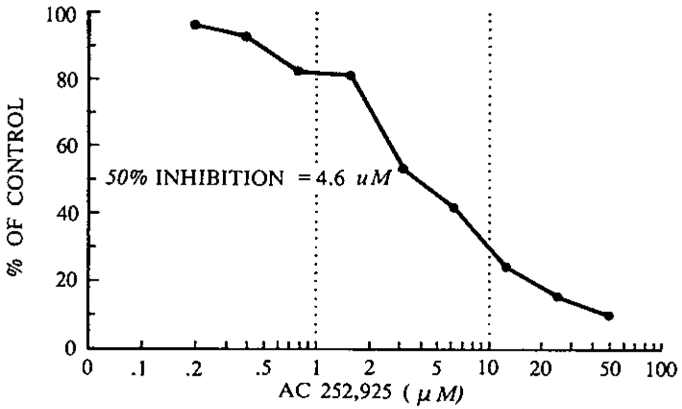

Figure 6. Effects of AC 252,925 on acetohydroxyacid synthase activity.

DISCUSSION

The response of several primary physiological processes in corn to AC 252,92: treatment supports a number of conclusions. The increase in the neutral suga content and the lack of an immediate response of green leaf tissue indicates tha photosynthesis is probably not immediately affected by AC 252,925. Lipid synthesi also was not affected within 24 hours after application of AC 252,925. Th inhibition of respiration in corn root tips by AC 252,925 does not appear to b large enough to account for the herbicidal activity of the chemical, although thi inhibition may play some role in the phytotoxic effects of AC 252,925. Protei synthesis, measured by incorporation of leucine, and RNA synthesis, measured b incorporation of uridine, were not severely inhibited by AC 252,925 treatmen after 24 hours.

The only process that was severely affected was DNA synthesis, measured b thymidine incorporation. This process was inhibited over 70% within 24 hour after treatment. However, further examination of this inhibition of DNA synthesi by AC 252,925 revealed that the inhibition was not measurable until 6 hour after introduction of the herbicide. Furthermore, the inhibition of DNA synthesis wa closely associated with growth of the roots. Because of the slowness of th response, it is highly probable that the inhibition of DNA synthesis by AC 252,92 is a secondary response to some primary event occurring during the first 6 hour after treatment.

The levels of soluble proteins and free amino acids were greatly affected b AC 252,925 treatment. The level of the proteins decreased while the amino aci levels increased. Although there had been no apparent affect on the rate o incorporation of leucine into proteins, these changes in the protein and amino aci levels indicated that AC 252,925 was causing some type of change in protei turnover. Following the discovery of these changes in protein and amino aci levels, the specific affects of AC 252,925 on the individual amino acids in cor suspension cultures was studied. This revealed that most of the amino acid reached very high levels, but the level of three of the amino acids, valine, leucine and isoleucine, decreased. When these three amino acids were exogenously supplie to AC 252,925 treated corn seedlings, the phytotoxic effects of AC 252,925 o both growth, over a 14 day period, and DNA synthesis, after 24 hours, were largel prevented. Furthermore, the inhibition of DNA synthesis by AC 252,925 coul be rapidly reversed by supplying valine, leucine and isoleucine to pretreate plants. These data strongly supported the hypothesis that AC 252,925 exerts it phytotoxic effects by inhibiting the ability of a plant to synthesize valine, leucine and isoleucine.

AC 252,925 was found to be a potent inhibitor of acetohydroxyacid synthas (acetolactate synthase), the first enzyme in the biosynthetic pathway for valine leucine, and isoleucine. The phytotoxic effects of AC 252,925 can be reversed b supplying susceptible plants with valine, leucine, and isoleucine. Limite structure-activity work has shown a good correlation between inhibition o AHAS activity and herbicidal activity.

CONCLUSION

Based on these data we propose that the mode of action of AC 252,925 is the inhibition of the synthesis of valine, leucine and isoleucine due to the inhibition of acetohydroxyacid synthase.

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UPTAKE, TRANSLOCATION AND MODE OF ACTION OF THE HERBICIDE GLUFOSINATE-AMMONIUM IN WARM CLIMATE WEED SPECIES

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ABSTRACT

The compound DL-homoalanin-4yl (methyl)-phosphinic acid monoammonium salt (proposed common name: glufosinate-ammonium) is a non-selective post-emergence herbicide with a rapid contact action. In addition, also systemic effects can be demonstrated.

Uptake, translocation and mode of action of this herbicide were studied on *Imperata cylindrica, Paspalum conjugatum, Pueraria phaseoloides, Echinochloa crus-galli, Sorghum halepense* and *Ipomoea purpurea*. When a mature leaf of these plants was treated with the ^{14}C-labeled compound, a minor portion of the applied amount of radioactive material was translocated to the nontreated parts of the plants. The percentage of foliar penetration and of subsequent translocation differed considerably among these plant species.

Contact damage on leaves became visible one or two days after herbicide treatment. But a few hours already after treatment the photosynthesis of the plants was reduced and the permeability of leaf tissue for potassium ions was increased. Glufosinate-ammonium and its free acid are strong inhibitors of glutamine-synthetase in plants, and thus prevent the refixation of ammonia produced in various processes of plant metabolism. As a consequence, rapid ammonia accumulation beginning in some species already 2 hours after foliar treatment with ammonia-free solutions of DL-homoalanin-4yl (methyl)-phosphinic acid was found in the leaves. Ammonia in higher concentrations is known to be toxic to plant cells. It is suggested that the rapid contact action of the herbicide is due to ammonia toxicity. Additional mechanisms of action of this herbicide are under discussion.

INTRODUCTION

Ammonium-DL-homoalanin-4-yl(methyl) phosphinate (Hoe 039866, proposed common name: glufosinate-ammonium) is the active ingredient of the herbicide Basta[(R)] of Hoechst AG. This non-selective herbicide rapidly acts on annual and perennial weed species, when applied to the foliage. It has no activity via the soil.

Glufosinate-ammonium and the free acid DL-homoalanin-4-yl (methyl)-phosphinic acid (glufosinate) are strong inhibitors of the enzyme glutamine synthetase in higher plants and thus block the reassimilation of ammonia produced in plant metabolism. As a consequence ammonia accumulates in plant tissues. Other effects reported are inhibition of photosynthesis and increased K^+-permeability of leaf tissue (Köcher, 1983, Wild and Manderscheid, 1984).

(R) trade mark of Hoechst AG

A previous paper reported on the potential of glufosinate-ammonium for weed control in tropical plantation crops (Langelüddeke et al., 1983). It was our objective to complement this information by data on foliar uptake, translocation and physiological effects of this herbicide in selected warm climate weed species.

MATERIALS AND METHODS

Spray solutions of glufosinate-ammonium were prepared from a 20% soluble liquid formulation. Spray solutions of the free acid glufosinate, prepared from the pure compound, contained 0.1% wetting agent Genapol(R), and pH was adjusted to 6.5 by NaOH. Spray volumes were equivalent to 1000 *l/ha (Imperata cyclindrica)* or 600 *l/ha* (other species). For radiotracer studies glufosinate-ammonium-(1-^{14}C), spec. act. 444 *MBq/g,* radiochemical purity 98%, was prepared by D. Gantz, Radiochemical Laboratory of Hoechst AG, and formulated as 20% soluble liquid.

Imperata cylindrica (L.) Beauv. was grown from rhizome pieces, *Paspalum conjugatum* Berg. from shoot cuttings in plastic pots (13 *cm* diam.), *Ipomoea purpurea* Roth and *Sorghum halepense* Pers. were grown from seeds in pots (10 *cm* diam.) filled with sandy loam under greenhouse conditions. Plants for radiotracer and mode of action studies were kept at 24-28° *C* (day), 16-18° *C* (night) and about 60% rel. humidity. *Ipomoea purpurea* was treated in the 1- to 2-leaf stage, the other species in the 4- to 5-leaf stage. *Imperata cylindrica* for studies on shoot regrowth from rhizomes was kept at 30° *C*/25° *C* (day/night) and about 60% rel. humidity and was treated, when 50 to 60 *cm* high.

Net CO_2-fixation of plants was measured in perspex containers with a type T 2 infrared gas analyzer (Hartmann and Braun, Melsungen) at 22° *C* and 40 W/m^2 light intensity. Ammonia was extracted from leaf tissue and determined by the method of Weatherburn (1967). Results were expressed as μg $HN^{+}4$-N/*g* fresh weight.

Radiolabelled glufosinate-ammonium solutions were applied to the adaxial surface of leaf blades by microsyringe. Rates of foliar uptake were determined after washing the leaves 3 × 5 *sec* with distilled water. Radioactivity was determined by liquid scintillation spectrometry, in washing solutions directly, in plant tissue after combustion in a Tri-Carb Sample Oxidizer (Packard Instruments).

Treated plants were watered by subirrigation. All treatments consisted of groups with 4 to 6 replicates.

RESULTS

Foliar uptake and translocation were studied by treating the 3rd or 4th leaf of *Imperata cylindrica* with 20 μl of a 0.25% solution, and *Paspalum conjugatum* with 10 μl of a 0.1% solution of ^{14}C-labelled glufosinate-ammonium. Four hours after treatment 53.7% and 45.1% of the total radioactivity were found within the treated leaves of *Imperata cylindrica* and *Paspalum conjugatum,* respectively, with a further increase of these percentages 24 hours after treatment. The rate of translocation was 0.8% and 1.9% in *Imperata cylindrica* and *Paspalum conjugatum,* respectively, 4 hours after treatment, and about twice as much after 1 day (Table 1). In *Imperata cyclindrica* 0.48% of the total radioactive material was found in rhizomes and roots 4 hours after treatment, and 0.19% after 1 day (Table 2). About 90% or more of the applied radioactive material was recovered in these studies.

Table 1 Foliar uptake and translocation of ^{14}C – labelled glufosinate-ammonium

Time (h)	Species	Percentage of total radioactivity		
		In leaf Washes	In treated leaf	Translocated
4	*Imperata cylindrica*	45.5 ± 10.7	53.7 ± 8.4	0.8 ± 0.3
24		21.0 ± 10.4	77.3 ± 8.8	1.7 ± 1.0
48		26.5 ± 6.1	70.6 ± 4.1	2.9 ± 1.8
4	*Paspalum conjugatum*	53.0 ± 6.9	45.1 ± 5.1	1.9 ± 0.5
24		36.8 ± 14.8	59.6 ± 12.1	3.6 ± 1.0
48		21.2 ± 13.2	75.0 ± 14.1	3.8 ± 0.8

Table 2 Translocation (%) of foliar applied ^{14}C-labelled glufosinate-ammonium in *Imperata cylindrica* (means of 6 replicates)

Time (h)	Shoot above treated leaf	Shoot below treated leaf	Rhizome	Roots
4	0.01	0.28	0.42	0.06
24	0.07	0.68	0.75	0.16
48	0.08	1.92	0.67	0.19

The translocation period required for suppression of regrowth of new shoots from rhizomes of *Imperata cylindrica* was studied with plants which were sprayed with 2.5 *kg* a.i./*ha* glufosinate-ammonium. At different periods after herbicide application the sprayed shoots were removed by cutting, and the number of new shoots regrown from rhizomes was recorded 3 weeks after spraying. Shoot removal immediately or 6 hours after spraying had no or little effect on shoot regrowth, but strong to nearly complete inhibition of shoot regrowth from rhizomes was found, when sprayed shoots were removed 1 or 7 days, respectively, after herbicide treatment (Table 3).

Table 3 Influence of translocation period on regrowth of shoots from rhizomes of *Imperata cylindrica* after treatment with glufosinate-ammonium (6 pots per treatment)

	Herbicide-treated groups				Controls
Period between treatment and shoot cutting (hours)	0	6	24	168	0
Number of shoots at treatment	50	47	40	44	39
Number of shoots regrown 3 weeks after treatment	43	30	9	2	35

Photosynthetic net CO_2-uptake of *Sorghum halepense* sprayed with an ammonia-free 0.2%solution of glufosinate was almost completely inhibited 8 hours after treatment, CO_2-uptake of *Ipomoea purpurea*, in a similar experiment, was inhibited even faster (Fig. 1). The analysis of leaf samples taken from these experiments showed rapid accumulation of ammonia in the leaf tissue. Already 1 hour after treatment ammonia levels were significantly higher than in control plants (Fig. 2). A similar rapid accumulation of ammonia was found in leaves of *Imperata cylindrica* and *Paspalum conjugatum* after spraying with a 0.1%ammonia-free solution of glufosinate (Fig. 3).

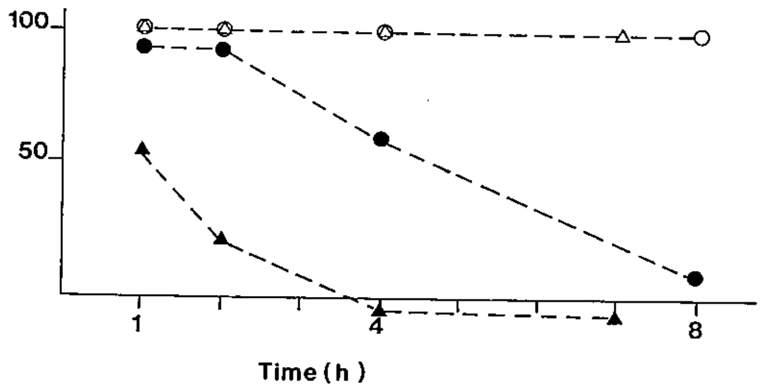

Figure 1

CO_2-uptake of *Sorghum halepense* and *Ipomoea purpurea* treated with glufosinate relative to control = 100. *S. halepense:* ○ control, ● treated;
I. purpurea: △ *control,* ▲ *treated.*

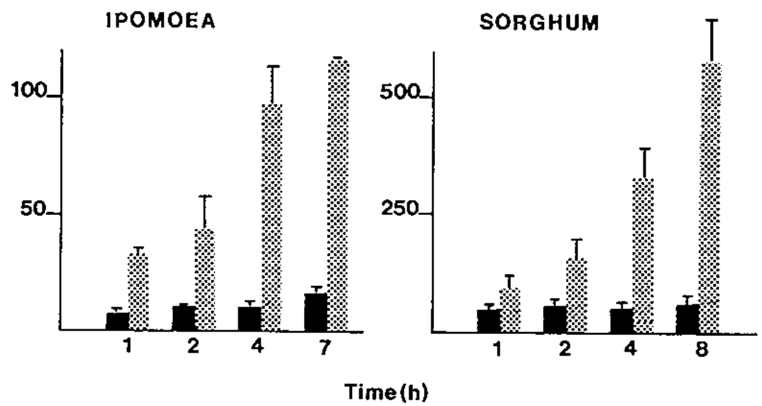

Figure 2

Ammonia accumulation ($\mu g\ NH_4^+ - N/g$ fresh weight) in leaves of *Sorghum halepense* and *Ipomoea purpurea* after treatment with glufosinate: ■ control, ▨ treated.

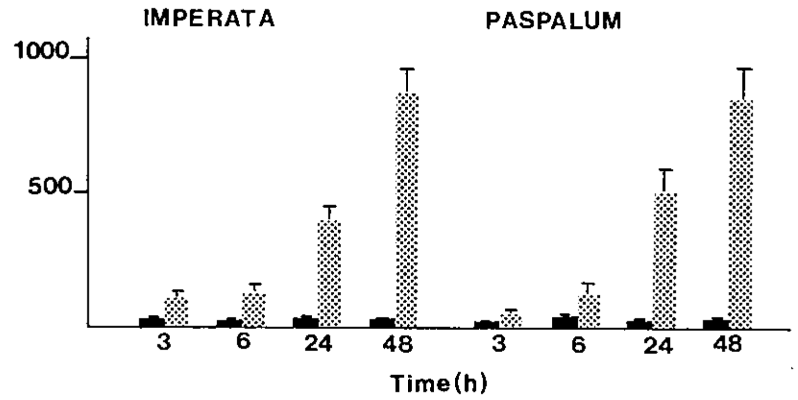

Figure 3

Ammonia accumulation ($\mu\ NH_4^+ - N/g$ fresh weight) in leaves of *Imperata cylindrica* and *Paspalum conjugatum* after treatment with glufosinate: ■ control, ▨ treated.

DISCUSSION

The studies with ^{14}C-labeled glufosinate-ammonium show that the herbicide is readily taken up by the leaves of *Imperata cylindrica* and *Paspalum conjugatum*. Elevated ammonia levels in leaf tissue of these grass species within few hours after foliar application of glufosinate are due to glutamine synthetase inhibition and indicate rapid transport of the inhibitor to the biochemical site of action in the leaf cells.

Despite of low basipetal translocation rate shoot regrowth from rhizomes of *Imperata cylindrica* was effectively inhibited in our greenhouse trial as well as in field studies (Langelüddeke et al., 1983).

The enzyme glutamine synthetase has key functions in plants, catalyzing the efficient reassimilation of ammonia and the synthesis of glutamine, which provides the organic N-metabolism with reduced nitrogen. High cellular ammonia levels as a consequence of glutamine synthetase inhibition are known to be toxic (Mothes, 1958) and appear to be responsible for increased K^+-permeability of membranes (Köcher, 1983) and subsequent leaf necrosis after application of glufosinate.

Inhibition of photosynthesis concomitantly to ammonia accumulation in *Ipomoea purpurea* and *Sorghum halepense* may either be due to uncoupling of photophosphorylation by high ammonia levels or be due to interruption of the photorespiratory nitrogen cycle by glutamine synthetase inhibition and hence decreased recycling of carbon from the photorespiratory cycle back to the Calvin cycle (Walker et al., 1984). Lack of glutamine for amide transfer reactions may be involved in the inhibition of shoot regrowth from rhizomes and other subterranean organs of perennial weed species. Kolodziej (1983) reported a reduction of protein, total nitrogen and soluble carbohydrates in roots of *Sinapis alba* after foliar application of glufosinate. Provided, glufosinate induces similar effects in rhizomes of *Imperata cyclindrica*, they might play a role in the overall effect of this herbicide on suppression of shoot regrowth from rhizomes.

ACKNOWLEDGEMENTS

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A CULTURAL PROGRAMME FOR SQUASH PRODUCTION

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ABSTRACT

Depth of sowing and time and rate of herbicide application were examined in a squash *(Cucurbita maxima)* production programme.

In moist soil and under precise experimental conditions cyanazine 1.2 *kg/ha* was well tolerated when applied to the soil surface one day after sowing the seed at a depth of 40 *mm*. Exellent weed control was obtained and fruit yields in excess of 20 *tonnes/ha* resulted. Crop safety was at risk with shallower sowing, later pre-emergence application or higher rate of cyanazine. Good correlation was obtained between crop vigour assessment in the seedling stage and yield of fruit at maturity.

INTRODUCTION

Crops of the family Cucurbitaceae are widely grown in both tropical and temperate climates and comprise a group in which chemical weed control techniques have made comparatively little headway. One of the main reasons for this is that most members of the family are inherently sensitive to the most effective herbicides.

In the search for safe and effective materials, cyanazine,2-(4-chloro-6-ethylamino-1, 3, 5-triazin-2-ylamino)-2-methyl propionitrile, shows promise as it is surprisingly well tolerated by pumpkins, squash and gherkins. Cyanazine, along with chlormethazole, was reported as a useful herbicide in minimum cultivation systems for pumpkins and gherkins (Cox 1979). A recent study in conventional seedbeds (Cox and Ingle, 1984) suggests that cyanazine may be used safely if contact with the germinating seed is minimised by applying the least effective herbicidal rate directly after sowing. Crop tolerance was reduced, however, when irrigation or rainfall exceeded 100 *mm* during a period of two to three weeks after sowing.

The work reported in the present paper was also carried out under moist conditions and in addition, introduces an important comparison of sowing depths.

METHOD

The trial was laid out on a prepared site in early December 1984. Beds of oats *(Avena sativa)* 1.5 *m* wide and 3.0 *m* apart had been drilled across the site as shelter for the squash plants in the early stages of growth. Seedbeds 1.5 *m* wide were prepared between the oats. A 12:10:10 NPK fertiliser was applied at 850 *kg/ha* and the soil was then cultivated with a reciprocating harrow and consolidated with a heavy roller. Squash seeds were sown 30 *cm* apart In single-row plots 7 *m* long arranged in a six-replicate randomised block design.

Sowing depths of 20 and 40 *mm* were compared and in order to achieve these accurately, each seed was laid on the surface of the soil and then pressed in to the required depth with the simple tool illustrated in Figure 1. A 75 *mm* nail inserted in the appropriate hole drilled through the bamboo stick provided the depth guide. The depression in the seedbed was then level-filled with a pinch of soil from nearby.

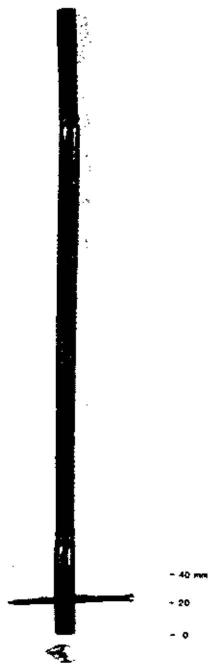

Figure 1. Seed sowing device

Cyanazine rates were nil, 0.8, 1.2 and 1.6 *kg/ha*. The herbicide was applied in 350 *litres/ha* of water by means of a four-jet, pressurised plot sprayer.

Two times of pre-emergence application were compared: one day after sowing (five days before emergence) and five days after sowing, (one day before emergence). It is important to note that depth of sowing made very little difference to the observed time of emergence; almost all seedlings of both sowing depths emerged during the day after the second time of spraying.

The seedbed condition was considered ideal for sowing. Soil type was a silt loam with a mechanical analysis of 23% sand, 61% silt and 16% clay. An organic carbon content of 3.5-4.0% is typical of this soil which has been described as well-structured, freely draining and friable (Ross and Cox, 1981).

Soil temperature in the surface 10 *cm* was 18-19° *C*, and during the days until emergence a total of 157 *mm* of rain fell. In the following week, at approximately two day intervals, 169, 240 and 132 *mm* of rain fell thus maintaining good conditions for seedling growth and herbicide activity.

During this period the oats were approximately 50 *cm* tall. They were killed with glyphosate 1.8 *kg/ha* sprayed two days after sowing the squash to prevent competition while continuing to provide some wind protection.

As all herbicide treatments gave excellent control of the weeds occurring - mainly *Capsella bursa-pastoris, Coronopus didymus, Portulaca oleracea* and *Solanum nigrum* - no detailed weed information is given.

Weed density on untreated plots was in excess of 1100 per m^2 and these plots were hoed and hand-weeded as the crop developed to provide a weed-and herbicide-free comparison. Detailed crop assessments were carried out on two occasions, 9 and 18 days after emergence, and crop yields were recorded 100 days after emergence. These assessments of crop vigour correlated well with yield (r = 0.74 and r = 0.79 respectively) thus details of total yields of squash fruit only are presented.

RESULTS

Total weights of squash of the order of 20 *t/ha* were obtained from the highest-yielding treatments, see Figure 2. Depth of sowing treatments alone made no difference to squash yield. The mean yields from treatments receiving cyanazine 0.8, 1.2 and 1.6 *kg/ha* were 20.1, 15.5 and 10.0 *t/ha* respectively. Generally cyanazine treatments reduced plant growth less when applied immediately after sowing than when applied

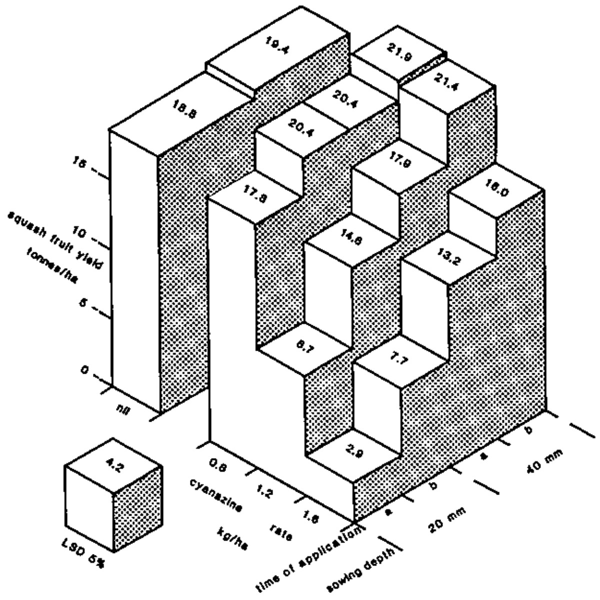

Figure 2. Effects of cyanazine rate and time of application on squash sown at two depths

just before emergence and also had less effect when seed was sown 40 *mm* rather than 20 *mm* deep. Yields from all treatments receiving the highest rate of cyanazine were reduced. When cyanazine 1.2 *kg/ha* was applied and seeds were sown 40 *mm* deep yields were not significantly reduced; the highest yield, 21.4 *tonnes/ha* was obtained when this herbicide treatment was applied immediately after sowing.

At the lowest rate of application, yields were not significantly affected by either time of application of cyanazine or depth of sowing.

DISCUSSION

Previous work with cyanazine in cucurbit crops has been confirmed and extended. A rate of application just less than 1 *kg/ha* is the generally accepted minimum effective weed control rate for this herbicide, (Anon, 1983) and under optimum conditions in this experiment, as in earlier experiments at Levin, 0.8 *kg/ha* gave excellent results.

The crop tolerance margin is narrow - under no circumstances was a x2 factor of safety demonstrated. However, at the intermediate rate of 1.2 *kg/ha* both early time of application and deep sowing improved crop safety and the combination of both conditions gave good growth and high yield.

In the development of chemical weed control in cucurbit crops, definite physiological selectivity is rarely attainable because of the natural sensitivity of the family to herbicides. By introducing precise sowing techniques and spray timing this work confirms that strategies can be devised to make practical use of a marginally safe herbicide.

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ALTERNATE WEED MANAGEMENT STRATEGIES IN IMPROVED CROPPING SYSTEMS ON VERTISOLS IN SEMI-ARID INDIA

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ABSTRACT

Experiments were conducted to develop alternate weed management systems and control methods for *Cynodon dactylon* in maize-chickpea sequential and sorghum/pigeonpea intercrop systems on Vertisols. Results revealed that a) application of pre-emergence herbicide to the rainy season crop or planting weed-smother crops such as cowpea between rows of the main crop were effective alternatives to the traditional interculture and hand weed system, b) the broadbed and furrow system recommended for improved drainage in high rainfall areas should be cross plowed and reformed every year in *Cynodon* infested fields, and c) effective control of *Cynodon* was achieved by post-emergence directed application of Glyphosate at inter-row space or post-emergence spray of Flauzifop butyl in legume crops.

INTRODUCTION

Vertisols are deep black soils characterized by high clay content (>30%), low infiltration (<1 *mm/hr*), and high water holding capacity (>200 *mm* of plant available water in the profile). They are sticky in wet condition and become hard and crack in dry condition, so they can be cultivated easily only in a limited range of moisture conditions. Additional problems are poor crop establishment in wet season, water logging and heavy weed infestation. Traditionally these soils in India have been fallowed during the rainy season and cropped only in the postrainy season with such crops as sorghum, chickpea, safflower, lentil, chilli or wheat. Fallowing in high and assured rainfall areas (>750 *mm*/year) where moisture is sufficient for two crops represents an under-utilization of natural reasources. Recently, ICRISAT has developed an improved farming systems technology based on i) graded broadbed and furrow (BBF) system that reduces runoff and soil erosion, and improves surface drainage and workability, ii) soil preparation immediately after harvest of postrainy season crops and sowing crops in the dry soil just before rains, iii) cropping systems that maximize the utilization of the rainy and postrainy seasons, and iv) improved implements for efficient cultivation (ICRISAT, 1982).

The broadbed and furrow system comprises of a 90 to 100 *cm* width bed where crops are planted and 50 to 60 *cm* furrow that provides path for draft animals and wheels of the improved animal-drawn equipment. The most promising cropping systems were a sequential system of two short duration crops one after the other (e.g. maize-chickpea) or an intercrop system based on long season crops such as pigeonpea (e.g. sorghum/pigeonpea). Operational-scale evaluation at

ICRISAT Center and in farmer's fields revealed that the improved system has potential to give six-times greater returns than the traditional system (ICRISAT, 1983).

In the traditional system weeds were managed by working repeatedly with blade harrows during dry spells in the rainy season. But the improved system presented greater weed problems due to the establishment of crops at the start of rains by dry seeding and because cultivations in BBF system were restricted only to the bed leaving furrows and edges of beds undisturbed. Timely intercultivation is often difficult on Vertisols in the rainy season because of the sticky soil. Restricted cultivation on beds has in certain situations led to increased infestation of the perennial weed *Cynodon dactylon*. Application of pre-emergence herbicide to the rainy season crop may control weeds from beginning of the season and avoid the uncertainty of intercultivations in the rainy season. Small-plot studies indicated the possibility of somthering early season weeds by introducing quick growing low canopy legumes. The present studies were conducted to i) examine the potential of alternate weed management practices in the improved cropping systems, and ii) evaluate different tillage systems on broadbed and furrows for the control of *Cynodon*.

MATERIALS AND METHODS

Two experiments were conducted using the two improved cropping systems, maize-chickpea sequential and sorghum/pigeonpea intercropping during 1979 to 1984 on Vertisols laid out into broadbed and furrows.

Experiment 1: The alternate systems evaluated were: i) hand weed system (one interculture +two hand weedings), ii) herbicide system (pre-emergence herbicide to the rainy season crop + two weedings), and iii) smother crop system (smother crops of cowpea or mung + two weeding), and iv) a weed-free system (one or two intercultures + two to three weedings). A weedy-check was also included in both trials conducted separately for the the two improved systems. The treatments were replicated three or four times in randomized blocks. Hand weedings were given depending on the requirement, and the labour imput was noted.

Experiment 2: This experiment was conducted on *Cynodon* infested medium-deep black soil for two years with sorghum/pigeonpea (1981 and 1982) and one year with maize-chickpea (1984). The treatments included in the initial trial were:

i) Strip tillage: Plowing twice with a left and right plow which cultivated a 20 to 25 *cm* strip on both edges of the bed, furrow cleaning with a ridger, and bed cultivation and shaping.

ii) Complete tillage (or split-strip tillage): Splitting the bed at center followed by plowing with a pair of right and left plow in two passes, furrow cleaning, and cultivation and shaping.

iii) Deep plow and rebuilding of beds: Cross plowing of beds and reforming of beds every year.

iv) Traditional system: Rainy season fallowing, frequent harrowing by blade harrows on flat land, only a postrainy season sorghum, and planting and interculture by local implements.

maize, post-emergence directed application of Glyphosate at between-row space, and post-emergence application of Flauzifop butyl — were included. Since cereals are sensitive to Flauzifop butyl, cowpea was planted instead of maize in the rainy season where this chemical was applied. Traditional system was also modified by planting maize-chickpea double cropping. The study was conducted in a randomized block design having two replications in 1981 and 1982 but three replications in 1984.

Both the studies were conducted in field-sized plots (200 to 500 m^2) using animal-drawn equipment for all cultural operations. Crops were planted in the dry soil around second week of June before the start of rains. One hundred *kg* of Diammonium phosphate (18N-20P-0K) was applied at basal and the cereal was top dressed later with 42 *kg* N/*ha*. Yields were estimated by harvesting three sub-samples of 45 m^2 from each plot. Net monetary retuens were computed using prices prevailing in the respective years and by deducting from gross returns the cost of seed, fertilizer, labour and cultivations.

RESULTS AND DISCUSSION

The weed free treatment gave the highest yields and monetary returns in both the cropping systems (Table 1) but in reality frequent hand weeding (three to four in addition to intercultures) would be difficult to provide because of labour shortage.

Table 1. Effect of alternate weed management systems on crop yields and net returns of a maize-chickpea and a sorghum/pigeonpea systems on Vertisols (Mean of four years data 1979-1982).

Weed management	Maize-chickpea			Sorghym/pigeonpea		
	Rainy (*kg/ha*)	Post-rainy (*kg/ha*)	Returns (*Rs/ha*)	Rainy (*kg/ha*)	Post-rainy (*kg/ha*)	Returns (*Rs/ha*)
1. Hand weed system	2830	550	3405	3485	685	4115
2. Herbicide system[a]	3395	610	4235	2920	1005	4600
3. Smother crop system						
a) Cowpea	2775	535 (215)	4080	3230 (255)	625	4520
b) Mungbean	2390	580 (100)	3360	3100 (100)	576	3980
4. Weed free	3655	690	4690	4220	1105	5830
5. Weedy check	1270	185	825	1475	335	1400
SEm ±	198	42	268	185	65	317

Values in brackets are smother crop yields.

[a] In the herbicide system Atrazine was applied @ 1.5 *kg a.i./ha* to maize in the sequential system and Fluchloralin @ 1 *kg a.i./ha* to sorghum/pigeonpea intercrop.

The returns in the unweeded check were lowest because yields in some years were so low that they did not cover input costs. The wide disparity in returns of these two treatments (4 to 6 times) indicate the potential benefits of complete weed control in improved cropping systems. One interculture and two hand weedings improved returns by 3 to 4 times over the check which represented about 72% of the potential returns. Use of pre-emergence herbicide to the rainy season crop gave 90% of the potential returns in maize-chickpea and 79% in sorghum/pigeonpea intercrop. The herbicide system gave lower returns in intercrop because Fluchloralin suppressed the sorghum yields, indicating the need for exploring better chemicals for the intercrop system. The smother crop system with cowpea produced about 80% of the maximum returns. Smother crop mung was less effective because it did not cover the ground well and produced poor yields due to pests and diseases. Since the smother crops in this study were allowed to mature they were competitive to the main crops, but if they are harvested for fodder around 45 days they may smother weeds without affecting much the main crops. Therefore, a pre-emergence herbicide or planting of a smother crop can be recommended to reduce labour input and avoid the uncertainty in excuting intercultivations for controlling weeds on Vertisols in the rainy season.

Double cropping on broadbed and furrows gave 1-1/2 to 2-1/2 times greater returns than single season cropping on flat (Table 2). Yields from double cropping on flat land with traditional tillage methods were low (Table 3), nevertheless returns were good because of less operational expenses. However, where no efforts were made to control *Cynodon* double cropping made a loss. Of the three tillage systems on BBF, cross plowing and remaking of beds every year was most effective in checking *Cynodon*. Though it involved some additional expenses it gave 51% higher returns in sorghum/pigeonpea and 33% in maize-chickpea over other tillage systems. There was no significant difference between strip tillage and complete tillage in net returns. Atrazine, generally recommended for weed control in maize, controlled all annual weeds but not *Cynodon*. In the absence of competition from other weeds *Cynodon* became more competitive at the end and reduced the yield of the low canopy chickpea (Table 3). This indicates the need for specific herbicides for controlling this weed. Glyphosate controlled *Cynodon* very well which was reflected in high chickpea yield but not in maize because the herbicide was applied as post-emergence at about 4 weeds stage by which time maize growth was already reduced by competition. or directed post-emergence application of this chemical in a standing crop suitable equipment (e.g. wick applicator, or normal sprayers with protective hoods) is a prerequisite. Flauzifop butyl was equally effective as Glyphosate. Since this herbicide can be applied safely as post-emergence in legume crops, control would be easy if the cropping system involves a sole legume in the beginning. Because of better premium for legumes, the cowpea-chickpea system gave the best returns.

Table 2. Effect of different tillage systems on the control of *Cynodon dactylon*, crop yields, and net returns of sorghum/pigeonpea intercrop (mean of 2 years 1981-82, 1982-83).

Treatment	Sorghum (*kg/ha*)	Pigeonpea (*kg/ha*)	Net Returns (*Rs./ha*)	Dry matter of Cynodon (g/m^2) At first inter-culture	At sorghum harvest (*kg/ha*)	At pigeonpea harvest
Strip tillage	3168	569	4780	49	319	113
Complete tillage	3535	598	5093	31	239	114
Deep plowing & rebuilding of beds	4029	1031	7473	12	135	82
Tradition	1106	-	2889	30	259	54
SEm ±	200	92	507	12	32	16

Table 3. Effects of different herbicide and tillage systems on the control of *Cynodon dactylon*, crop yields and net returns of a maize-chickpea sequential system (1984-85).

Treatment	Maize (*kg/ha*)	Chichpea (*kg/ha*)	Net returns (*Rs./ha*)	Dry matter of Cynodon (g/m^2) At first inter-culture	At sorghum harvest	At pigeonpea harvest
Strip tillage	1255	433	3772	6	8	64
Complete tillage	876	461	3371	21	24	76
Deep plowing & rebuilding of beds	1170	629	4747	4	17	58
Atrazine (@ 1.3 *kg a.i./ha*)	1270	335	2993	10	37	159
Glyphosate (@ 1.5%)	895	726	4485	2	12	34
Flauzifop butyl (0.3 *kg a.i./ha*)	826*					
Traditional	863	339	3739	4	30	61
Unweeded (check)	165	29	-334	10	23	22
SEm ±	132	92	565	1.3	5.5	10.0

* Cowpea yield

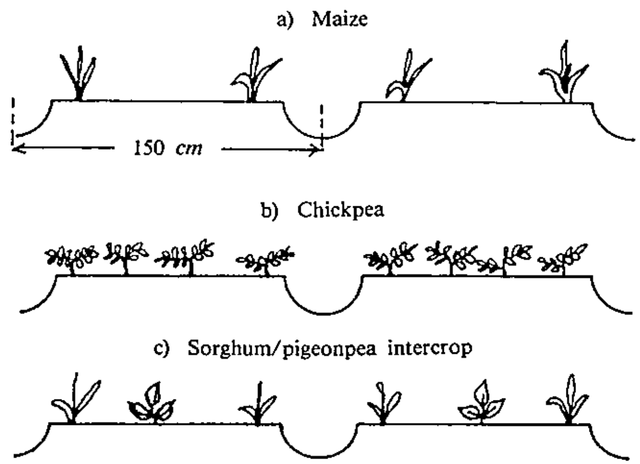

Fig. 1. Broad bed and furrows showing planting arrangement of maize and chickpea in sequential systems, and sorghum and pigeonpea in intercropping. In the case of smother crop system two rows of cowpea or mung were planted per bed.

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AN INTEGRATED APPROACH TO THE MANAGEMENT OF *Mimosa pigra* L. IN AUSTRALIA AND THAILAND

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ABSTRACT

The habitat favoured by *Mimosa pigra* is described, relative abundance in its native and introduced range is contrasted and problems caused by infestation in the introduced range are outlined. A cooperative research program between Australia and Thailand is summarised. The objective of this program is to develop a management strategy integrating biological, herbicidal and other control practices. Progress towards this objective is given and preliminary recommendations are presented.

INTRODUCTION

Mimosa pigra L. is a woody, prickly, leguminous shrub which originated in sub-tropical and tropical regions of America. Two varieties are known, *M. pigra* var. *pigra* which is native to Mexico and areas southwards to the Tropic of Capricorn, and *M. pigra* var. *berlandieri* (Gray) which is native to southern USA and north east Mexico (B.L. Turner, personal communication, 1981). The variety referred to in this paper which has become a weed in Thailand, Australia and other countries is var. *pigra*.

M. pigra favours seasonally flooded habitats but, once established, it may grow vigorously in better drained situations. In its introduced range large infestations occur on flood plains where the seed is distributed by water and conditions for germination and seedling survival are suitable. Plants adapt to flooded conditions by producing adventitious roots. Prolonged dry conditions may cause plants to regress. In both its native and introduced ranges *M. pigra* occurs primarily in the tropical summer rainfall zone (Walter et al., 1975). In Australia this weed is generally known as giant sensitive plant or mimosa, and in Thailand as maiyarap yak or giant mimosa.

In its introduced range *M. pigra* forms huge impenetrable thickets on wetlands and adjacent to streams, canals, water holes and reservoirs. In these and to a lesser extent in better drained situations, it out-competes pastures and other vegetation. It prevents access to irrigation and stock watering points, interferes with the use of water for dometic purposes and for recreation, restricts flow in canals, rivers and streams thereby increasing the severity of flooding and erosion, increases sedimentation in reservoirs, is a safety hazard along roadways and interferes with access to electric power lines (Miller et al., 1981; Napompeth, 1983a; Robert, 1982; Thamasara, 1983).

Inherent characteristics of *M. pigra* which make it a weed, and which have assisted in its spread, include ability to form dense monocultures especially under moist conditions, height (4 - 5 metres), possession of thorns, high seed production and the ability of pod segments to float on water for long periods (Miller et al., 1981; Miller, 1983; Robert, 1982).

A joint project on biological control of *M. pigra* was initiated by the Northern Territory Department of Primary Production and the Division of Entomology, CSIRO, in 1980. With support from the Australian Centre for International Agricultural Research (ACIAR) a research program was started in 1984 to:

(a) study the natural enemies of *M. pigra* in its native range and select suitable species for use as biological control agents and establish these agents in Australia and Thailand.
(b) determine herbicide applications compatible with different control strategies.
(c) integrate biological, herbicidal and other control practices for economical, effective management.
(d) develop an overall management strategy for control of *M. pigra* in Thailand

Thus a proposal for collaboration on management of this weed in Australia and Thailand, which was conceived at the International Symposium on *Mimosa pigra* Management held at Chiang Mai in 1982, came to fruition.

Under this program, research is being carried out in Australia and Maxico by the Division of Entomology, CSIRO and the Northern Territory Department of Primary Production and in Thailand by the National Biological Control Research Centre, the Royal Irrigation Department and cooperation institutions such as the Maejo Institute of Agricultural Technology and Chiang Mai University.

RESEARCH AND CONTROL IN AUSTRALIA AND THAILAND

Biological control:

Thickets of *M. pigra* in its native range are very small by comparison with those in its introduced range and are attacked by a much larger complex of insects (natural enemies). This suggests that natural enemies in the native range of the plant are an important factor in maintaining the population at low levels and that biological control may be effective in reducing population levels in its introduced range.

During 1980/81, exploration for natural enemies of *M. pigra* covered most of the distribution in Brazil south of a line through the cities of Ilheus and Brasilia. Subsequently short surveys were made in central Venezuela, near San Fernando de Apure, and along the Pacific coast of Mexico, near Acapulco, where the climate resembled more closely the region infested with *M. pigra* in northern Australia than did any region of Brazil. In 1984 a field station was established at Acapulco for detailed survey of natural enemies in that region. Seven species of insects were selected for detailed evaluation as biological control agents (Table 1). The two *Acanthoscelides* spp. (Bruchidae) have subsequently been liberated for control of *M. pigra* in Australia and Thailand and the release of *Chlamisus* sp. has been approved in both countries. The exploratory work in Mexico is still in progress.

Table 1. Insect species candidate as control agents for *Mimosa pigra*

Species	Country of origin	Host specific	Released	
			Australia	Thailand
Bruchidae				
Acanthoscelides quadridentatus	Mexico	Yes	Yes	Yes
A. puniceus	Mexico	Yes	Yes	Yes
Halticinae				
Syphraea flavipes	Brazil	Studies in progress		
Near *Altica* sp.	Mexico	Doubtful		
Cryptocephalinae				
Cryptocephalus sp.	Brazil	No		
Chlamisinae				
Chlamisus sp.	Brazil	Yes	Approved for release	
Gelechiidae				
Undetermined species	Mexico	Doubtful		

M. pigra is not damaged by the adults of *Acanthoscelides* spp. which feed on pollen, but their larvae feed within and destroy the seeds. The possible effectiveness of seed- destroying insects as biological control agents was discussed by Harley (in press).

The adults and larvae of *Chlamisus* sp. feed on the terminal portions of stems, petioles and leaflets causing wilting and sometimes death of the terminal portions of stems (R.C. Kassulke, pers. comm.).

M. pigra is less of a problem in Indonesia than in Thailand, in spite of having been established there for a much longer period. Napompeth (1983b) postulated that this may be due to attack by insects and made a survey of the natural enemies of the weed in the Bogor area. Subsequently he selected a cerambycid, *Milothris irrorata* (F.) for detailed study.

Exploration for biological control agents began in Mexico in 1984 and although a large number of insects have been collected most have not yet been identified. However, field and insectary observations suggest that a number of species are host specific and that they have potential as biological control agents.

In Australia and Thailand measurements of *M pigra* infestations are being made to establish a base-line against which any changes subsequent to establishment of biological agents may be evaluated. Studies on the ecology and population dynamics of the plant are in progress in Australia and Mexico and will shortly be extended to include Thailand. These studies will help identify factors restricting the abundance and distribution of *M. pigra* in its native range in Mexico compared with its introduced range in Australia and Thailand

The ultimate objective is to reduce the abundance and distribution of *M. pigra* to levels at which it is no longer a pest and to hold it at these levels using biological control agents. Achievement of this goal requires an integrated approach using physical methods, herbicides and biological control agents. The use of physical methods and herbicides is especially important in minimising spread from existing infestations and controlling small outlying infestations in regions where, if uncontrolled, such infestations could spread to form much larger infestations.

Herbicidal control:

Herbicidal control methods have been tested over a number of years in both Thailand and Australia (Davis and Simagrai, 1979; Kittipong, 1980, 1983; Kittipong et al., 1983; Miller et al., 1981, 1983; Premasthira and Shibayama, unpublished results; Suwunnamek, 1983a, 1983b; Thamasara, 1983). Of the many herbicides tested, those which have been used in field control operations are bromacil, dicamba, dicamba + MCPA, ethidimuron, fosamine, glyphosate, hexazinone, 2,4,5-T and 2,4,5-T + picloram.

As part of the ACIAR program additional testing of herbicides is being undertaken to refine rates of application, previously untried herbicides are being tested, various methods of application are being evaluated for different land management systems and seasonal effects on herbicide efficacy are being studied. Field trials in progress in Thailand and Australia are listed in Table 2.

Table 2: Herbicides and methods of application being evaluated in the field for control of *Mimosa pigra* in Australia (A) and Thailand (T) in 1985

Herbicide (Active Ingredient)	Method of Application					
	Soil	Cut Stump	Injection	Basal Bark	Foliar Ground	Foliar Air
AC 252,925					T	
Dicamba	T	A,T	A	A,T	A,T	A
Glyphosate		A,T	A		T	
Hexazinone	T	A,T	A			
Picloram + 2,4-D				T	T	
Picloram + 2,4,5-T		A	A	A		
Tebuthiuron	A,T					
Triclopyr		A,T	A	A,T	T	
Triclopyr + picloram		A	A	A	A	A
Triclopyr + picloram + 2,4-D		T		T		

Cut stump, basal bark and tree injection are useful application methods on small infestations and where foliar application may damage nearby susceptible crops. Soil application has similar advantages where the herbicide used has selective properties or where residual control of infestations is required. These methods also require low volumes of herbicide carrier and hence have advantages where access by high volume spray equipment is difficult and where there is a shortage of clean water.

Cutting of *M. pigra* along roadsides in the north and in small isolated infestations further south is a common practice in Thailand. However plants quickly regrow from the cut stumps. Herbicide application to freshly cut stumps will achieve more effective control.

While it is too early to give final results of these trials an interesting aspect to emerge is that good initial defoliation was achieved using water as the carrier for basal bark spraying in place of diesel.

After initial screening research will aim at determining the most cost effective herbicide for each application method.

DEVELOPMENT OF MANAGEMENT STRATEGIES

Although the cooperative research program is still in its initial stages, it is recommended that in areas which are inaccessible or unsuitable for herbicide application both in Australia and Thailand, biological control using *Acanthoscelides* spp., *Chlamisus* sp. and other potential agents be employed. It is also recommended that control, and if possible eradication, of isolated infestations be undertaken using normal, mechanical and chemical measures.

In Thailand this means control of all infestations outside of the eight heavily infested northern Provinces. This is in accordance with a decree by the Ministry of Agriculture and Cooperatives under the Plant Quarantine Act, aimed at preventing establishment of *M. pigra* in uninfested or lighly infested areas. It is recommended that a mobile squad be established and equipped to carry out control on a country wide basis, and to advise on and encourage control by landholders.

In Australia this means control of areas isolated from the Adelaide River system, increased landholder participation, use of existing spray teams and expansion of the existing aerial spraying programme.

Methods and rates of application for herbicides in different types of infestation are given in Table 3.

Table 3. Recommended herbicides, methods and rates of application for control of *Mimosa pigra* in different land use situations in Australia and Thailand

Herbicide		Method of Application and Land Use
Active Ingredient	Rate of Product	
AUSTRALIA		
Dicamba as the dimethylamine salt (200 *g/l*)	1%*v/v* (spot spray) or 6-7 *l/ha* +0.25%nonionic surfactant (aerial spraying)	Foliar spray in town areas and pastoral areas, roadsides and water reservoirs
Ethidimuron (700*g/kg*)	0.5%*w/v* (spot spray) or 7.5 *kg/ha*	Soil application for residual control on small isolated infestations in pastoral areas
Glyphosate as the isopropylamine salt (480/*g/l*)	1%*v/v* (spot spray)	Foliar spray in town areas
Hexazinone liquid (250 *g/l*)	4 *ml* of concentrate per plant or 4 ml/m^2 in grid pattern	Soil application for residual control on isolated plants in pastoral areas and roadsides
Picloram (100 *g/l*) +2,4,5-T (400 *g/l*) both as the isooctyl ester	2%*v/v* in diesel carrier	Basal bark spray on isolated plants in pastoral areas and roadsides
THAILAND		
Bromacil (800 *g/ kg*)	12.5 *kg/ha*	Soil application for residual control on dam walls and non agricultural areas
Bromacil (800 *g/ kg*) +diuron (800 *g/kg*) 1:1 *w/w*	18.75-25 *kg/ha*	Soil application for residual control on dam walls and non agricultural areas
Dicamba as the dimethylamine salt (480 *g/l*)	0.5 – 1.5%*v/v* (spot spray) or 9.4 - 21.9 *l/ha* + 0.25%non-ionic surfactant	Foliar spray along roadsides, canals if water depth > 1 m, and non agricultural areas
Fosamine ammonium (480 *g/l*)	0.75 - 1.25%*v/v*+0.25%non-ionic surfactant	Foliar spray beside canals, roadsides and in water reservoirs
Glyphosate as the isopropylamine salt (480 *g/l*)	0.75 - 1.25%*v/v* (spot spray) or 6.25 - 12.5 *l/ha*	Foliar spray beside canals, roadsides, in water reservoirs and in agricultural areas before cropping or after harvest

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BANVEL 520 - A NEW BASAL APPLICATION TO RUBBER CUT STUMP IN THAILAND

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ABSTRACT

Banvel 520 (dicamba + 2, 4-D isooctyl ester) mixed in diesel oil was applied as a basal treatment on rubber cut stumps, short cut and normal cut, at Chandi Rubber Experiment Station, Nakorn Si Thamarat, Thailand in January 1983. Evaluation taken after two and a half years showed that the treatments gave very good control for both cuts. Banvel 520 at the rates of 2.35 - 4.7 *g* ai per stump in diesel solution gave similar stump kill as triclopyr at the rates of 1.11 - 2.21 *gm*(a.e.) stump in diesel. In short cut, Triclopyr at the rates of 1.11 - 1.66 *g* a.e. per stump in water was less effective.

INTRODUCTION

2,4,5-T used to be the standard chemical for killing rubber cut stump in Thailand. A five percent solution of 2,4,5-T in diesel oil applied at 100 *ml* per stump was recommended as a standard basal paint application (Charuck and Prasert, 1977). During the past years, however, the use of 2,4,5-T has been banned. The Rubber Research Center of Thailand (RRCT) at Hat Yai under the Rubber Research Institute, Department of Agriculture, Bangkok, Thailand and The Office of the Rubber Replanting Aid Fund (ORRAF) have started looking for possible substitutes for 2,4,5-T. In 1981 the RRCT reported that triclopyr ester was effective in rubber tree cut stumps when applied as a basal treatment (Charuck and Paopong, 1981). In 1982 the RRCT recommended triclopyr (Garlon 4) at the rate of 2.21 *gm*(a.e.) or 5*cc* with 95*cc* of water per stump.

Another substitute chemical considered by RRCT was dicamba + 2, 4-D isooctyl ester. This combination is marketed worldwide under the trade name Banvel 520. Dicamba is a herbicide readily absorbed by plant roots, stems, trunks and leaves. Following absorption, dicamba is translocated throughout the plant, with greatest accumulation occurring in areas of greatest metabolic activity. It is highly effective on a wide range of woody plants and broadleaves. Banvel 520 is widely used in the U.S.A. as a basal spray or paint in diesel for the control of woody plants. With such properties the herbicide appeared a likely substitute for 2,4,5-T.

MATERIALS AND METHODS

The trials were conducted by RRCT at Chandi Experiment Station during 1983 - 1985 to determine the efficacy of dicamba + 2,4-D on rubber cut stump using two different methods.

Table 1. Rating scale used to evaluate herbicide efficacy

				%Control
0	-	Fresh stump with white latex bleeding	=	0
1	-	Fresh stump with latex bleeding on some part	=	10 - 20
2	-	Dried on the top of stump, some bleeding at the bottom part	=	20 - 40
3	-	Dried on the top of stump, no latex, hard wood, few borer attack	=	40 - 60
4	-	Dried stump without latex bleeding, much borer attack and rotted	=	60 - 80
5	-	Friable stump, heavy borer attack, ready to decompose	=	80 - 100

(1) Normal cut trial

The experiment was conducted at Chandi Experiment Station in Nakorn Si Thamarat province, January 1983, to evaluate the efficacy of dicamba + 2,4-D at different rates mixed with diesel. The different herbicide rates were mixed with a total resulting volume of 100 *cc* of water or diesel per stump. There were 20 stumps per treatment. An untreated control also of 20 stumps was maintained for comparison. Triclopyr (Garlon 4; 44.3% *a.e.*) was applied at the recommended rate of 2.21 *g (a.e)* per stump mixed with water.

The treatments were applied 1 day before cutting. Application was basal paint treatment. The rubber tree was cut at about 40 - 50 *cm* above the ground and the chemical applied with a brush. Dicamba + 2,4-D was applied at 2.35, 3.53 and 4.7 *g a.e.* per stump.

(2) Short cut trial

The experiment was conducted at Chandi Rubber Experiment Station in Nakorn Si Thamarat province, February 1983, to evaluate the efficacy of dicamba + 2,4-D at different rates mixed with diesel.

The treatments were applied 1 day after cutting. Application was basal paint treatment. The rubber tree was cut at about 10 - 15 *cm* above the ground and chemical was applied with a brush. Triclopyr was applied at 1.11, 1.66 and 2.21 *g a.e.* per stump either in water or diesel oil. Dicamba + 2,4 - D was applied at 2.35, 3.53 and 4.7 *g a.e.* per stump in diesel oil. The different herbicide rates were mixed with a total resulting volume of 50 *ml* of water or diesel per stump. There were 20 stumps per treatment. An untreated control also of 20 stumps was included.

The rubber trees used in the experiment were of a native cultivar about 25 years old with an average girth of 105 *cm*. Temperature during application was at 27 - 30° *C*. Rating scale (Table 1) was done by sampling 10 stumps out of 20 for each treatment. For visual assessment an axe was used to chop around the stump from top to bottom including top surface roots.

Observation of each stump kill was made periodically for two and a half years.

RESULTS AND DISCUSSION

Table 2 shows the results of the Normal Cut Trial. Triclopyr at the recommended rate of 2.21 *g a.e.* per stump in water gave complete control after 18 months. Dicamba + 2,4-D at all rates in diesel gave complete control after 24 months. All dicamba + 2, 4-D and triclopyr treatments did not show any significant difference in efficacy from the 3rd to the 12 month.

Table 3 shows the result of the Short Cut Trial. Triclopyr at the recommended rate of 2.21 *gm a.e.* per stump in water gave complete control after 30 months. Triclopyr mixed with diesel at all rates gave complete control until after 24 months.

Table 2. Normal Cut Trial. Decomposition degree of rubber stump at 3, 6, 9, 12, 18, 24, 30 months after basal application 1 day before cutting.

Treatment chemical (mixed with)	rate per stump *ae* or *ai*	girth *(cm)*	Decomposition rating months 3	6	9	12	18	24	30
1. Banvel 520	2.35	101	1	2	3	4	4	5	5
2. Banvel 520	3.53	109	1	2	3	4	4	5	5
3. Banvel 520	4.7	96	1	2	3	4	4	5	5
4. triclopyr (water)	2.21	109	1	2	3	4	5	5	5
5. Control (untreated)	—	99	0	0	0	0	0	1	1

Remark: The rubber tree was cut at about 40-50 *cm* above the ground and treated with a total resulting volume of 100 ml.

Table 3. Short Cut Trial. Decomposition degree of rubber stump at 3, 6, 9, 12, 18, 24, 30 months after basal application 1 day after cutting.

Treatment chemical (mixed with)	rate per stump *ae* or *ai*	girth *(cm)*	Decomposition rating months 3	6	9	12	18	24	30
1. triclopyr (water)	1.11	103	1	1	2	3	3	4	4
2. triclopyr (water)	1.66	113	1	1	2	3	3	4	4
3. triclopyr (water)	2.21	109	1	1	2	3	3	4	5
4. triclopyr (Diesel)	1.11	100	1	2	3	3	4	5	5
5. triclopyr (Diesel)	1.66	103	1	2	3	4	4	5	5
6. triclopyr (Diesel)	2.21	99	1	2	3	4	4	5	5
7. Banvel 520	2.35	100	1	1	2	3	3	4	5
8. Banvel 520	3.53	108	1	1	2	3	3	4	5
9. Banvel 520	4.7	93	1	1	2	3	3	4	5
10. Control (untreated)	—	99	0	0	0	0	0	1	1

Remarks: The rubber tree was cut about 10 - 15 *cm* above the ground and treated with a total resulting volume of 50 *ml.*

All rates of dicamba + 2,4-D mixed with diesel gave complete control on the 30th month.

Comparing the results from the two methods of cutting:

In the Normal Cut method at 40 - 50 *cm,* chemicals gave faster control than in the Short Cut method because the Normal cut method have more surface area for brush application.

In both methods the chemicals mixed with diesel gave faster and uniform results than when the chemical was mixed with water. Triclopyr gave slightly faster kill than dicamba +2,4-D.

CONCLUSION

In the Normal Cut Method, Dicamba + 2,4-D at the rates of 2.35, 3.53 and 4.7 *g a.i.* in diesel gave the same complete control as triclopyr at the recommended rate of 2.21 *g a.e.* in water.

In the Short Cut Method, all rates of dicamba + 2,4-D in diesel provided complete control at 30 months. Triclopyr at the recommended rate of 2.21 in water gave complete control in 30 months while the lower 1.11 and 1.66 *gms* did not provide any control. All the rates of triclopyr in diesel killed the stump in 24 months.

Presently, RRCT is conducting trials using the same herbicides and similar rates for further confirmatory purposes.

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Mr. Rusamee Montree - Deputy Development Manager, T.J.C.

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® BASTA (GLUFOSINATE - AMMONIUM), A NEW NON - SELECTIVE HERBICIDE FOR GENERAL WEED CONTROL IN PLANTATIONS; RESULTS OF LONG TERM TRIALS IN MALAYSIA

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ABSTRACT

In six large-scale trials conducted over a period of one year, ® Basta (200 *g/l* glufosinate-ammonium) at 1.4 to 2.8 *l/ha* showed good long term control in mixed weed conditions.

In *Paspalum conjugatum* predominant areas, 1.4 *l/ha* of Basta under shades exihibits similar control as paraquat (200 *g/l* at 2.8 *l/ha*) or a paraquat +diuron mixture (200 +200 *g/l*) at 2.1 *l/ha*. Depending on the level of shade, one to two spraying rounds are required per year. Under open conditions, Basta at 2.8 *l/ha* shows superior control when compared to paraquat at 4.2 *l/ha* and paraquat +diuron at 2.8 *l/ha*, with three spraying rounds per year.

In *Ottochloa nodosa* predominant areas under shaded conditions, Basta at 2.8 *l/ha* shows similar control to paraquat at 2.8 *l/ha* and paraquat +diuron at 2.1 *l/ha* with two-spraying rounds per year.

Basta at rates of 2 - 5 *l/ha* also effectively controlled a wide range of broadleaves, ferns and shrubs.

INTRODUCTION

For plantations in Malaysia, weed control in general weed or mixed weed situations is of most importance. The general weed control in plantations is mainly confined to strip spraying in the rubber plantations, circel spraying and harvesting paths (similar to strips) in oil palm plantations and selective spraying of some shrubs and woody plants.

This paper describes the efficacy, long term results and number of applications needed per year in general weed-situations for Basta (code number: Hoe 39866; proposed common name: glufosinate-ammonium) and compares it with the performance of currently used standard products. The evaluation was conducted in *Paspalum conjugatum* and *Ottochloa nodosa* predominant areas on the assumption that these are the main weed species in the general weed situation in plantations. The efficacy of Basta against other important weed species has been reported earlier (Langelueddeke et al 1983).

® Basta = registered trade mark of Hoechst AG

MATERIALS AND METHODS

Trials were laid out both in immatured and matured rubber plantations and immatured oil palm plantations. Different shade conditions (from 0 to more than 70%) shade on well drained as well as on low lying water - logged soils were considered. Trials were designed as single replication of large plots and variation in infestation was taken into consideration. Plots were long, narrow strips ranging from 120 to 180 *sq.m.* The common Knapsack sprayer was used with 5/64 fan jet nozzle. The spraying volume was 450 *l/ha.*

During the evaluation, the plots were devided into 4 - 6 sub-plots and assessed individually and the average being taken at fixed intervals. In the first months, the ratings were done at 2 weeks intervals and subsequently at every 4 weeks for 12 months. Assessments were done using a 0 - 100 scale for rating the direct effect on the green parts of the weeds (% weed control) for the assessments 2 and 4 weeks after application. For later assessments, the coverage of the regrowth was recorded in absolute figures. The second application was made when the average coverage attained 30 - 50%.

Glufosinate-ammonium is formulated as an aqueous solution with 200 g *ai/l.* Two reference products were used: A 200 g/l paraquat formulation and a product containing 200 *g/l* paraquat + 200 *g/l* diuron.

RESULTS AND DISCUSSION

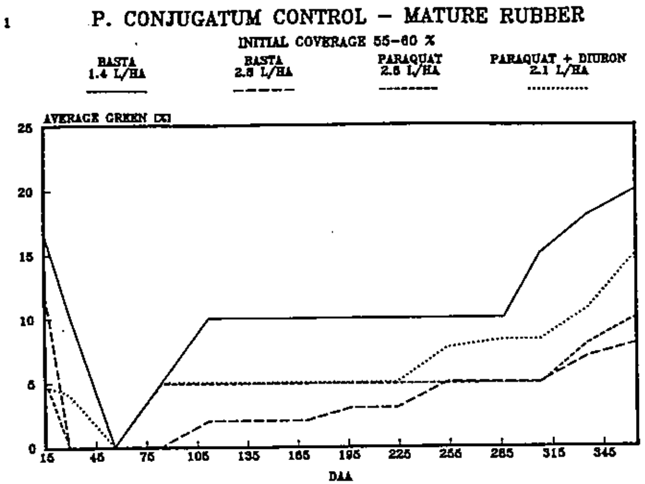
A total of 6 field trials were laid down throughout the years 1983 - 1984. Four of these trials were in *Paspalum conjugatum* predominant areas, of which two were under shade and two under open conditions. Another two trials were done in *Ottochloa nodosa* predominant areas under shade. *Ottochloa nodosa* is shade tolerant and therefore predominantes under shady conditions (Faiz and Liu Sin, 1982).

Field trials I and II

These trials were laid down in areas which were mainly infested with *Papalum conjugatum* under different shade levels and weed densities, both on clay loam soil. The results are illustrated in figures 1 and 2.

In figure 1, the trial commenced in early June. The initial weed density was around 55 - 60%. All treatments required only one application for a year's control. Differences between treatments were insignificant, with Basta at 2.8 *l/ha* giving the lowest coverage throughout the 12 months period. In figure 2, the trial commenced in late June. The initial weed infestation level was higher, 75 - 90% and the shade level lower, 50 - 70%. Under this condition, Basta 1,4 and 2.8 1 *l/ha* and paraquat + diuron at 2.1 *l/ha* required two applications per year. Three applications of paraquat at 2.8 *l/ha* were required to attain similar control. The difference in control exhibited in these two trials could be explained mainly by the difference in shade level: Better control being given under higher shade level. Other factors that may also influence the results are the weather conditions at the time of application (for instance in early June slightly lower rainfall was received) and the initial level of infestation

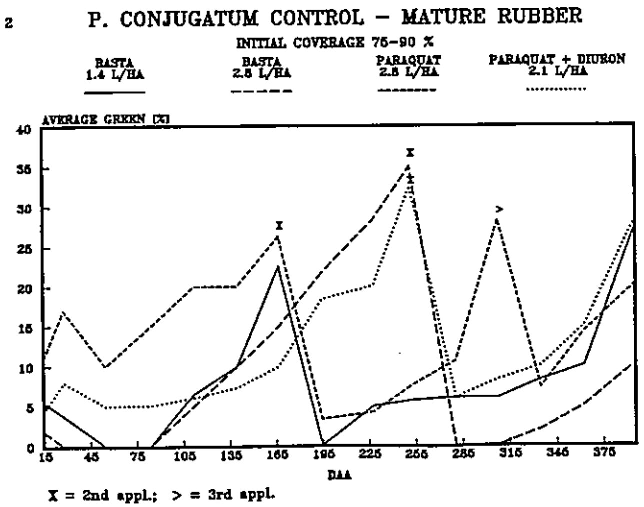
Fig. 1



Figures 1 to 6:

In these figures, the graphic evaluation of the individual trials is shown. The curves represent the average green (coverage in %) for the different treatments. The assessments at 15 DAA (days after application) were made as % efficacy and transformed to coverage in %.

Fig. 2



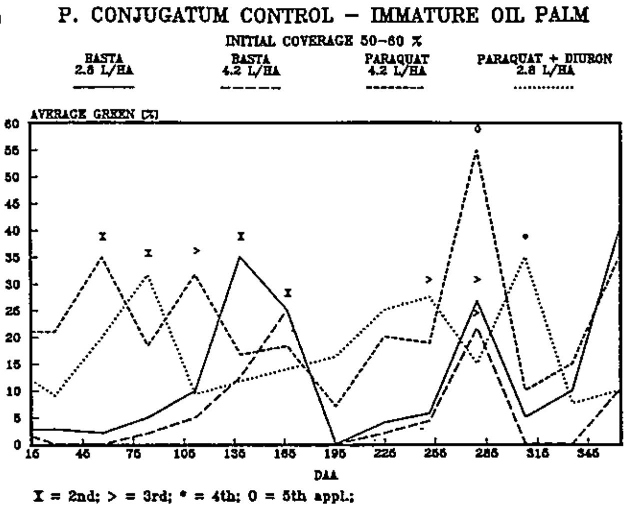
In a very high and uniform shade condition of 80% or more, one application of Basta at 1.4 *l/ha* gives excellent control (Figure 1) where mainly *Paspalum conjugatum* dominated. When percentage of shade decreases, the number of applications could increase to two for a period of 12 months (Figure 2). Similar trend of control was also observed with higher rates of paraquat at 2.8 *l/ha* and paraquat + diuron at 2.1 *l/ha*.

Higher infestation also contributed to faster regeneration from seeds, as illustrated by the fact that after the second application of Basta 1.4 *l/ha*, a better control was exhibited than after the first application.

Field trials III and IV

These two trials were laid down also in *Paspalum conjugatum* areas under open conditions. Figure 3 is the graphical representation of the results of Field Trial III (begin: mid August). Basta at 2.8 and 4.2 *l/ha* showed the best result, requiring only three rounds per year. Paraquat + diuron at 2,8 *l/ha* requires four and paraquat at 4.2 *l/ha* five rounds.

Fig. 3

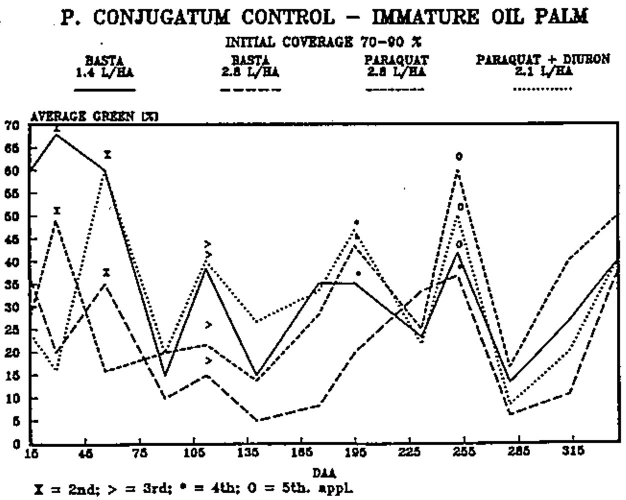


In the plots treated with Basta, proliferation of secondary weeds was significantly more after the first application as compared to other treatments. This could be due to the fact that the damage of *Paspalum conjugatum* was more complete than in plots treated with the other products where the damage was relatively less. This could have had the consequence that the plots treated with Basta had more open grounds suitable for seed germination. In other plots, less damage and quicker regrowth reduced the germination of seeds of other secondary weeds. Under these conditions, tankmixtures of Basta with diuron could provide a longer weed control by inhibiting the germination of secondary weeds.

Field Trial IV (Figure 4) was done (application: end August) on clay loam soil having a high water table (water-logged). Basta at 2.8 *l/ha* was superior to other treatments, requiring four applications a year. Paraquat + diuron at 2.1 *l/ha* and paraquat at 2.8 *l/ha* required five rounds. In this trial the effect of drier weather was shown by the longer control of all treatments applied around the middle of the third month. This period coincides with a short period of lower rainfall.

Thus, under normal open conditions, three rounds of Basta at 2.8 *l/ha* will provide good control in *Paspalum conjugatum* areas and an extra round is required under more severe wet conditions.

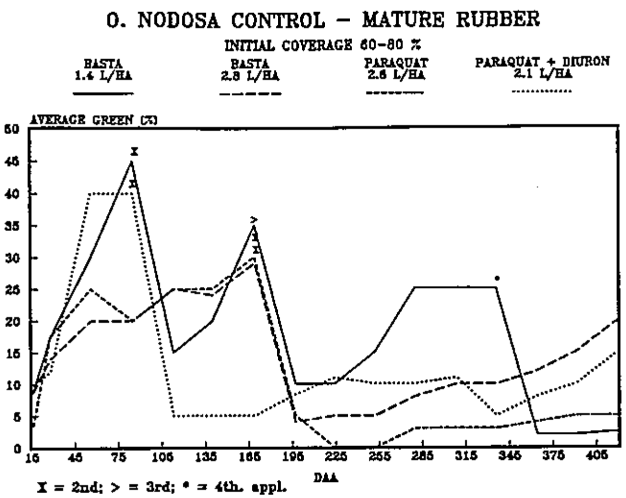
Fig. 4



Field trials V and VI

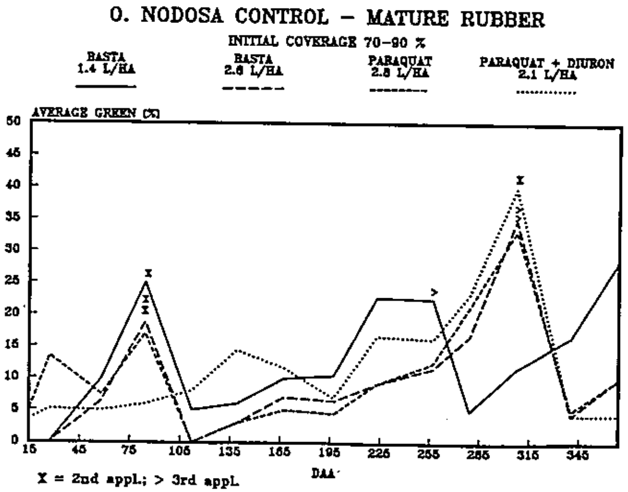
These two trials were done in *Ottochloa nodosa* predominant areas on clay loam soil and under 30 - 70% shade. Field trial V (Figure 5) commenced in mid February 1983, having several dry periods, namely the first, the third, fifth, sixth and the twelfth months. Under these conditions, Basta at 1.4 *l/ha* required four applications a years. Basta at 2.8 *l/ha* required only two applications and so does paraquat (2.8 *l/ha*) and paraquat + diuron (2.1 *l/ha*).

Fig. 5



Field trial VI (Figure 6) commenced in early August 1983 which coincided with the wet season of the year. In this trial, higher initial infestation of *Ottochloa nodosa* was also recorded as compared to Field Trial V. Basta at 1.4 and 2.8 *l/ha* and paraquat at 2.8 *l/ha* all required three applications per year. Paraquat + diuron at 2.1 *l/ha* required only two rounds in the same periods.

Fig. 6



Thus under shaded conditions, Basta at 1.4 *l/ha* provides good weed control in *Ottochloa nodosa* predominant areas with three rounds of application per year. Basta at 2.8 *l/ha* can reduce the number of spraying rounds to two in drier areas.

Paraquat + diuron and paraquat at 2.1 and 2.8 *l/ha* respectively, require two rounds for sufficient control over 12 months.

CONCLUSION

In plantations a very wide spectrum of weeds can be found inclusive of grasses, shrubs and ferns (Barnes & Chandapillai 1972, Wycherley and Ahmad 1974). In earlier trials it could be shown that the weed spectrum, controlled by Basta includes the perennial grass *Axonopus compressus,* the perennial dicots *Centrosema pubescens, Clidemia hirta, Eupatorium odoratum, Mikania cordata, Pueraria phaseoloides* and the ferns *Gleichenia linearis, Nephrolepis biserrata, Stenochlaena palustris* (Langelueddeke et al, 1983). In the trials reported in this paper, however, these species occured only sporadically; consequently, further trials are necessary in order to confirm the early results on a broader basis.

The trials reported here were carried out under actual field conditions, using normal estate practice, so results obtained are quite indicative of practical plantation situations.

The results and discussions presented show that Basta is very suitable for mixed weeds control in plantations. Table 1 below indicates the rates and number of rounds required per year for mixed weed control in *Paspalum conjugatum* and *Ottochloa nodosa* predominant areas.

Number of rounds per year

Basta Rate	Weeds	Shade above 30%	Shade below 30%
1.4 l	*P. conjugatum*	1 - 2	-
	O. nodosa	3	-
2.8 l	*P. conjugatum*	1 - 2	3 - 4
	O. nodosa	2 - 3	-

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CHEMICAL CONTROL OF COIX (*Coix aquatica* Roxb.) IN IRRIGATION CANAL

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ABSTRACT

Field experiments were conducted in the first right canal of Channasut irrigation project, Sing Buri province, to determine the effect of 5 herbicides, namely 2, 2-dichloropropionic acid (dalapon), methyl-sulfanyl carbamate (asulam) + dalapon, N-(phosphonomethyl) glycine (glyphosate), 3-cyclohexyl-6-(dimethylamino)-1-methyl-1-, 3, 5-triazine-2, 4 (1H, 3H) dione (hexazinone) and 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl) nicotinic acid (AC 252,925) on *Coix aquatica* Roxb. (coix)

Results obtained from visual evaluation, based on EWRC method, indicated that hexazinone and glyphosate showed good control for coix on 15-30 days after application. The effect of all herbicides could be seen within 60 days after application, but regrowth were occuring in all treated plots after 90 days. The most effective herbicides for controlling coix throughout the period of 120 days were AC 252,925 at 1.0 *kg* ae/*ha* and glyphosate at 3.375 *kg* ae/*ha*. Although some of the plants regrew from nodes near the lower parts of plants, they were still chlorosis and stunted. Similar results were also obtained on the basis of fresh weight and dry weight analyses on 120 days. AC 252,925 at dosage of 1.0 *kg* ae/*ha* and glyphosate 3.375 *kg* ae/*ha* were found to be the most effective compounds.

INTRODUCTION

Coix (*Coix aquatica* Roxb.), a perennial grass, is in the family Poaceae. It is an emergent aquatic weed in ditchs and pools. The plant is 1-3 meters long, floating or erect and branched. Leaf blades linear to ovate-lanceolate, leaf sheaths glabrous or with long tubercled hairs at apex. Inflorescence partly enclosed in a nut-like hardened, ovoid or cylindric sheath with united margins (Cook, 1974).

Coix is one of the major aquatic weed in the central plain of Thailand. Because of its semi floating, robust habit, Coix advance far in to the rivers and canals forming thick floating mats which are very resistant to wind and wave action. (Junk, 1977 and Thamasara, 1984).

The main problem caused by Coix is the blockage of waterways which presents a serious obstacle to water traffic. There is no doubt that Coix in canals cause a major problem in efficiently operating an irrigation system. Coix reduces the capacity of the canal that it often is difficult to furnish sufficient irrigation water to the farmers. Structurer are often clogged, causing delays and additional costs in clearing the congestion. When drains become clogged with weed growths their efficiency is seriously impaired. Another difficulty in the present situation of water distribution is that many areas cannot be drained adequately; farmers in the lower lying parts receive more water than they like, while at the same time the higher-lying fields along the same canal have a shortage of water.

In the past few years, attempts have been made to evaluate prospective herbicides for Coix. However, there was only one herbicide, namely dalapon has been recommended (Siriworakul and Thamasara, 1976). Nowadays, there are many new herbicides which appear promising for chemical control of Coix. The objective of these experiments were to determine the effect of five herbicides, and select the appropriate and high efficacy herbicides to use in control of Coix.

MATERIALS AND METHODS

The experiments were conducted under practical field condition in the first right canal of Channasut irrigation project, Sing Buri province in November 1984. Plot measuring 2 × 2 *meters* with a space of 5 *metres* were demarcated by bamboo sticks along the side of the canal. Treatments were arranged in randomized complete block design with 3 replications. The herbicides were applied on a long tail boat as a foliar spray while the weed were approximately 2 - 2.5 *meters* high. Spraying was done using a power knapsack sprayer fitted with two cone nozzles on a long lance. The average spray volume of herbicide was 1,000 *litres/ha*.

The visual herbicidal effect was recorded at 15, 30, 60, 90 and 120 days after herbicide application. A rating scale based on European System of Weed Control (EWRC) was used (1 = complete kill, 9 = no effect). Percentage of fresh weight and dry weight of regrowth of the plant was also recorded at 90 and 120 days after herbicide application. Plant fresh weight could be made by placing a 1 m^2 quadrate at random locations in plots and weighting plants within the quadrate. After harvesting plants were cut and sun dried for 15 days to determine dry weight. The experiments include 15 treatments as follow:-

No.	Treatments	Rates (*kg* a.i./*ha*)
1.	control (untreated)	—
2.	dalapon 85% a.i.	16.000 + 8.000 (Two times application technique)
3.	dalapon 85% a.i.	24.000
4.	asulam 40% a.i. + dalapon 85% a.i.	2.000 + 10.00
5.	" "	2.500 + 7.500
6.	" "	5.000 + 15.000
7.	glyphosate 36% a.e.	1.687
8.	"	2.250
9.	"	3.375
10.	hexazinone 90% a.i.	4.219
11.	"	5.625
12.	"	7.031
13.	Ac 252,925 25% a.e.	0.500
14.	"	0.750
15.	"	1.000

RESULTS

The visual herbicidal effects are given in table 1 and figure 1. Hexazinone and glyphosate were found to have medium control to good control of Coix 15-30 days after application. The plants appeared as a slight to strong chlorosis. The effect of all herbicides could be seen within 60 days after application. Dalapon at the rate of 16 + 8 *kg* a.i./*ha.* and 24 *kg* a.i./*ha.*, asulam + dalapon at 5 + 15 *kg* a.i./*ha.*, glyphosate at 1.687 - 3.375 *kg* a.e./*ha.* and Ac 252,925 at 0.75 - 1.0 *kg* a.e./*ha.* were found to be effective. The plants exhibited strong chlorosis and on necrosis with some plants fell onto water surface. At 90 days after application, Ac 252,925 at the highest rate of 1.0 *kg* a.i./*ha.* gave best weed control. While some regrowth from the nodes of floating stems were occurring in all treated plots, Ac 252,925 was found to effect regrowth of Coix by causing delayed growth rate and subsequent chlorosis. At 120 days after application, Ac 252,925 at the highest rate of 1.0 *kg* a.e./*ha.* and glyphosate at the highest rate of 3.375 *kg* a.e./*ha.* were found to be the most effective herbicides. Although some new shoots regrew from floating stems, they were still strong chlorosis and stunted.

The percentage of fresh weight and dry weight of regrowth of the plants 90 days and 120 days after application are given in table 2 and figure 2 and indicated that there were significant difference between all herbicide treatments and control treatment 90 days after application. Results obtained from fresh weight and dry weight analysis 120 days indicated that Ac 252,925 at 1.0 *kg* a.e./*ha.* and glyphosate 3.375 *kg* a.e./*ha.* were found to be the most effective herbicides.

Table 1. The effect of herbicides on the control of Coix.

Herbicides				Visual Control Rating[1]				
				15 DAA[2]	30 DAA	60 DAA	90 DAA	120 DAA
1.	control			8.0 a	8.7 a	9.0 a	8.3 a	7.7 a
2.	dalapon	16+8	*kg* a.i./*ha*	7.0 ab*	4.7 bc	2.7 c	4.0 bc	4.3 bc
3.	dalapon	24	"	6.3 ab	5.0 bc	3.3 c	5.3 b	4.7 b
4.	asulam + dalapon	2+10	"	8.0 a	5.7 b	5.7 b	6.0 ab	6.3 ab
5.	"	2.5+7.5	"	7.3 ab	5.0 bc	6.0 b	5.7 b	5.7 ab
6.	"	5+15	"	7.3 ab	5.3 bc	5.0 c	5.0 bc	4.7 b
7.	glyphosate	1.68	*kg* a.e./*ha*	6.7 ab	3.7 c	4.3 c	5.0 bc	5.0 b
8.	"	2.25	"	5.7 bc	4.0 c	5.3 bc	5.0 bc	5.0 b
9.	"	3.375	"	5.7 bc	3.3 c	5.0 c	4.3 bc	2.7 cd
10.	hexazinone	4.22	*kg* a.i./*ha*	5.0 c	6.0 b	6.0 b	6.0 ab	5.0 b
11.	"	5.62	"	4.7 c	4.0 c	5.3 bc	5.3 b	4.7 b
12.	"	7.03	"	4.7 c	5.0 bc	5.3 bc	5.0 bc	5.0 b
13.	Ac 252,925	0.5	*kg* a.e./*ha*	8.0 a	6.7 ab	5.3 bc	6.0 ab	5.7 ab
14.	"	0.75	"	7.7 ab	6.0 b	4.3 c	4.0 bc	4.3 bc
15.	"	1.0	"	7.7 ab	5.0 bc	2.7 c	2.7 c	2.3 d

[1] Rating scale 1 = complete kill, 9 = no effect.
[2] DAA = day after application.
* Average of three replications. Values within a column followed by the same letter do not differ at 1% level (Duncan's Multiple Range Test).

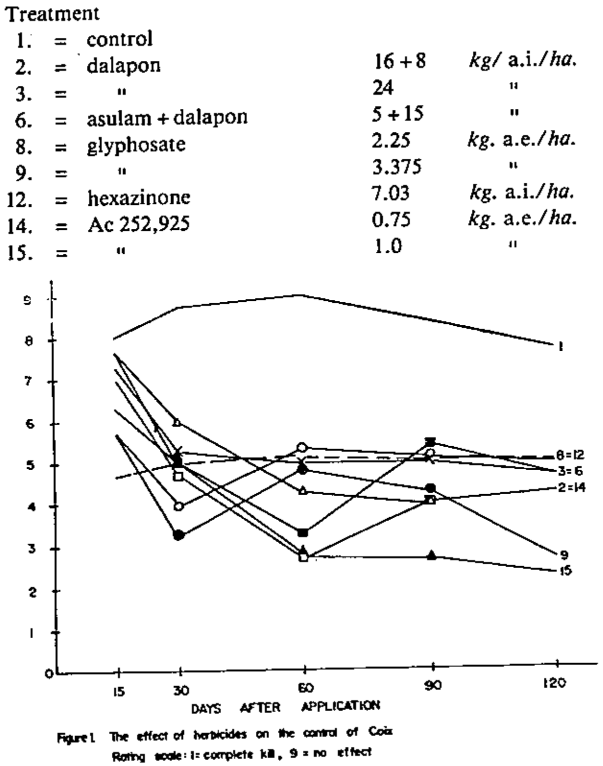

Figure 1. The effect of herbicides on the control of Coix
Rating scale: 1 = complete kill, 9 = no effect

Table 2. The percentage of fresh weight and dry weight of Coix regrowth.

Herbicides				% Fresh Weight		% Dry Weight	
				90 DAA[1]	120 DAA	90 DAA	120 DAA
1.	control	—		100 a	100 a	100 a	100 a
2.	dalapon	16+8	kg a.i./ha.	29 b	45 bc*	30 c	29 bc
3.	"	24	"	45 b	56 bc	53 bc	39 bc
4.	asulam-dalapon	2+10	"	55 b	62 bc	53 bc	50 bc
5.	"	2.5+7.5	"	42 b	64 bc	48 bc	53 bc
6.	"	5+15	"	54 b	53 bc	50 bc	40 bc
7.	glyphosate	1.68	kg a.e./ha.	35 b	57 bc	36 bc	52 bc
8.	"	2.25	"	41 b	45 bc	40 bc	39 bc
9.	"	3.375	"	29 b	27 c	37 bc	18 c
10.	hexazinone	4.22	kg a.i./ha.	55 b	45 bc	58 b	40 bc
11.	"	5.62	"	41 b	42 bc	48 bc	34 bc
12.	"	7.03	"	50 b	51 bc	66 b	44 bc
13.	Ac 252,925	0.5	kg a.e./ha.	35 b	62 bc	42 bc	36 bc
14.	"	0.75	"	31 b	48 bc	29 c	35 bc
15.	"	1.0	"	22 b	29 c	20 c	18 c

[1] DAA = day after application.
* Average of three replications. Value within a column followed by the same letter do not differ at 1% level (Duncan's Multiple Range Test).

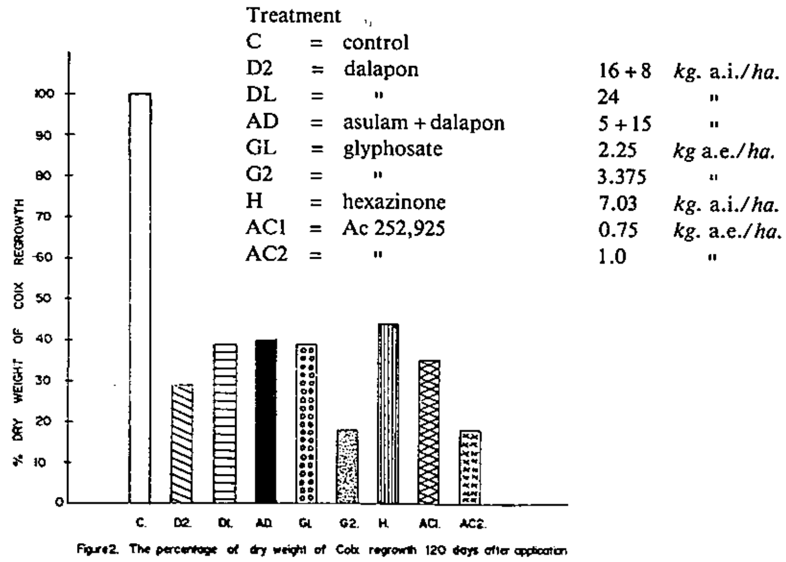

Figure 2. The percentage of dry weight of Coix regrowth 120 days after application

DISCUSSION

There was no difference between the result of dalapon at the same rate with one time and two times application technique on the control of Coix. Although dalapon, asulam + dalapon, and hexazinine were applied at the highest rates, they gave only sufficient in practice and medium weed control. Because of its semi floating, robust habit, and with very dense stands, a high spray volume rate of 1,000 *l/ha.* was required to provide better spray coverage. Ac 252,925 and glyphosate were applied without surfactant, while some other herbicides were added with 0.25% non-ionic surfactant. Addition of surfactant can improve the efficacy of Ac 252,925 and glyphosate against Coix at high spray volumes. To conclude, it has been shown that the use of 1.0 *kg* a.e./*ha.* Ac 252,925 and 3.375 *kg* a.e./*ha.* glyphosate provide an effective control of Coix growing vigorously in irrigation canals in the central plain of Thailand.

ACKNOWLEDGEMENTS

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CHEMICAL CONTROL OF *Echinochloa crusgalli* IN DIRECT SEEDED RICE

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ABSTRACT

Echinochloa crusgalli (L.) Beauv was found to be a major weed in direct seeded ricefields. Among several herbicides evaluated, molinate was found to be the most effective for the control of this weed. The application of this herbicide at 3.3 *kg a.i./ha* 7 days before sowing or 14 days after sowing was equally effective. An increase in rice grain yield up to 107 per cent greater than untreated plots was obtained.

INTRODUCTION

In direct seeded rice, *Echinochloa crusgalli* is a major weed. This weed has become a dominant species in direct seeded rice fields due to the cultural practice for direct seeding and the ability of the weed to multiply rapidly. Unlike for transplanted rice, direct seeded rice fields are not flooded at the time of planting, thus allowing the weed seeds to germinate at the same time as the rice seeds. In addition, each plant of *E. crusgalli* had been reported to produce up to 58 tillers, each bearing between 8,415 to 72,691 seeds (MARDI Ann. Rep., 1983). These factors, together with the rapid growth of the weed lead to severe infestation in the rice fields if no control measures are carried out.

Manual weeding of direct seeded rice fields is a problem due to the difficulty in entering the field without causing extensive damage to the rice plants particularly when seeds are broadcasted. A suitable alternative to manual weeding is through the use of herbicides. Several herbicides have been reported to be suitable for use in direct seeded rice (De Datta and Bernasor, 1973; Moody and Mian, 1979; Chiang and Lew, 1981). In this study, three promising herbicides were evaluated and the results are presented in this paper.

MATERIALS AND METHODS

The experiment was conducted at the MARDI Rice Research Station at Bumbung Lima during the 1983/84 growing season using the cultivar Setanjung. A seeding rate of 40 *kg/ha* was used.

The herbicides studied were 2, 4-DIBE-butachlor at the rates of 1.2 and 2.4 *kg a.i./ha,* butachlor at 1.5 and 3.0 *kg a.i./ha* and molinate at 3.3 and 6.7 *kg a.i./ha.* These herbicides were applied as a preemergent, 7 days before sowing and as a postemergent, 14 or 35 days after sowing. For comparisons, an unweeded control was included.

A randomized complete block design with three replications was used for the study. Each treatment occupied an experimental plot measuring 5 *m* × 5 *m* which was surrounded by a soil bund.

Data collection were carried out at various stages of crop growth and at harvest. Yield data was obtained from the centre 3 *m* × 3 *m* of each plot while weed regrowth sampling and crop growth measurements were taken from them remaining area.

RESULTS

Weed regrowth

The weed regrowth was determined at 44, 74 and 104 days after seeding. In the control plots the predominant weed was *E. crusgalli*. This weed in comparison with sedges and broadleaves was most competitive with the rice crop and made up between 67 and 80% of the total weeds found (Table 1).

Table 1. Weed regrowth in unweeded plots

Type of weed	Time of sampling (Days after seeding)					
	44		74		104	
	Dry wt. *g.m.*	%	Dry wt. *g.m.*	%	Dry wt. *g.m.*	%
E. crusgalli	95.5	67.2	185.7	80.0	158.3	72.0
Sedges	35.5	25.0	35.4	15.2	30.3	13.8
Broadleaves	11.1	7.8	11.1	4.8	31.3	14.2

Effect of herbicides on *E. crusgalli*

Visual assessment on the effect of the herbicides recorded 14 days after each treatment showed that molinate was very effective for the control of *E. crusgalli* irrespective of the time of application. Butachlor and 2, 4-DIBE-butachlor was also effective against *E. crusgalli* when applied early at 7 days before seeding or 14 days after seeding. Late application of the latter two herbicides at 35 days after seeding gave poor control of the weed. There were no obvious differences between the high and the low rate of the herbicides used (Table 2).

Table 2. Visual assessment of the effectiveness of molinate for the control of *E. crusgalli*

Herbicide	Rate *kg a.i./ha*	Time of application		
		7 DBS	14 DAS	35 DAS
2,4-DIBE-butachlor	1.2	***	***	*
	2.4	***	***	*
Butachlor	1.5	***	***	*
	3.0	***	***	*
Molinate	3.3	***	***	***
	6.7	***	***	***

DBS = Days before seeding
DAS = Days after seeding
* = less than 50% control
** = 50% to 75% control
*** = 75% to 100% control

In terms of weed dry weight, application of the herbicides generally resulted in significantly lower regrowth of *E. crusgalli* than the control at all stages of the rice crop growth. However, among the herbicides studied, molinate was the most effective for the control of *E. crusgalli*. The dry weight of *E. crusgalli* that regenerated was significantly lower than that found in plots treated with 2, 4-DIBE-butachlor and butachlor when sampled at 44, 74 and 104 days after seeding (Table 3).

Table 3. Effect of selected herbicides on the regrowth of *E. crusgalli* (g/m^2)

Herbicides	Time of weed sampling (Days after seeding)		
	44	74	104
Control (Unweeded	95.48 a	185.75 r	118.33 x
2, 4-DIBE-butachlor	74.54 b	133.15 s	86.83 y
Butachlor	65.11 b	117.42 s	83.11 y
Molinate	25.40 c	5.68 t	5.59 z

For each time of weed sampling, means followed by the same letter are not significantly different at p = 0.05.

On the basis the number of tillers of *E. crusgalli* found in each square metre of the rice field, plots treated with molinate also gave the lowest regrowth of *E. crusgalli* (Table 4). Molinate treated plots were significantly lower in the number of *E. crusgalli* tillers than the other two herbicides. Even late application at 35 days after seeding gave good control of the weed.

Table 4. Effect of selected herbicides on the number of *E. crusgalli* tillers

Time of weed sampling	Time of herbicide application	Herbicide		
		2,4-DIBE-butachlor	Butachlor	Molinate
74 DAS	7 DBS	39.7 b	34.4 b	7.5 a
	14 DAS	31.3 b	39.3 b	1.3 a
	35 DAS	77.0 c	68.7 c	5.3 a
	Mean	49.8 s	47.4 s	4.7 r
104 DAS (NS)	4 DBS	54.2	57.5	5.3
	14 DAS	58.2	32.5	0.3
	35 DAS	51.0	47.7	0.0
	Mean	54.4 z	45.9 y	1.9 x

DBS = Days before seeding
DAS = Days after seeding

For each comparison, means followed by the same letter are not significantly different at P = 0.05.

(NS) = No significant differences for the component Time of application x Herbicide interaction when weed sampling was carried out at 104 days after seeding.

The rate of the herbicides used did not significantly affect the amount of *E. crusgalli* regrowth except when the amount of weed regrowth was sampled at 74 days after seeding. During this period, the regrowth of the weed was found to be significantly less when the high dosage of the herbicides were applied (Table 5).

Table 5. Effect of herbicide rate of application on the dry weight of *E. crusgalli* *(g/m^2)*

Time of weed sampling	Rate of herbicide	Herbicide			Prob.
		2, 4-DIBE-butachlor	Butachlor	Molinate	
44 DAS	Low	65.41	85.65	31.80	> 0.05
	High	83.68	44.83	19.96	
74 DAS	Low	158.79	127.51	11.04	< 0.01
	High	107.51	107.33	0.33	
104 DAS	Low	76.56	83.55	6.78	> 0.05
	High	97.11	82.66	4.40	

DAS = Days after seeding

Grain yield of rice

In general the grain yield of rice was higher in plots that were treated with the herbicides. However, plots treated with molinate gave the highest yields irrespective of the time of application of the herbicide. No dirrerence in yield was found for plots treated at 3.3 or 6.7 *kg* molinate/*ha*. In plots treated with 2, 4-DIBE-butachlor or butachlor, the yield obtained varied with the time of application and the rate used. Generally yields were higher for early applications than late applications given at 35 days after seeding (Table 6).

Table 6. Effect of rate and time of application of selected herbicides on rice grain yield

Herbicides	Rate *(kg a.i./ha)*	Time of application	Yield *(kg/ha)*
2, 4-DIBE-butachlor	1.2	7 DBS	2,687 fgh
		14 DAS	3,682 abcd
		35 DAS	3,066 cdef
	2.4	7 DBS	2,813 fg
		14 DAS	3,009 cdef
		35 DAS	1,481 ij
Butachlor	1.5	7 DBS	2,606 fgh
		14 DAS	2,457 gh
		35 DAS	1,659 ij
	3.0	7 DBS	3,213 cdef
		14 DAS	3,548 abcdef
		35 DAS	1,953 hi
Molinate	3.3	7 DBS	4,032 ab
		14 DAS	4,106 a
		35 DAS	3,818 abc
	6.7	7 DBS	4,106 a
		14 DAS	3,143 cdef
		35 DAS	4,056 ab
Unweeded control (No herbicides)			1,980 gh

Means followed by the same letter are not significantly different at P = 0.05.

DBS = Days before seeding
DAS = Days after seeding

The grain yield of rice was found to be negatively correlated with the dry weight and density of *E. crusgalli* per m^2 for all sampling periods (Table 7). The competition due to *E. crusgalli* significantly contributed to yield reduction of the rice crop.

Table 7. Correlation between rice grain yield and *E. crusgalli* infestation

Comparsion	Correlation coefficient (r)		
	44 DAS	74 DAS	104 DAS
Rice yield and No. of *E.crusgalli* tillers	n.a.	-0.82**	-0.71**
Rice yield and dry wt. of *E. crusgalli*	-0.68**	-0.84**	-0.70**

DAS = Days after seeding (weed infestation)
** P = < 0.01

n.a. Tiller number not determined.

DISCUSSION

In crop production, early weed control is essential to ensure maximum yields. Preferably the herbicides must be applied as a preemergent or as an early postemergent so that crop–weed competition would be minimised and weed regrowth suppressed. In the study, both the preemergent application at 7 days before seeding and the early postemergent application at 14 days after seeding for all the three herbicides gave good control of *E. crusgalli* when compared to the late application 35 days after seeding. Molinate was the only herbicide that effectively controlled *E. crusgalli* when applied as a late postemergent. The weed was more tolerant to the herbicides as it became more established and larger. At the later stage of crop growth, it was also more difficult to apply the herbicides due to the interference caused by the crop. However granular formulation of molinate used was easy to apply compared to the spray applications of the other two herbicides. This may account for the better control obtained with molinate.

In weed control even though late applications may control the weed, it is not desirable for optimum crop production. When weed control is carried out late, crop–weed competition is present up to the time the weed is controlled and this would adversely affect yield. The lower grain yields for late applications of the herbicides have been shown and this is correlated to the weed infestation. Therefore, it is not merely a case of only controlling the weed but also to control the weed early.

The rate of the herbicides used generally did not differ in their ability to control the weed. The lower rate was sufficient to give good control of *E. crusgalli.* The high rate used may cause some phytotoxicity which could result in yield reduction. Although the amount of regrowth of the weed was lowest in plots treated with the high rate of molinate, there was no improvement in rice yield. The yield improvement obtained with the use of herbicides was significant and the highest yields were obtained from molinate treated plots where yields ranged from 3,143 to 4,106 *kg/ha* representing an increase of between 59 and 107 per cent over the unweeded control which only yielded 1,980 *kg/ha*. The increase in yield was largely the result of controlling infestation by *E. crusgalli.*

In direct seeded rice where *E. crusgalli* is the major weed, molinate would be an effective means of chemical control. On the basis of the results obtained, the application of the herbicide at the rate of 3.3 *kg a.i./ha* 7 days before seeding or 14 days after seeding is optimum. In comparison to the unweeded plot it is estimated that the return from the additional 2,000 *kg* of rice grain/*ha* would be in the region of $1,300 Malaysian Ringgit. The cost of herbicide inclusive of application, is expected to be less than $200, thus making it worthwhile to control *E. crusgalli* chemically.

CONCLUSION

The major weed in direct seed rice was found to be *E. crusgalli.* The herbicides 2, 4-DIBE–butachlor, butachlor and molinate may be used to control the weed. Applications of these herbicides 7 days before seeding or 14 days after seeding were most effective. Among the herbicides, molinate was found to give significantly better control than the other herbicides and also resulted in highest grain yield of rice. A rate of 3.3 *kg a.i./ha* effectively controlled *E. crusgalli* for optimum returns.

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CONTROL OF WEEDS BY PLANTING OF LEGUMINOUS COVERS – ESPEK EXPERIENCE

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ABSTRACT

This paper outlines the ESPEK's Estate practical experience of establishing leguminous cover crops in the redevelopment of abandoned oil palm areas as a method of weed control. The usage of fairly intensive chemical weed control in the legume establishment was found to help the creeping covers to achieve a 70% coverage in the 4th month and subsequently 95% in the 6th month onwards, thus reducing weed growth to a bear minimum of 5% in the area. Extra expenditures incurred for establishing and maintaining a good coverage of leguminous covers over a 12 – month period was found to be 52% more than maintaining a similar crop area with natural grass cover.

INTRODUCTION

In the development of plantation from jungle clearing, it is often that one faces the problem of contractor abandoning the work half way. This usually results in the area under development reverting back to secondary jungle. One such estate faced by ESPEK management was the Trengganu Tengah Phase II Estate which had about 40 hectares of abandoned area covered by noxious weeds such as Siam weeds *(Eupatorium odoratum)*, Bracken *(Dicranopteris linearis)*, wild cherries, *Croton hirtus, Clidemia hirta,* bamboo grass, *Mikania* and *Cylindrica imperata.*

The ESPEK management hence decided to take over the development of the area in mid 1984. Establishment of leguminous covers was employed as a method for weed control in view of its many other advantages which are well documented.

For the successful establishment of a pure and vigorously growing legume cover, competitive weeds must be eliminated before they themselves can become established. Owing to labour shortage and high cost of manual weeding a cheaper system of chemical weed control was used in establishing the leguminous cover.

This paper describes the practical experience of ESPEK on the technique of weed control by using leguminous creeping covers.

MATERIALS AND METHODS

The woody and thick secondary jungle growth in the abandoned area was first slashed by using parang (Malaysian jungle knife) and axes. It was then followed by initial blanket spray of MCPA sodium salt (18.6% *w/w*), Diuron (24% *w/w*) and Amitriole (47.5% *w/w*) at the rate of 2.24 *kg* per hectare and paraquat dichloride at the rate of 2.8 *lit.* per hectare.

Trees and woody growths of radii 1.3 *cm* and above were poisoned by using 245 — T mixed with diesel at a concentration of 5% a.i.

Leguminous cover mixture used was at the following rates:

Calopogonium caeruleum	:	454 *g/ha.*
Centrosema pubescence	:	1361 *g/ha.*
Pueraria javanica	:	1361 *g/ha.*
Calopogonium mucunoides	:	1361 *g/ha.*

The above amount was decided because of poor seed viability which was approximately 20%.

The leguminous cover seeds were sown in two single rows in the unplanted area between terraces, one row at the upper end and the other at the lower end as shown in the diagram below:

2.4 *m*	Terrace	
1 *m*		1 row C.C
6.7 *m*	Unplanted Area	
1 *m*		1 row C.C
2.4 *m*	Terrace	

Pre-emergence spray was done on a 1 *m* strip along the planted cover rows by using diuron (85% *w/w*) mixed with paraquat at the rate of 1.2 *kg/ha* and 1.2 *lit/ha* respectively.

Ustinex, paraquat, diuron and roundup were used in the subsequent selective sprayings and spot sprayings of noxious weeds.

Weeds in the inter cover rows were allowed to grow initially to not more than 50% coverage. Once the legumes begin to grow and cover the ground, mainly diuron + paraquat mixture at 1.2 *kg/ha* and 1.2 *lit/ha* respectively was used to control the noxious weeds. This helped to reduce the risk of erosion. Selective and spot spraying were continued until the leguminous cover achieved about 95% coverage (See Table 1).

RESULTS

In the weeding regime as shown in Table 1, competition of weeds in the cover crop rows was always kept to a minimum by using manual weed control and selective spraying. The continual spot and selective spraying of competitive noxious weeds in the unplanted area between cover rows for the first 3 months resulted in the spread of covers into these areas. The weed growth in the inter cover rows was

Table 1. Weeding regime adopted in establishing the leguminous covers.

Months After Sowing	% Weed Appeared In Cover Rows	Action Taken	% Weed Appeared In Unplanted Area	Action Taken
1	5%	Nil	50%	Spraying of noxious weeds only
2	10%	Hoeing	50%	- same -
3	5%	Selective spraying & border spraying	50%	- same -
4	5%	- same -	30%	- same -
5	5%	Hoeing	10%	- same -
6–12	5%	Hoeing	5%	- same -

reduced to 30% in the 4th month and to 10% in the 5th month respectively. From the 6th month onwards, the cover crop was able to achieve a 95% coverage in the unplanted interrow, hence reducing the weed control cost to a bear minimum.

The total cost incurred in clearing the secondary jungle of the abandoned area and the subsequent establishment of leguminous covers which include cost of weeding up to a 12–month period was M$766/*ha* (See Table 2). On the other hand, another similarly abandoned area in the same estate was being redeveloped by allowing the establishment of natural grass cover. The total weed control cost incurred for this area up to a period of 12 months was $510/*ha* as shown in Table 3.

Table 2. Cost incurred on Leguminous cover establishment in redeveloping the abandoned area.

Particulars	M$/*Ha*
1. Slashing of secondary jungle growth	94.00
2. Blanket spraying of interrows after slashing.	88.00
3. Strip spraying before sowing cover seeds.	36.00
4. Planting of leguminous covers – seeds, rhizobium, rock phosphate & labour.	216.00
5. Preemergence spray with diuron & paraquat	66.00
6. Spraying in 1 st month.	45.00
7. Spraying in 2nd month.	45.00
8. Spraying in 3 rd month.	36.00
9. Spraying in 4th month.	30.00
10. Spraying in 5th month.	30.00
11. Spraying in 6th – 12th month.	90.00
Total :	$776.00

Note : All spraying costs include cost of weedicides used and labour.

Hence in our experience, the additional cost incurred for establishing a 95% pure legume cover using the method described above was found to cost an additional 52% more than maintaining a natural grass cover.

Nevertheless we are confident that the extra cost incurred will be returned in various forms which will all contribute towards increasing the yield and minimising the subsequent weed control cost.

Table 3. Cost incurred in weed control of areas with natural grass covers in redeveloping the abandoned area.

Particulars	M$/*Ha*
1. Slashing of secondary jungle growth	94.00
2. Blanket spraying of interrows after slashing.	88.00
3. Selective and spot spraying of noxious weeds in 2nd month.	82.00
4. Selective and spot spraying of noxious weeds in 5th month.	82.00
5. Selective and spot spraying of noxious weeds in 8th month.	82.00
6. Selective and spot spraying of noxious weeds in 12th month.	82.00
Total:	$510.00

Note : All spraying costs include cost of weedicides used and labour.

Evaluations in terms of long term cost savings in weed control and yield increase are however still not available at this juncture as the palms in the areas concerned are still in the immature stage. Nonetheless the expected advantages and benefits that will be derived are reviewed below.

DISCUSSION

The planting of creeping leguminous covers is now widely accepted as a desirable practice in oil palm cultivation. Besides controlling weed growth, its establishment and maintenance in the interrows during the immature stage have been shown to improve growth and yield of oil palm (Gray and Hew, 1968). Similarly according to W.J. Broughton (1976), oil palm grown in association with legumes produced average yield increase of about 2 tonnes FFB/*ha*/year more than with any other systems. K.H Yew, T.K. Tam and Mohd. Hashim (1981) reported that in the first 10 years of bearing, palms grown in association with *Pueraria* for 2 or 4 years out–yielded palms in plots where natural vegetation was maintained *Mikania* free by 34.24 and 38.28 tonnes FFB per hectare respectively at a higher level of nitrogen application. In addition, Agamuthu and Broughton (1979) found that over 2½ years legume covers grown in association with oil palm returned 250 – 300 *kg* of N per hectare through litter decomposition.

Hence there is a distinct profit advantage to be gained through use of legume covers, provided that maintenance does not become excessively expensive and erode the profit margin as maintaining a pure legume cover can represent as much as ¼ of the total expenditure to maturity on replanting (Hew, C.K. & Tam T.K. 1972). In areas where the planted cover more effectively controls weeds, thus requiring little maintenance, the profitability would be proportionately higher.

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EFFECTIVE *Imperata cylindrica* (L) BEAUV. CONTROL WITH REDUCED RATES OF GLYPHOSATE AND MANAGEMENT PRACTICES

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ABSTRACT

Treatment of *Imperata cylindrica* (L) Beauv. with glyphosate 1.62 or 2.16 *kg* ae/*ha* followed by a touchup application of the herbicide at 120 days after initial treatment or establishment of a legume cover crop 60 days after the initial treatment, provided acceptable control for 10-12 months. The final absolute glyphosate rates required were 2.34 and 2.77 *kg* ae/*ha* with comparable control results even in the wet months. The results offer an alternative *I. cylindrica* control practice to the commonly employed one-shot treatments of glyphosate at 2.16 to 4.32 *kg* ae/*ha* for the dry and wet season applications, respectively. Selection of the most suitable practice should be considered based on labor availability and the monetary requirement of followup treatment.

INTRODUCTION

Roundup® herbicide (Isopropylamine salt of glyphosate) is known to provide effective and long-lasting control of many perennial weeds, especially those with underground reproductive parts. In Southeast Asia, Roundup® herbicide is widely used for the control of one of the most noxious perennial weeds, *Imperata cylindrica* (L) Beauv., in plantation crops like rubber, oil palm, tea and fruit orchards.

The most important factor contributing to the excellent perennial weed control of glyphosate is its ability to be completely translocated with the plant assimilates resulting in down-to-the-root control. Consequently, the physiology of the weed plays an important role in the efficacy of glyphosate. This is supported by results from Malaysia indicating the amount of active glyphosate required for effective control of *I. cylindrica* is dependent upon seasonal effects (Wong, 1972); more glyphosate is required during the wet (monsoon) season for the same degree of control as in dry (non-monsoon) season. These results led to our current label recommendation rate of 1.8 to 2.16 *kg* ae/*ha* of glyphosate for dry season applications and nearly twice these rates for wet season applications.

In this paper we present results from trials conducted in Malaysia and Indonesia during 1984 indicating the wet season rate of glyphosate could be reduced significantly when combined with a management system of followup treatment or legume cover crop establishment.

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MATERIALS AND METHODS

Experiments were conducted in Malaysia and Indonesia to test two management-type practices, touchup application and legume cover crop establishment, following the initial variable rate glyphosate treatments especially in wet season.

A total of eleven non-replicated trials were carried out at various locations in Malaysia.

All sites were in open conditions and had an average density of 250–350 *I. cylindrica* plants per square meter with a height of 1.0 – 1.5 *m*. Glyphosate at 1.08, 1.62 and 2.16 *kg* ae/*ha* was applied with knapsack sprayers equipped with the appropriate nozzles to deliver 100 and 200 *l* of water/*ha*. Each treatment plot was divided in half 120 days after application. One-half received a touchup application with a 0.36% solution of glyphosate acid equivalent while the other half received no treatment and served as a comparison. The amount of spray solution required for the touchup application in each plot was recorded and used to determine the total amount of chemical needed. The untreated plots served as control.

In Indonesia, two trials were conducted to determine the efficacy of glyphosate at 1.62 and 2.16 *kg* ae/*ha* followed by a touchup application for physical misses 1 month after treatment or establishment of legume cover crop, without touchup, 2 months after herbicide treatments. Plot size and *I. cylindrica* conditions were similar to those described above. Herbicide applications were made with a knapsack sprayer using 200 *l* of water/*ha*.

Control of *I. cylindrica* was assessed visually at monthly intervals until 180 days after treatment (DAT) thereafter evaluations were at two-month intervals.

RESULTS

Results from the trials in Malaysia are presented in Figure 1. Control of *I. cylindrica* by single applications of all glyphosate rates reached a maximum 90 DAT, after which time the control declined and dropped sharply at 180 DAT to an unacceptable level at some time between 180 and 240 DAT. Touchup application at 120 DAT provided acceptable control 300–360 DAT, especially the 1.62 and 2.16 *kg* ae/*ha* rates. The amount of additional glyphosate required for the touchup application varied and is presented in Table 1.

Table 1. Average amount of glyphosate required for touchup application using a 0.36% solution of glyphosate acid equivalent.

Application Volume (*l/ha*)*	*kg* ae/*ha* of glyphosate			
	Initial appln	Touchup	Total	$\bar{x}$
100	1.08	1.02	2.10	2.24
200	1.08	1.30	2.38	
100	1.62	0.73	2.35	2.34
200	1.62	0.71	2.33	
100	2.16	0.53	2.69	2.77
200	2.16	0.69	2.85	

Table 2 presents results from trials conducted in Indonesia to compare the efficacy of glyphosate treatments followed by either a touchup application or establishment of legume cover crop. Results indicate that if a legume cover crop was established 2 months after treatment, the touchup application for physical misses was not necessary.

Table 2. *Imperata cylindrica* control with glyphosate followed by touchup application and legume cover crop establishment (average of two trials from Indonesia).

Treatment*		% control at days						
Glyphosate (*kg ae/ha*)	Mgt system*	30	60	90	120	150	180	210
1.62	TU	62	87	89	95	95	90	78
1.62	LCC	66	76	91	93	93	88	77
2.16	TU	69	94	93	98	98	100	100
2.16	LCC	72	90	89	100	100	100	100

* Glyphosate was applied in 200 *l/ha* of water.
** TU, touchup application with 0.36% solution of glyphosate acid equivalent at 30 days after the first application; LCC, establishment of legume cover crop at 60 days after treatment.

DISCUSSION

The results from Malaysia which were obtained during the wet months of 1984 clearly indicate the highest rate of 2.16 *kg* ae/*ha* of glyphosate tested in our experiment was not sufficient to provide effective long-term control of *I. cylindrica*, similar to findings of Wong (1975). However, with a touchup application of 0.36% solution of glyphosate acid equivalent at 120 DAT, acceptable control was provided for an additional 180 days (Figure 1).

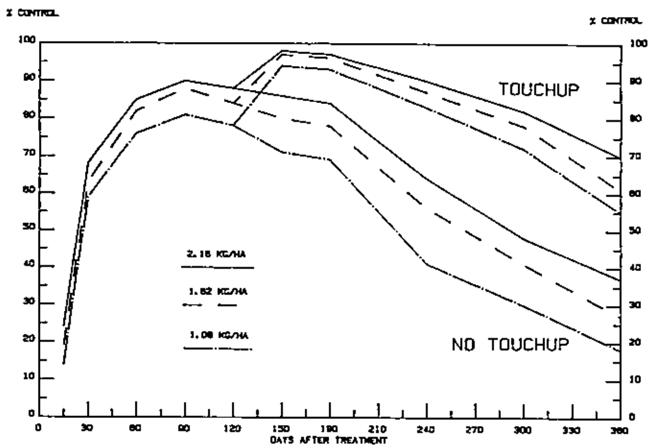

Fig. 1. *Imperata cylindrica* control by various glyphosate rates applied with 100 and 200 *l/ha* of water (average of 11 trials in Malaysia).

Results from our experiments also indicated that when touchup applications were employed, the initial glyphosate rate can be reduced to 1.62 *kg* ae/*ha* with the resulting control performance similar to that obtained with the 2.16 *kg* ae/*ha*. Yeo and Pushparajah (1976) observed the same results with the second application timed the 18th week after the first application (120 DAT). The treatment with 1.62 *kg* ae/*ha* followed by touchup application seems to be the most economical management system for *I. cylindrica* control since the total average amount of chemical required for the system was lower than the treatment with initial rate of 2.16 *kg* ae/*ha* of glyphosate (2.34 versus 2.77 *kg* ae/*ha*; Table 1). The initial treatment of 1.08 *kg* ae/*ha* plus touchup is not favored because the total amount of glyphosate required is nearly equal to that of the 1.62 *kg* ae/*ha* treatment (2.24 versus 2.34 *kg* ae/*ha*). However, the reduced control obtained does not justify the saving of only 0.1 *kg* ae glyphosate/*ha*.

The results from Indonesia 210 DAT also suggest that the 1.62 *kg* ae/*ha* rate of glyphosate can be used for effective *I. cylindrica* control prior to the establishment of a legume cover crop without any touchup application.

When the legume cover crop was not planted after glyphosate treatment of *I. cylindrica,* a touchup application was necessry for maximum control at low glyphosate rates.

Findings from our experiments offer more choices for glyphosate users for *I. cylindrica* control. The user can select either a one-shot treatments of 2.16 to 4.32 *kg* ae/*ha* of glyphosate for dry and wet season application, respectively, or an initial treatment of a reduced glyphosate rate followed by a touchup application or legume cover crop establishment, regardless of season. The system of choice should be based upon the local economic situations such as labor availability or labor cost required for the followup treatment.

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FIELD TRIALS ON SOYBEANS, ADZUKI BEANS, KIDNEY BEANS AND SUGAR BEETS WITH 10% EC OF HALOXYFOP EE ESTER IN JAPAN IN 1984

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ABSTRACT

Official field trials were carried out through the arrangements by the Japan Association for Advancement of Phyto-Regulators (JAPR) in Japan during the 1984 crop season to evaluate the efficacy of the ethoxyethyl (EE) ester of haloxyfop (DOWCO 453) on annual gramineous weeds in crops. The formulation tested contained 10% of active ingreidient and 20% of adjuvant. The formulation was applied at the rates of 1.0, 1.5 and 2.0 *liter/ha* when the grasses were 2-7 leaf-stage to the fields which had been pre-treated with a pre-or post-emergence herbicide such as dinoseb, linuron and phenmedipham.

Haloxyfop EE ester gave excellent control of gramineous weeds, such as *Echinochloa crus-galli, Digitaria adscendens* and *Eleusine indica* in soybeans (8 locations), adzuki beans (2), kidney beans (2) and sugar beets (one of the two locations) at all the rates tested. Only exception was *Poa annua* existed in one of the two sugar beet trials, for which the results were erratic. One *liter/ha* of 10% haloxyfop EE ester was similar to or better than 1.5 *kg* of 75% alloxydium-sodium in the control of gramineous weeds.

No phytotoxicity was observed on all the crops treated with haloxyfop EE ester.

INTRODUCTION

Haloxyfob (DOWCO 453) is a new selective post-emergence herbicide discovered and developed by the Dow Chemical Company. It has an extremely high level of activity when applied as a foliar spray at suggested use rates to a wide range of annual and perennial grasses without injury to broadleaf crops (Handly and Hammand, 1983, Hunter and Barton, 1983).

In order to introduce haloxyfob into the Japan crop market, the official field trials were carried out through the arrangements by JAPR during the 1984 crop season to evaluate the efficacy of 10% EC formulation of haloxyfob EE ester with 20% of adjuvant on gramineous weeds in soybeans, adzuki beans, kidney beans and sugar beets (JAPR, 1984).

MATERIALS AND METHODS

Ten percent EC formulation of haloxyfop EE ester with 20%adjuvant was applied at the rate of 1.0, 1.5 and 2.0 *l/ha* diluted with 0.7 to 1.0 *kl/ha* of water. One of the following herbicides was used as the commercial standard.

KUSAGARD water soluble powder: alloxydim-sodium 75%
PREMERGE emulsifiable concentrate (EC): dinoseb (alkanolamine salt) 47%
AFALON wettable powder (WP): linuron 50%
SATURN-VALOR EC: thiobencarb 50% + prometryn 5%
SATURN-P granules: thiobencarb 8% + prometryn 0.8%
SIMAZINE WP: simazine 50%

All the plots to be treated with post-emergence herbicides were pre-treated with one of the following pre-on post-emergence herbicides.

Pre-emergence Herbicides
PREMERGE EC: dinoseb (alkanolamine salt) 47%
ARETIT WP: dinoseb-acetate 40%
AFALON WP: linuron 50%

Post-emergence Herbicides
BETANAL EC: phenmedipham 13%
LENAPAC WP: lenacil 40% + pyrazon 30%

Crops, locations and experimental details were summarized in Table 1.

Herbicidal efficacy was assessed 2 to 5 weeks after treatment by weighing either fresh or air-dry weight of all the existing weeds by species.

RESULTS AND DISCUSSION

The results were summarized in Tables, 2 for soybeans, 3 adzuki beans, 4 kidney beans and 5 sugar beets. Haloxyfop at all the rates tested gave excellent control of annual gramineous weeds without giving any phytotoxicity, such as suppression of growth and decrease in grain or root production on any crops. Only exception was *Poa annua* existed in one of the two sugar beet trials, at Tenpoku, for which the results were erratic. It was considered that the dosage applied was not sufficient to control it completely.

The dosages applied in the field trials were equivalent to 0.08 to 0.17 *ka ae/ha.* Based on the excellent annual grass control obtained in 1984 season trials, lower range of the rates, i.e. from 0.06 to 0.125 *kg ae/ha* are being carried out in 1985 season.

Table 1 Crops, locations and experimental details

LOCATION	CROP	VARIETY	PLOT SIZE m^2	REPLICATION	DATE SOWN OR *TRANSPLANTED*	SOIL TYPE	DATE OF PRE-TREATMENT	DATE OF TREATMENT	GRASS STAGE LEAF-AGE	DATE OF ASSESSMENT
Tokachi	Soybean	Kitamusume	7.2	2	5/23	Volcanic	5/29	6/11	2-6	7/10
	Adzuki bean	Hayateshozu	4.8	2	5/25		5/31	6/11	2-6	7/10
	Kidney bean	Kaishokintoki	5.4	2	5/25		5/31	6/11	2-6	7/10
	Sugar beet	Monohiru	14.4	2	*5/07*		5/30	6/05	2-6	7/10
Kitami	Soybean	Kitamusume	9.6	2	5/22	Volcanic ash	5/30	6/09	2-6	7/14
	Adzuki bean	Hayateshozu	9.6	2	5/22		5/30	6/09	2-6	7/14
	Kidney bean	Taishokintoti	9.6	2	5/22		5/30	6/09	2-6	6/29
Tenpoku	Sugar beet	Karbepori	12	2	*5/16*		6/04	7/05	2-5	7/23
Aomori	Soybean	Wasesuzunari	14	2	5/09	Alluvial	5/11	6/11	2-6	6/30
Miyagi	Soybean	Tanrei	8	2	5/18	Brown forest	5/19	6/20	3.5-5	7/06
Igaragi	Soybean	Enrei	9	2	6/22	Volcanic ash	6/22	7/23	3-7	8/08
Nagano	Soybean	Enrei	10.7	2	5/29	Volcanic ash	5/31	6/20	3-5	7/04
Kumamoto	Soybean	Akishirome	12	3	7/23	Volcanic ash	7/24	8/10	5-6	9/03
Kagoshima	Soybean	Fukuyutaka	10.8	3	7/19	Volcanic ash	7/20	8/06	2-5	3/21

Table 2 Official field trials on soybeans with Haloxyfop EE Ester in 1984

LOCATION	HERBICIDE APPLIED PRE-TREATMENT/TREATMENT (*l* or *kg/ha*)		GRAMINEOUS WEED[a] % CONTROL[b]			NON-GRAMI. WEED % CONTROL[b]	GRAIN PRODUCTION %[c]
			Ech.	Dig.	Ele.		
Tokachi	PREMERGE/Haloxyfop	(5.0/1.0)	98			86	86
		(5.0/1.5)	100			96	93
		(5.0/2.0)	100			87	92
	/KUSAGARD	(/1.5)	99			-58	80
	PREMERGE/	(5.0/)	-72			90	98
	No weeding[d]		147			706	62
	Hand weeding[f]						2.7
Kitami	PREMERGE/Haloxyfop	(5.0/1.0)	88			54	121
		(5.0/1.5)	95			66	104
		(5.0/2.0)	95			67	106
	PREMERGE/KUSAGARD	(5.0/1.0)	79			51	122
	No weeding[d]		142			209	115
	Hand Weeding[f]						3.2
Aomori	AFALON/Haloxyfop	(1.0/1.0)	100	100			110
		(1.0/1.5)	100	100			117
		(1.0/2.0)	100	100			137
	AFALON/KUSAGARD	(1.0/1.5)	100	100			119
	No weeding[d]		1.5	0.4			104
	Hand weeding[f]						3.3
Miyagi	AFALON/Haloxyfop	(1.5/1.0)	100	100		91	89
		(1.5/1.5)	100	100		92	95
		(1.5/2.0)	100	100		94	100
	AFALON/KUSAGARD	(1.5/1.5)	100	100		95	101
	AFALON	(1.5/)	53	45		90	97
	No weeding[d]		14	169		597	96
	Hand wdding[f]						3.1
Ibaragi	AFALON/Haloxyfop	(1.0/1.0)		100		-349	98
		(1.0/1.5)		100		-154	105
		(1.0/2.0)		100		90	98
	AFALON/KUSAGARD	(1.0/1.5)		99		-3	98
	AFALON/	(1.0/)		92		84	96
	No weeding[d]			174		84	100
	Hand weeding[f]						3.1
Nagano	AFALON/Haloxyfop	(1.5/1.0)	100			45	90
		(1.5/1.5)	100			44	99
	AFALON/	(1.5/)	49			74	92
	SATURN-VALOR/	(8.0/)	94			98	87
	No weeding[d]		1060			600	88
	Hand weeding[f]						4.0
Kumamoto	AFALON/Haloxyfop	(1.0/1.0)		93	90	49	116
		(1.0/1.5)		100	100	-66	118
		(1.0/2.0)		100	100	20	99
	SATURN-P/	(50 /)		42	78	82	83
	SIMAZINE/	(0.75/)		1	77	51	66
	No weeding[e]			248	115	20	55
	Hand weeding[f]						3.9
Kagoshima	AFALON/Haloxyfop	(1.0/1.0)	100	100	100	75	97
		(1.0/1.5)	100	100	100	80	104
		(1.0/2.0)	100	100	100	61	104
	AFALON/	(1.0/)	-118	46	35	74	103
	No weeding[e]		2	12	29	37	95
	Hand weeding[f]						2.5

a) Abbreviations: Ech. *Echinochloa crus-galli*, Dig. *Digitaria adscendens*, Ele. *Eleusine indica*
b) The grass weight in the no weeding plot was used as the basis of % calculation.
c) The weight of grain yield in the hand weeding plot was used as the basis of % calculation.
d) g fresh weight/m^2
e) *g* dry weight/m^2
f) *t/ha*

Table 3. Official field trials on Adzuki Beans with Haloxyfop EE Ester in 1984

LOCATION	HERBICIDE APPLIED PRE-TREATMENT/TREATMENT (*l* or *kg/ha*)		GRAMI. WEED[a] % CONTROL[b]	NON-GRAMI. WEED % CONTROL[b]	GRAIN PRODUCTION %
			Ech.		
Tokachi	ARETIT/Haloxyfop	(5.0/1.0)	97	81	97
		(5.0/1.5)	99	92	100
		(5.0/2.0)	99	74	107
	ARETIT/KUSAGARD	(5.0/1.0)	98	27	60
	ARETIT/	(5.0/)	-134	90	96
	No weeding[d]		427	1735	59
	Hand weeding[f]				2.22
Kitami	PREMERGE/Haloxyfop	(5.0/1.0)	97	90	121
		(5.0/1.5)	98	85	122
		(5.0/2.0)	96	96	124
	PREMERGE/KUSAGARD	(5.0/1.0)	84	95	134
	No weeding[d]		81	531	110
	Hand weeding[f]				1.89

a, b, c, d and f are the same as TABLE 2.

Table 4. Official field trials on Kidney Beans with Haloxyfop EE Ester in 1984

LOCATION	HERBICIDE APPLIED PRE-TREATMENT/TREATMENT (*l* or *kg/ha*)		GRAMI. WEED[a] % CONTROL[b]	NON-GRAMI. WEED % CONTROL[b]	GRAIN PRODUCTION %
			Ech.		
Tokachi	ARETIT/Haloxyfop	(5.0/1.0)	97	91	93
		(5.0/1.5)	98	93	90
		(5.0/2.0)	100	79	91
	ARETIT/KUSAGARD	(5.0/1.0)	95	18	84
	ARETIT/	(5.0/)	-230	96	95
	No weeding[d]		79	948	83
	Hand weeding[f]				2.95
Kitami	PREMERGE/Haloxyfop	(5.0/1.0)	98	97	111
		(5.0/1.5)	93	97	110
		(5.0/2.0)	98	90	97
	PREMERGE/KUSAGARD	(5.0/1.0)	87	96	110
	No weeding[d]		95	610	74
	Hand weeding[f]				2.19

a, b, c, d and f are the same as TABLE 2.

Table 5. Official field trials on Kidney Beans with Haloxyfop EE Ester in 1984

LOCATION	HERBICIDE APPLIED PRE-TREATMENT/TREATMENT (*l* or *kg/ha*)		GRAMI. WEED[a] % CONTROL[b]		NON-GRAMI. WEED % CONTROL[b]	GRAIN PRODUCTION %[c]
			Ech.	Poa		
Tokachi 7/10	BETANAL/Haloxyfop	(6.0/1.0)	95		94	95
		(6.0/1.5)	99		94	109
		(6.0/2.0)	99		94	104
⅓	BETANAL/KUSAGARD	(6.0/1.5)	82		-12	93
	BENTANAL	(6.0/)	63		98	101
	No weeding[d]		41		484	90
	Hand weeding[f]					62.7
Tempoku 7/23	LENAPAC/Haloxyfop	(2.0/1.0)	100	29	70	110
		(2.0/1.5)	100	71	65	103
		(2.0/2.0)	100	43	91	112
	LENAPAC	(2.0/)	-225	100	62	100
	No weeding[d]		4	7	1690	75
	Hand weeding[f]					41.9

a, b, c, d and f are the same as TABLE 2.
Abbreviation: Poa, *Poa annua*

c) *The weight of root yield in the hand weeding plot was used as the basis of %* calculation.

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GENERAL WEED CONTROL IN CITRUS ORCHARDS WITH GALLANT*/STARANE* MIXTURE

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ABSTRACT

A new grass postemergence herbicide — GALLANT (haloxyfopmethyl) and a new broadleaf postemergence weed killer — Starane (Fluroxypyr) were tested for general weed control in citrus orchards in Taiwan during 1984-1985. Gallant herbicide at rates of 0.125-1.0 *kg ae/ha* was very active against grass species — *Paspalum conjugatum* and *Digitaria* spp., but was moderately active against *Setaria palmifolia*. Starane herbicide at rates of 0.25-0.50 *kg* ae/*ha* gave very excellent control perennial broadleaf weeds — *Polygonum chinense* and *Commelina undulata*. The mixture of Gallant herbicide and Starane herbicide provided a synergistic response in controlling grasses and didn't reduce efficacy on broadleaf weeds. The results indicate that Gallant herbicide and Starane herbicide will be a good partner with excellent commercial potential for general weed control.

INTRODUCTION

Weed control in citrus orchards in Taiwan comprises a large part of a farmer's work. During the raining season of May to August, mowing is prefered by citrus growers to suppress weed growth, avoid competition for nutrients, prevent soil erosion and increase humus in the soil. However, during the dry period from Sept. to April of the following year herbicide applications are desirable. Herbicides are usually applied to curtail weed growth and so to facilitate harvest activities[1]. Postemergence herbicides such as 3 Paraquat and 4 Glyphosate are most widely used by citrus growers in Taiwan. Though the effective period of Paraquat from application to regrowth is only 30 days and Glyphosate can control on many weed species for a longer period (60 to 100 days after application)[2]; both of them do not provide satisfactory result in controlling troublesome perennial weeds, especially *Polygonum chinense, Commelina undulata* and other vines. The control of these weeds are becoming a major concern for citrus growers, and more research and development is needed to find the most effective chemicals.

* Trademark of the Dow Chemical Company Ltd.
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3 4 Common name officially designated by USDA
5 Common name officially designated by USDA
6 Trademark of the Dow Chemical Company.
The active ingredient in Garlon herbicide is trichlopyr.

Gallant* (haloxyfop-methyl), a new selective postemergence herbicide is active against a wide range of annual and perennial grass species in establishing broadleaf crops such as soybean and cotton[3,4,5]. Starane* (Fluroxypyr), is readily trans-locatable non-phenoxy herbicide, exhibits a high degree of activity in controlling broadleaf weeds; it induces characteristic auxin type responses, frequently within a few hours after application[6]. Both herbicides were discovered and developed by the Dow Chemical Company, and were initially tested in Taiwan from 1984.

This article presents the results of the field trials conducted during 1984-1985. The major objectives of these trails were:

(1) To define and compare the herbicide activities of Gallant herbicide, Glyphosate, Paraquat, and Gallant herbicide in combination with broadleaf weed killers — Starane herbicide, [5]Diuron and [6]Garlon* herbicides.

(2) To determine the best combination of Gallant/Starane mixture.

(3) To define field use rate.

MATERIALS AND METHODS

During 1984-1985, seven field trials were conducted at a 7-10 year-old citrus orchards in Yunlin, Taiwan. A knapsack sprayer was used for foliar application on weeds. Total spray volume was 1000 *L/ha*.

All experiments utilized randomized complete block design with 3 or 4 replicates per treatment. For comparison purposes, the commercial standard, 41% Glyphosate or 24% Paraquat, was used to compare its weed controlling efficacy with various Gallant mixtures.

Weed controlling efficacy was determined by visual evaluation on a scale of 0 - 100%. An acceptable level for growers is supposed to be 85%. Visual evaluations were started 7 to 20 days after herbicide applications. Three to five consecutive evaluations were made at 1 to 3 week interval for each trial. Data of 1984 trials reported here represent only the evaluations made 5 to 6 weeks after herbicide applications.

Herbicides tested in these trials were as follows:

Gallant herbicide — Dowco 453 ME-240 *g* ae/*L* haloxyfop methyl ester.

Starane herbicide — Dowco 433-200 *g* ae/*L* fluroxypyr methyl heptyl ester.

Garlon 4E herbicide — 61.6% triclopyr emusifiable concentrate.

Diuron 80WP — 80% diuron wettable powder.

Glyphosate — 41% glyphosate solution.

Paraquat — 24% paraquat solution.

XGA 2027 contains 100 *g* ae/*L* Gallant and 100 *g* ae/*L* Starane emusifiable concentrate.

* starane herbicide technical information.

XGA 2028 contains 100 *g* ae/*L* Gallant and 150 *g* ae/*L* Starane emusifiable concentrate.

In 1984, 4 field trials were conducted to compare weed controlling efficacy of Gallant herbicide, Gallant herbicide tank mixed Diuron, Garlon herbicides and Starane herbicide, and 2 commercial standards — Glyphosate and Paraquat.

In 1985, Gallant herbicide tank mixed with Starane herbicide and 2 Gallant/Starane formulations (XGA 2027 and XGA 2028) were tested for determining the best combination ratio and field use rate.

RESULTS AND DISCUSSION

The major weed species recorded in the testing area were:

Annual grass — *Digitaria* spp. (crabgrass)

Perennial grasses — *Paspalum conjugatum* (sour paspalum)
Setaria palmifolia (palmgrass)

Annual broadleaf weeds — *Drymaria cordata* (heart drymary)
Eretites valerianaefolia (Nodding burnweed)
Ageratum conyzoides (tropic ageratum)
Solanum nigrum (black nightshade)
Bidens bipinnata (Spanish needles)
Borreria latifolia

Perennial broadleaf weeds — *Commelina undulata* (diffuse dayflower)
Polygonum chinense (chinense knotweed)

(A) Weed control efficacy of gallant herbicide, gallant herbicide/diuron, gallant herbicide/ garlon herbicides and gallant herbicide/starane herbicide.

The trial conducted in April to May, 1984 (Table 1.) indicated that Gallant herbicide gave more than 90% control rate on *P. conjugatum* at rates of 0.125 to 1.0 *kg* ae/*ha*, and provided no control to the broadleaf weeds — *C. undulata, D. cordata,* and *P. chinense.* Gallant herbicide tank mixed with Diuron or Starane herbicide gave good control on *P. conjugatum,* but Gallant/Starane mixture at rates of either 0.25 + 0.25 or 0.25 + 0.50 *kg* ae/*ha* offered a more satisfactory efficacy on *C. undulata, D. cordata* and *P. chinense* compared with Gallant herbicide/Diuron mixture.

Phytotoxicity to citrus leaves was observed in the plots treated with Gallant/Starane mixture. Deformation (leafcurling and yellowing) occurred on some leaves at the basal part of citrus trunk. Since no rain was encountered during this trial within 10 days after application, crop injury caused by drifting of Starane herbicide was suspected.

The trial conducted in May to July, 1984 (Table 2.) showed that Gallant herbicide at 0.50 *kg* ae/*ha* gave high control on the grass species — *D.* spp., *P. conjugatum,* but moderate control on *S. palmifolia* and no control against broadleaf weeds — *P. chinense, C. undulata* and *D. cordata.* Gallant herbicide tank mixed with Starane herbicide (0.25 + 0.25 and 0.50 + 0.50 *kg/* ae/*ha*) or Garlon herbicide (0.25 + 0.50 and 0.5 + 0.50 *kg* ae/*ha*) gave superior efficacy to the commercial standard, Glyphosate (1.64 *kg* ai/*ha*). Furthermore, the Gallant/Starane mixture provided better broadleaf weed control in comparison with Gallant/Garlon combinations. Heavy rain was encountered within 2 hours after herbicide application in this trial. It is suspected that the low weed controlling efficiency of Glyphosate was due to rain. It implied that absorption of Gallant/Starane and Gallant/Garlon by foliar parts of weeds were faster than that of Glyphosate. No phytotoxicity was observed in this trial.

Table 1. Weed control of Gallant herbicide and its tank mixture with Diuron or Starane herbicide.

Chemicals	*kg* ae/*ha*	Weed Species			
		Paspalum conjugatum	*Commelina undulata*	*Drymaria cordata*	*Polygonum chinense*
Gallant	0.125	95	0	0	0
Gallant	0.25	97	0	0	0
Gallant	0.50	99	0	0	0
Gallant	1.00	98	0	0	0
Gallant + Diuron	0.125 + 1.6	98	10	40	35
Gallant + Diuron	0.25 + 1.6	96	5	74	40
Gallant + Diuron	0.50 + 1.6	97	8	78	40
Gallant + Diuron	1.00 + 1.6	98	18	56	30
Gallant + Starane	0.25 + 0.25	98	99	99	97
Gallant + Starane	0.25 + 0.50	98	99	99	97

* Application date: April 4, 1984
** Evaluation was held 40 days after application.

Table 2. Weed control of Glyphosate, Gallant herbicide and its tank mixture with Garlon herbicide or Starane herbicide.

Chemicals	*kg* ae/*ha*	Weed Species					
		Digitaria spp.	*Paspalum conjugatum*	*Setaria palmifolia*	*Commelina undulata*	*Drymaria cordata*	*Polygonum chinense*
Glyphosate	1.64	70	50	55	50	90	45
Gallant	0.5	99	99	80	0	0	0
Gallant + Garlon	0.25 + 0.50	90	99	85	87	77	85
Gallant + Garlon	0.50 + 0.50	95	98	85	73	67	60
Gallant + Starane	0.25 + 0.25	99	99	90	83	95	85
Gallant + Starane	0.50 + 0.50	99	99	85	87	95	87

* Application date: May 16, 1984
** Evaluation was held at 35 days after application.

Results of the above 2 trials (Table 1, 2) indicated that Starane herbicide is a good partner of Gallant herbicide for general weed control in citrus orchards.

In the trial carried out from June to July, 1984 (Table 3), Gallant/Starane mixture at rate of 0.25 + 0.50 *kg* ae/*ha* gave consistently higher efficacy compared to Gallant/Starane mixture at 0.25 + 0.25 *kg* ae/*ha* and Gallant/Garlon mixture.

Table 3. Weed control of Glyphosate, Gallant herbicide and its tank mixture with Garlon herbicide or Starane herbicide.

Chemicals	*kg ae/ha*	Weed Species					
		Digitaria spp.	*Paspalum conjugatum*	*Setaria palmifolia*	*Commelina undulata*	*Drymaria cordata*	*Polygonum chinense*
Glyphosate	1.64	90	99	85	87	99	83
Gallant	0.50	99	99	80	0	0	0
Gallant + Garlon	0.25 + 0.50	85	93	70	60	65	40
Gallant + Garlon	0.50 + 0.50	87	96	65	83	85	65
Gallant + Starane	0.25 + 0.25	90	95	75	70	94	85
Gallant + Starane	0.25 + 0.50	88	99	75	97	99	99

* Application date: June 6, 1984

** Evaluation was held at 35 days after application.

In comparison with Glyphosate at 1.64 *kg* ai/*ha,* Gallant/Starane mixture at 0.25 + 0.50 *kg* ae/*ha* gave subequal to superior control to *D.* spp., *P. conjugatum, D. cordata, C. undulata* and *P. chinense,* but poorer control to *S. palmifolia.* The results indicated that the proper field use rate for Gallant/Starane mixture is 0.25 + 0.50 *kg* ae/*ha.*

In the trial conducted from July to August, 1984 (Table 4.), the Gallant/Starane mixture at rate of 0.25 - 0.50 *kg* ae/*ha* gave nearly equally high weed control compared to that of the same mixture at rate of 0.50 + 0.50 *kg* ae/*ha*. Just like most of the previous held trials, the efficacy of the g Gallant/Starane mixture is similiar to that of Glyphosate. The plots treated with Paraquat offered the poorest efficacy among all treatments.

Table 4. Weed control of Gallant/Starane mixtures, Glyphosate and Paraquat.

Chemicals	*kg ae/ha*	Weed Species				
		Digitaria spp.	*Paspalum conjugatum*	*Setaria palmifolia*	*Drymaria cordata*	*Polygonum chinense*
Gallant + Starane	0.25 + 0.50	99	99	80	90	97
Gallant + Starane	0.50 + 0.50	99	99	82	70	99
Glyphosate	1.64	95	99	99	80	90
Paraquat	0.84	96	73	73	73	30

* Application date: July 12, 1984

** Evaluation was held 40 days after application.

Comparing weed coverage at 75 days after application (Table 5.), the plots applied with Gallant/Starane mixture and Glyphosate presented higher coverage of annual broadleaf weeds — *E. valerianaefolia, B. bipinnata, A. conyzoides,* and *B. latifolia* in contrast with the plots treated with Paraquat which showed higher perennial weed coverage. It indicates that Gallant/Starane mixture and Glyphosate can extinguish perennial weeds and may change weed flora from troublesome perennial weeds into annual weeds which are easier to manage by farmers.

Table 5. Weed coverage in citrus orchard before and after application of Gallant/ Starane mixture, Glyphosate and Paraquat.

Treatments	*kg ae/ha*	*Paspalum conjugatum*		*Setaria palmifolia*		*Polygonum chinense*		*Drymaria cordata*		*Borreria latifolia*		*Erechtites hieracifolia*		*Ageratum conyzoides*		*Bidens bipinnata*		Others	
		B*	A**	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
Gallant + Starane	0.25 + 0.50	10	3	29	10	15	7	15	30	0.5	15	0.5	12	1	5	9	8	20	10
Gallant + Starane	0.50 + 0.50	5	3	23	5	23	5	19	27	1.0	10	2	12	1	10	13	12	13	16
GLYPHOSATE	1.64	4	0	20	0	12	6	31	27	1.0	23	5	15	1	7	8	10	18	12
PARAQUAT	0.84	5	8	15	10	6	43	29	23	6	3	5	0	1	0	1	0	32	13
UNTREATED		18	10	27	22	10	35	13	20	0	1.5	5	0	1	0	5	0	21	12

* : % Coverage before application.

** : % Coverage at 75 days after application.

Application: July 12, 1984

Table 6. Weed control by Gallant herbicide, Satarane herbicide, Gallant/Starane formulations, Glyphosate and Paraquat in citrus orchard.

Chemicals	*kg ae/ha*	*Paspalum conjugatum*					*Polygonum chinense*					*Commelina undulata*					*Drymaria cordata*				
		7*	14*	21*	28*	40*	7	14	21	28	40	7	14	21	28	40	7	14	21	28	40
GALLANT	0.2	25	57	68	82	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALLANT	0.4	20	60	85	90	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STARANE	0.2	0	0	0	0	0	63	84	77	85	85	57	80	68	74	48	57	96	98	91	68
STARANE	0.4	0	0	0	0	0	70	86	84	94	90	62	86	88	92	83	75	96	98	95	83
STARANE	0.6	0	0	0	0	0	73	87	86	95	93	70	88	91	94	89	70	96	98	99	96
XGA-2027	0.2 + 0.2	40	75	88	94	97	50	78	73	75	75	37	58	52	68	50	40	90	93	85	83
XGA-2027	0.3 + 0.3	-	-	-	-	-	56	79	68	83	80	47	74	60	77	57	55	87	94	88	78
XGA-2027	0.4 + 0.4	-	-	-	-	-	62	84	77	91	85	57	78	72	82	68	67	93	97	90	88
XGA-2028	0.2 + 0.3	40	95	95	99	99	63	79	75	85	85	60	80	73	81	60	63	93	96	92	85
XGA-2028	0.3 + 0.45	25	92	95	99	99	70	88	85	92	90	60	86	87	91	87	75	97	98	97	97
XGA-2028	0.4 + 0.6	60	90	98	99	99	75	87	92	96	97	70	88	92	94	83	83	98	98	99	99
GLYPHOSATE	1.64	45	60	65	60	80	50	62	62	72	77	17	53	55	68	78	90	94	96	97	99
PARAQUAT	0.72	93	80	70	30	35	53	72	57	20	13	92	88	92	92	57	93	91	84	65	55

* Days after application.

Application date: Mar. 20, 1985

(B) Herbicide activity of gallant herbicide, starane herbicide and gallant starane combinstions

The trial conducted on March 20, 1985 (Table 6.) at budding and flowering stage of citrus showed that both Gallant/Starane formulations — XGA 2027 and XGA 2028 at all rates provided better and quicker killing response on *P. conjugatum* which were completely browned out at 14 days after application when compared with Gallant herbicide alone, but did not have a significant improvement of broadleaf weed control. It indicated that Gallant/Starane mixture probably has a synergistic effect on herbicidal activity of grass species. Meanwhile, XGA 2028 at all rates gave better weed control than XGA 2027. Among 3 application rates, XGA 2028 at 0.3 + 0.45 and 0.4 + 0.6 *kg* ae/*ha* consistently gave 85% control of all weed species at 14 to 40 days after application. Both commercial standards — Glyphosate and Paraquat didn't perform effectively on the control of weed species recorded in this trial.

Leaf-wrinking and yellowing was also observed on some young leaves at the lower part of citrus trunk in the plots treated with Starane herbicide or its combination with Gallant herbicide. It is suspected that Starane herbicide may cause phytotoxicity by root uptake or vaporation when treated at budding and flowering stage of citrus.

The trial carried out on Mar. 26, 1985 (Table 7) offered that Gallant/Starane combination gave improvement of grass and annual broadleaf weed control by Gallant herbicide or Starane herbicide alone. XGA 2028 at rate of 0.2 + 0.3 *kg* ae/*ha* gave the best weed controlling efficacy, followed by Gallant herbicide tank mixed with Starane herbicide at 0.2 + 0.3 *kg* ae/*ha*, XGA 2027 at 0.2 + 0.2 *kg* ae/*ha* and Gallant herbicide at 0.2 *kg* ae/*ha* or Starane herbicide at 0.3 *kg* ae/*ha* consecutively. It confirms that XGA 2028 is good formulation.

The trial conducted on May 1, 1985 (Table 8.) confirmed that Gallant/Starane mixture is a good partner for general weed control. Satisfactory results may be achieved with application of Gallant herbicide tank mixed with Starane herbicide at 0.25 + 0.50 *kg* ae/*ha* or Gallant/Starane (at 1 : 1.5 combination ratio) at 0.3 + 0.45 to 0.4 + 0.6 *kg* ae/*ha*.

CONCLUSIONS

Gallant herbicide at rates of 0.125 to 1.0 *kg* ae/*ha* are very active against major grass species — *Paspalum conjugatum* and *Digitaria* spp. but moderately effective to one of trouble-some perennial weeds — *Setaria palmifolia* in citrus orchards of Taiwan.

To maximize its capacity in weed management of citrus orchard, Gallant herbicide must be used in conjunction with an effective broadleaf weed killer.

The trial results during 1984 - 1985 indicated that Gallant herbicide mixed with Starane herbicide at rate of 0.25 + 0.50 *kg* ae/*ha* and Gallant/Starane combination (XGA 2028) at rate of either 0.3 + 0.45 or 0.4 + 0.6 *kg* ae/*ha* provided excellent control on the most abundant grasses and broadleaf weeds in citrus orchards in

Table 7. Weed control by Gallant, Starane, tank mixed Gallant/Starane, and Gallant/Starane formulations.

Chemicals	*kg* ae/*ha*	*Paspalum conjugatum*				*Drymaria cordata*				*Eretites valerianaefolia*				*Solanum nigrum*			
		7**	14	24	35	7	14	21	35	7	14	21	35	7	14	21	35
Gallant	0.2	7	53	72	85	0	0	0	0	0	0	0	0	0	0	0	0
Starane	0.3	0	0	0	0	70	92	85	58	40	50	60	50	40	40	50	40
Gallant + Starane*	0.2 + 0.3	32	82	84	87	80	96	93	80	45	68	70	85	45	80	80	75
XGA 2027	0.2 + 0.2	23	82	87	88	63	78	80	68	30	50	50	50	40	68	75	90
XGA 2028	0.2 + 0.3	33	88	92	93	80	96	94	88	45	60	85	80	45	75	88	93

* Tank mixed
** Days after application

Application date: Mar. 26, 1985

Table 8. Weed control of Gallant herbicide, Starane herbicide, Gallant/Starane mixtures and Glyphosate.

Chemicals	*kg* ae/*ha*	*Paspalum conjugatum*	*Polygonum chinense*	*Commelina undulata*	*Polygonum perfoliatum*	*Erechtites valerianaefolia*	*Ageratum conyzoides*	*Drymaria cordata*	*Solanum nigrum*	*Borreria latifolia*
Gallant	0.25	95	0	0	0	0	0	0	0	0
Starane	0.25	0	96	94	88	99	95	99	99	60
Starane	0.5	0	97	93	93	99	99	99	99	75
Gallant + Starane*	0.25 + 0.50	98	95	92	94	99	-	99	99	77
XGA-2028	0.3 + 0.45	97	94	93	92	99	-	99	-	68
XGA-2028	0.4 + 0.6	98	98	95	95	99	99	99	99	57
Glyphosate	1.64	80	70	63	85	97	99	99	99	70

* Tank mixed.
Evaluation was held 20 days after application.

Application date: May 1, 1985

Taiwan. This mixture gave synergistic response in controlling grasses and didn't reduce efficacy on broadleaf weed control, and may change the weed flora from perennial weeds into annual weeds which can be controlled easier. However, Starane herbicide may cause phytotoxicity on the basal part of citrus leaves by drifting, root uptake or vaporation when citrus are at budding and flowering stage. For general weed control, its efficacy can compete with Glyphosate — one of the competitive postemergence herbicide, but need to avoid spraying to budding and flowering stage of citrus. It indicates that Gallant/Starane mixture will be a Dow product with commercial capability in Taiwan.

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HALOXYFOP-ETHOXY ETHYL FOR THE SELECTIVE CONTROL OF PERENNIAL GRASSES IN FORESTRY IN NEW ZEALAND.

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ABSTRACT

Field trials demonstrate haloxyfop-ethoxy ethyl at rates up to 2 *kg ai/ha* plus 0.25% *v/v* non ionic alkyl aryl poly-oxyethylene glycol surfactant is completely selective to newly transplanted *Pinus radiata* and *Eucalyptus regnans*. The addition of either atrazine or simazine did not reduce selectivity.

In experiments on mixed grass weed populations haloxyfop-ethoxy ethyl at 250 - 500 *g ai/ha* gave adequate season long suppression of brown top *(Agrostis tenuis)*, sweet vernal *(Anthoxanthum odoratum)*, cocksfoot *(Dactylis glomerata)*, perennial ryegrass *(Lolium perenne)*, Yorkshire fog *(Holcus lanatus)*, crested dogstail *(Cynosurus cristatus)*, and paspalum *(Paspalum dilatatum)*.

Field trials on mono cultures of Indian doab *(Cynodon dactylon)*, paspalum, kikuyu *(Pennisetum clandestinuim)* and pampas *(Cortaderia jubata)* show that paspalum is controlled at 0.25 - 0.5 *kg ai/ha*, kikuyu at 0.4 - 0.6 *kg* and Indian doab at 0.5 - 1 *kg ai/ha* although 0.8 - 1 *kg* may be more reliable. Preliminary results on pampas show 1 - 1.5 *kg ai/ha* plus 1% *v/v* of an emulsifiable crop oil is required to give adequate control.

INTRODUCTION

A wide range of grasses and broadleaf weeds compete with newly planted *Pinus radiata* and *Eucalyptus* species in New Zealand. Herbicides such as triazines, hexazinone and amitrole are used for selective weed control in *P. radiata* but have a low safety margin and tree damage can occur. *Eucalyptus* species are only tolerant to a few triazines. The development of highly active selective grasskillers such as haloxyfop EE which have a high level of tree tolerance will allow the control of grasses in *Eucalyptus* and provide a useful alternative for *P. radiata*.

Haloxyfop EE, was assessed in 18 small plot trials on typical forest sites during the period 1982/1984. The efficacy data for haloxyfop EE on the various grass species and the tolerance of *P. radiata* and *E. regnans* are presented. In addition efficacy information was obtained from a further 19 small plot field trials containing grass species which present problems in establishing forests.

MATERIALS AND METHODS

The trials were applied either by precision broadcast sprayer, (32 trials) spot gun (4 trials) or knapsack (1 trial).

The precision broadcast sprayers were fitted with a boom using fan tip nozzles applying 200 - 400 *L/ha* at 100 - 200 *kPa*. The spot gun was a modified drench gun fitted with a cone nozzle applying 15 - 30 ml/m^2. The knapsack was fitted with a fan tip nozzle calibrated to apply 440 *l/ha*. Trial design was 2 - 3 replicate random block using 1 to 3 × 10 - 3 *ha* plots except for the spot gun and knapsack trials which were single replicate, with 10 - 30 trees or *Cortaderia* plants per plot. The tree tolerance trials were 3 replicate with 10 trees per plot.

Four tolerance trails were conducted on *P. radiata* (Trials 1 + 2) and *E. regnans* (Trials 3 + 4). Trials 1 and 3 were applied to dormant trees 200 - 400 *mm* high three weeks after planting. Trials 2 and 4 were applied to actively growing trees 15 weeks after planting. Tolerance was assessed both visually and by height measurement.

Fourteen trials were conducted throughout the North and South Islands on typical forestry sites and a further 19 trials were done on monocultures of other problem grasses in the North Island. Grasses ranged from vegetative, 100 - 250 *mm* high, to flowering, 150 - 300 *mm* high.

Grass control was assessed visually as a percent brown out and/or regrowth suppression.

Materials

Formulations used were haloxyfop EE, XRM 4638; atrazine flowable, simazine flowable, alkyl aryl poly oxyethylene glycol-non ionic surfactant, and emulsifiable parafinic spraying oil (crop oil).

RESULTS AND DISCUSSION

Tree tolerance

Mean height at 8 - 11 months after treatment are presented in Table 1. The high variance in trial 4 is due to a site effect. Trials were conducted on sites where no significant weed competition occurred. Tree vigour was visually assessed but no noticeable change from untreated was observed.

Grass weed control

A general assessment of the control of individual species is summarized in Figure 1. All the grasses listed compete with the trees for light, moisture and nutrients in varying degrees. It was evident during assessment of results that the inclusion of a soil sterilant with broadleaf activity is essential to prevent the broadleafs dominating the treated areas. The chloro-triazines simazine and/or atrazine were suitable and did not cause antagonism.

Agrostis tenuis

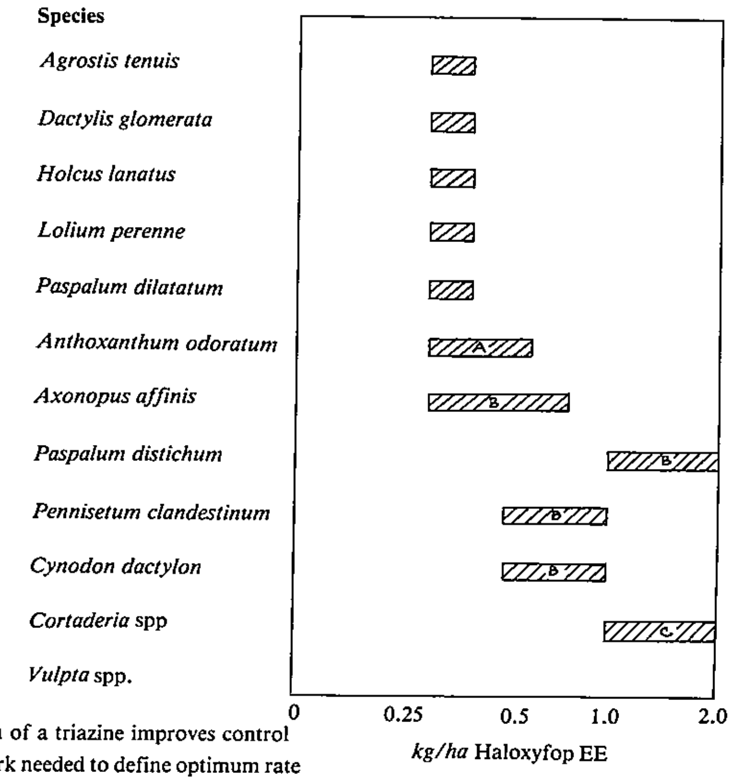
A common low growing rhizomatous grass which forms a dense mat to smother trees. Spring treatments (Sept) gave almost complete (95%) control using 0.25 *kg/ha* of haloxyfop EE. The triazines gave only marginal (60%) control. Mixtures of haloxyfop EE with the triazines did not change the level of grass control.

Table 1. Haloxyfop EE Tolerance of *P. radiata* and *E. regnans*

Treatment	Rate *kg/ha*	*P. radiata* Trial 1	*P. radiata* Trial 2	*E. regnans* Trial 3	*E. regnans* Trial 4
haloxyfop EE + atrazine/ simazine	0.5 + 2/2	94*	111	87	115
	1 + 2/2	101*	100	95	120
	2 + 2/2	102*	127	102	-
atrazine/simazine	2/2	100*	97	93	81
Untreated	-	100	100	100	100
Statistics		NS	NS	NS	NS
CV%		13.9	15.5	18	41

* atrazine/simazine used at 3/3 *kg/ha*
** non-ionic surfactant 0.25% *v/v* added to all haloxyfop EE treatments.
*** Index based on untreated = 100

Figure 1. Rates of haloxyfop EE needed for acceptable control of various grass species



A Addition of a triazine improves control
B more work needed to define optimum rate
C brown out only

Anthoxanthum odoratum

A common low growing, low fertility grass, which is not a major problem in forests. Spring treatments (Sept) gave variable (50 - 80%) control at 0.4 *kg/ha* of haloxyfop EE. In one trial a rate of 0.2 *kg/ha* was effective (95%). The triazines alone gave a high level (90%) of control.

Axonopus affinis

A low growing localized grass that is not generally very competitive with the trees. Variable results occurred in spring, 0.5 - 0.6 *kg/ha* + 5 *kg/ha* of atrazine gave best (50 - 75%) control. In autumn 0.25 *kg/ha* of haloxyfop EE was very good (90%).

Dactylis glomerata

A common pasture species which can grow 0.5 - 8 *m* high and be a vigorous competitor. Haloxyfop EE at 0.25 *kg/ha* in spring achieved excellent (95%) control. The triazines alone were weak (20%).

Holcus lanatus

A common low fertility species which can grow up to 1 *m* high and collapse onto the trees. Very good control (90%) was gained with 0.25 *kg/ha* of haloxyfop EE.

Lolium perenne

A common pasture species which can be very competitive. Spring treatment with haloxyfop EE at 0.2 - 0.25 *kg/ha* gave adequate (80%) control. The addition of the triazines did not change results.

Paspalum dilatatum

A common summer perennial, growing up to 1 *m* high, which dies down over winter. Generally difficult to control. Both spring and autumn treatments with haloxyfop EE at 0.25 *kg/ha* gave adequate (80%) control. The addition of a triazine did not change the level of control. The triazines alone were weak (20%) on paspalum. Increasing the haloxyfop rate up to 0.5 *kg/ha* gave no additional knockdown, even at 1 *kg/ha* complete control (98% + 2.4) was not always achieved.

Paspalum distichum

A localized problem grass in warmer districts and similar to *P. dilatatum*. This species appears to require higher rates of haloxyfop EE, 1 *kg/ha* gave marginal control (70%).

Vulpia spp

A common low fertility annual species occurring in forest sites, and generally not considered competitive to trees. No control was achieved with haloxyfop EE at rates up to 0.8 *kg/ha* either alone or with a triazine.

Cortaderia spp

The species *C. jubata* and *C. selloera* are now recognised as a potential major problem in existing and newly planted forests (Ecroyd et al 1984). A tall plant growing up to 6 *m* high, very dense competing strongly with new and established trees. The results obtained to date reflect brownout. Brownout has been very slow taking 4 - 6 months and only haloxyfop EE at 3 *kg/ha* has been complete. Rates of 0.5 - 2.4 *kg/ha* are giving 80 - 94% brownout. Using crop oil or increasing surfactant from 0.25% up to 1% or 2% increased the speed of brownout but little difference was apparent by 3 - 5 months after treatment. No data on regrowth suppression is available yet, as trials are incomplete.

Cynodon dactylon

A rhizomatous summer growing tropical/sub tropical perennial that dies off over winter. Can form a dense *0.5 m* high mat. Common in localized areas. A minimum of 0.5 *kg/ha* with crop oil was required to give acceptable control (80%) and even 1 *kg/ha* did not always give complete control. More work is needed to define the optimum rate between 0.5 - 1 *kg/ha*.

Pennisetum clandestinum

A rhizomatous tropical/sub tropical summer growing perennial forming a dense mat up to 0.5 *m* high. Common in localized mainly coastal areas. A difficult to control grass. Variable (60 - 80%) results occurred at rates between 0.5 - 0.8 *kg/ha*. The most reliable (85% + 1.5) control was gained at 1 *kg/ha*. Further work is required to define the optimum rate and compare spring with autumn treatments.

CONCLUSIONS

Haloxyfop EE up to 2 *kg/ha* was shown to be safe when applied to either dormant or actively growing *P.radiata* and *E.regnans* in combination with atrazine and/or simazine up to 6 *kg/ha*. Adequate (80% +) overall grass control was achieved in the forestry sites with haloxyfop EE at 0.25 *kg/ha* using a surfactant as the adjuvant. The forestry sites did not contain the more difficult to kill grasses such as *Cortaderia, Pennisetum* and *Cynodon*. These species require higher rates 0.5 - 1 *kg* for *Pennisetum* and *Cynodon* and probably 1 - 2 *kg* for *Cortaderia*.

Some species in the forestry sites will also need higher rates (0.5 *g/ha*) of haloxyfop EE such as *A.odoratum, A.affinis* unless a triazine is added.

The use of crop oil (1% v/v) as an adjuvant can speed up brown out of some species *(Cortaderia)* and was necessary to obtain control of some species *(Cynodon)*.

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HOW QUICKLY CAN INSECTS CONTROL SALVINIA IN THE TROPICS?

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ABSTRACT

Two insects, *Cyrtobagous salviniae* Calder and Sands (Coleoptera: Curculionidae) and *Samea multiplicalis* Guenee (Lepidoptera: Pyralidae) were released in tropical Australia during 1981 and 1982 for the biological control of the floating fern, *Salvinia molesta* Mitchell. At a coastal site, the weevil controlled the growth of the weed in as little as 12 months but took up to 4 years at cooler, elevated sites. By contrast, the moth did not control growth of the weed after 4 years in the field.

INTRODUCTION

Salvinia molesta Mitchell is a floating fern, native to southeastern Brazil (Forno and Harley 1979) where it occurs in the subtropical to temperate zone. The plant has been introduced to many tropical and sub-tropical regions of Africa, Asia and Australia, to Papua New Guinea and some Pacific Islands where it is an aggressive invader of fresh water. Thick mats of the weed impede boats and the operation of pumps, cause economic losses to agriculture and fishing industries and change the ecology of a water system.

Early attempts to biologically control *S. molesta* were made using the weevil, *Cyrtobagous singularis* Hustache and the grasshopper *Paulinia acuminata* De Geer *(Bennett 1975)* but were unsuccessful (Julien 1982). In 1978 CSIRO (Australia) carried out exploratory work in Brazil and introduced a weevil, *C. salviniae* Calder and Sands, recently described as a new species (Calder and Sands 1985), and a moth *Samea multiplicalis* Guenee. Adult *C. salviniae* feed preferentially on buds, and larvae tunnel in the rhizome ultimately causing the plant to disintegrate and sink (Forno et al. 1983). Larvae of the moth feed preferentially on leaves and only occasionally on buds, and cause severe damage to leaves (Sands and Kassulke 1984). This paper describes changes in infestations of *S. molesta* following attack by these insect species and discusses the ability of each to affect control of *S. molesta* in tropical areas.

MATERIALS AND METHODS

Colonies of the weevil and the moth were brought to Australia from Joinville, Santa Catarina State, Brazil where mean maximum temperatures in summer and mean minimum in winter are 30°*C* and 15°*C* respectively. Following host specificity studies in quarantine *C. salviniae* and *S. multiplicalis* were released at Lake Moondarra, Queensland and later, colonies of the weevil were taken from the lake to sites in northern Queensland and the Northern Territory. Numbers of adult weevils released varied from 400 to 1,500. A further release of 1,000 larvae of the moth was made at Ingham, north Queensland from an insectary culture in Brisbane (Room et al. 1984).

Coastal sites and other cooler, elevated sites were selected to study if, and how quickly, each of these two species could control the growth of *S. molesta* in the tropics. The weevil was released at three elevated sites and one coastal site and the moth at one coastal site. Subsequently, the moth spread naturally and studies at two other coastal sites were commenced. The sites were described in detail by Room *et al.* (1984) and were representative of man-made lakes and dams, a creek which was seasonally flushed and a land-locked lagoon (Table 1). The criteria by which control of *S. molesta* was assessed were a decline in weed biomass expressed as grams dry weight/m^2 and an increase in the area not covered by the weed as estimated from a series of photographs. Changes in the status of the weed were related to changes in insect population density, estimated by extracting insects using a Berlese funnel (Boland and Room 1983, Whiteman and Room 1985) and expressing density as number/m^2 of *S. molesta.*

Table 1. Characteristics of sites infested with *Salvinia molesta* in tropical Australia giving area covered by *S. molesta,* mean air temperatures and % dry weight of nitrogen (N), phosphorus (P) and potassiumsm (K) in plant tissue

Site	Area *(ha)*	Habitat	Lat. S	Altitude *(m)*	N	P	K	Mean Temperature °*C* Summer max.	Summer min.	Winter max.	Winter min.
Kaban	3	Dam	17.2	900	1.1	.19	2.8	28.4	17.8	21.3	9.7
Mt Garnet	3	Dam	17.2	610	1.4	.05	1.2	31.7	22.8	25.5	12.1
Mt Molloy	0.5	Lagoon	17.2	335	1.3	.06	2.1	31.2	21.0	25.3	11.9
Cairns	2	Lakes	16.5	3	1.5	.19	2.1	31.4	23.5	25.9	17.5
Ingham	> 10	Creek	18.4	14	1.4	.21	2.1	32.5	20.6	26.5	15.1
Townsville	> 10	Dam	19.1	3	1.3	.14	2.5	31.1	23.7	25.5	14.3

The chemical composition of plant tissue, particularly content of nitrogen, is important for development of larvae of *S. multiplicalis* (Taylor 1984) and *C. salviniae* (Sands et al. 1983) and in these studies plant samples were analysed for nitrogen, phosphorus and potassium content at irregular intervals. Temperature data were obtained from the nearest meteorological station except at Mt Garnet, where data were recorded at the site.

RESULTS

Tissue nitrogen, phosphorus and potassium concentrations were low at all sites, with nitrogen being equal to or less than 1.5%, the average value for field sites in Australia (Table 1; Room et al. 1984). At coastal sites, mean maximum temperatures in summer and mean minimum in winter varied from 32.5°*C* to 14.3°*C* and at the inland elevated sites from 31.7°*C* to 9.7°*C* (Table 1).

Control by *C. salviniae*

Tissue nitrogen concentration was low (mean 1.1% dry weight) at the elevated site, near Kaban, and mean minimum temperatures in summer and winter were frequently below 19°*C*, the temperature below which Forno et al. (1983) reported no breeding and little feeding by the weevil. The biomas of the thick mat of *S. molesta* averaged 325 *g* dry wt/m^2 and the sudd of *S. molesta,* grasses and *Polygonum* sp., 500 *g* dry wt salvinia/m^2 in May 1982 when 600 adult weevils were released (Table 2). Damage by the weevil increased slowly with 5 m^2 of weed affected after 9 months, 1 hectare after 2 years and the whole dam of 3 hectares damaged after 3 years. Although the plant density in the damaged area of the thick mat declined after 1 year to 173 *g* dry wt and the sudd after 2 years to 325 *g* dry wt salvinia/m^2 (Table 2), open water was not observed until the end of the third year. A little more than 3 years after weevils were released, the thick mat had been almost destroyed and sudd areas were 50% less dense. Weevil density averaged between 100 and 200 adults/m^2.

Table 2. Numbers of insects released, initial and current plant biomass and mean number of adult *C. salviniae* (a) and larvae of *S. multiplicalis* (1) at the six study locations

Site	Plant mat status	No. adults(a) /No. larvae(1) released	*S. molesta* biomass/m^2 Initial	June 1985	No. adults(a)/m^2 No. larvae(1)/m^2	Time to control
Kaban	thick	600 a	325	173	100-200 a	≈ 4 years
	sudd		500	325		
Mt Garnet	loose	1500 a	114	≈ 0	< 10 a	13 mths
Mt Molloy	thick	600 a	480	350	100 a	2 years
Cairns	thick	≈ 400 a unknown larvae (1)	680	100	< 100 a	12 mths
Ingham	thick	> 500 1	≈ 250	≈ 200	0-100 1	No control
Townsville	thick	unknown	≈ 450	≈ 400	0-100 1	No control

At the two other elevated sites, Mt Garnet and Mt Molloy, nitrogen levels in the plant and winter temperatures were higher than at Kaban and more favourable for breeding by *C. Salviniae* (Table 1). When the weevils were released, plant biomass was not very dense at Mt Garnet, but at Mt Molloy it was similar to Kaban, (Table 2). At Mt Garnet *C. salviniae,* destroyed 3 *ha* of *S. molesta* within 18 months and only a few plants remain at that site. These are often obscured by water lilies which have increased since the weed was destroyed. Currently, weevil density is estimated at 10 adults/m^2. At Mt Molloy, *C. salviniae* reduced the cover of weed from 0.5 *ha* to 10 m^2 in 2 years and there was little change in the following year. At this site, weevil density averages less than 100/m^2 and plant density 350 *g* dry wt/m^2 (Table 2).

The coastal site at Cairns was invaded by dispersing *S. multiplicalis* in October 1983 and *C. salviniae* was introduced in March 1984. Temperatures during the year were favourable for the weevil, and with average nitrogen concentration in the plant at

1.5%, the weevil bred rapidly. Twelve months after the weevil was released, there was 50% open water on the lake, weevil density was 475 adults/m^2 and the biomass of the remaining mat of weed was reduced by 45%. Three months later, in June 1985, weevil density had declined to 100 adults/m^2 and there was no *S. molesta* on 90% of the lake (Table 2).

Control by *Samea multiplicalis*

At the coastal sites of Cairns, Ingham and Townsville, mean temperatures are above 19°*C* for most of the year and above 30°*C* for 4 to 5 months of the year. At Ingham and Townsville nitrogen concentration in the plant was only slightly less than at Cairns (Table 1).

At Cairns the moth heavily damaged the weed soon after it was first observed in October 1983 but had little apparent effect on growth of *S. molesta* in the 6 months prior to the release of *C. salviniae*. At Ingham, in the 4 years following release of the moth in February 1981, larval populations and damage consistently increased during the cooler months from March to July sometimes reaching 100 larvae/m^2, and declined in summer to an almost undetectable level (Table 2). There was no overall decline in plant biomass or in the area covered by the weed. The pattern was similar at the Black Weir on the Ross River at Townsville which was invaded by dispersing populations of the moth from Ingham. Damage to the mat of *S. molesta* in Townsville was first observed in April 1982. At this site there has been no significant decline in plant biomass during the past three years (Table 2) and the number of other plant species growing on the mat has increased.

DISCUSSION

The first reported success of *C. salviniae* (then thought to be *C. singularis)* was at Lake Moondarra, Queensland where a population of the weevil destroyed - 8,000 *tonnes* fresh weight of *S. molesta* in 3 months (Room et al. 1981). Since then good control of the weed has been achieved in the Northern Territory near Darwin and Nhulunbuy and in Papua New Guinea (Thomas and Room, 1984) where winter mean minimum temperatures are above 19°*C* and higher than those sites reported in this paper. In the Sepik R. of PNG the infestation of *S. molesta* has gone from 200 km^2 to less than 5 km^2 in 3 years (Room pers. comm. 1985). The time taken by *C. salviniae* to affect control of *S. molesta* is probably influenced more by temperature and initial plant biomass/m^2 than the concentration of NPK in the plant.

The dam at Kaban was particularly interesting in that the low concentration of nitrogen in the plant and winter temperatures were unfavourable for colonization by *C. salviniae*. This site also contained sudd, a habitat not preferred by *C. salviniae* (Forno pers. obs in Australia 1984; Thomas and Room, 1984). Nevertheless, after 3 years, it was obvious that the weed would be controlled at that site, probably within another 12 months. By contrast, control was rapidly attained at Mt Garnet (13 months), Cairns (12 months) and less rapidly at Mt Molloy (2 years) even though nitrogen concentrations in the plant were similar. At these sites, temperature and initial plant biomass/m^2 differed and the time taken by *C. salviniae* to affect control of *S. molesta* was influenced probably more by these parameters than the concentration of NPK in the plant.

Control at the Cairns site is the first reported success by the weevil when introduced to a mat of *S. molesta* which had been heavily attacked, but not destroyed, by the moth *S. multiplicalis*. It is still no known why *S. multiplicalis* has not been an effective control agent in tropical Australia but the repetitive decline in the population each summer when maximum temperatures are above 30°*C* and when nitrogen concentrations have not declined, suggests that temperature is a major cause.

These studies and others cited in this paper are evidence that *C. salviniae* should be a successful control agent in tropical countries. We can be confident of predicting the success of *C. salviniae* in coastal tropical areas where mean minimum temperatures are generally above 19°*C* and in cooler elevated areas where mean minimum temperatures are below 19°*C* for several months. Control at the former could be achieved in 1 - 2 years and at the cooler sites in four or more years. These rapid rates for biological control of an aggressive waterweed are exceptional and highlight the success of *C. salviniae*.

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NEW POSSIBILITY IN WEED CONTROL IN THE NURSERY-BEDS

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ABSTRACT

Sofit is a new herbicide discovered and being sold now by CIBA-GEIGY Ltd. in several Asian countries for use in mud-sown rice. Sofit consists of a mixture of pretilachlor, 2-chloro-2,6-diethyl-N-(2-propoxyethyl)-acetanilide, a highly active early-season herbicide, for use in transplanted rice, and the safening agent CGA 123'407, 4,6 dichloro-2 phenyl-pyrimidine. This new safening agent, CGA 123'407 permits a safe pre-emergent use of the herbicide pretilachlor in direct seeded rice. Due to the exceptional tolerance of rice to Sofit, pre-emergence applications in nursery beds are also possible. With a broad spectrum of activity, Sofit effectively controls the most important weeds, for example *Echinochloa* spp., sedges and broadleaved weeds such as *Monochoria vaginalis.* Thus by using Sofit, the undesirable transplanting of *Echinochloa oryzicola* together with rice can be avoided.

INTRODUCTION

At every level of rice production, weed control plays an essential role in alleviating the detrimental effects of weeds which otherwise result in loss of rice yields (De Datta 1981).

High seedling quality at transplanting time is a prerequisite for high yields of transplanted rice. Young seedlings are very sensitive to weed competion and therefore weed control in rice nursery beds has always been and will continue to be an important operation if high seedling quality is to be achieved (Matsuo 1961).

Among the several weed species infesting nursery beds, *Echinochloa oryzicola* is becoming increasingly important. Probably this grassy weed has become so important because it mimics the rice plants; its morphology is almost identical to that of rice and it is very difficult to distinguish them in the early growth stages (Yabumo 1966).

For this reason control of barnyardgrass in nurseries is increasingly necessary, but increasingly difficult to achieve.

The problem is twofold; firstly the vigour of rice seedlings in the seedbed is reduced and secondly, because it is almost impossible to take them apart, seedlings of Echinochloa spp. are often transplanted into the paddy field together with rice plants.

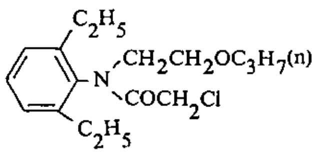
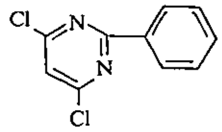
In addition, the transplanted barnyardgrass seedlings cannot be controlled with the available selective pre- or early-post-emergence herbicides, since they are in the same development stage as the rice plants.

Barnyardgrass competes with the rice plants for light and nutrients and causes severe damage to a crop into which the weed has been transplanted (Nagamatsu 1951).

Sofit is a new pre-emergence herbicide which was discovered and is being sold by CIBA-GEIGY Ltd. for use in mud-sown rice (Quadranti and Ebner 1983). Due to the exceptional tolerance of rice to Sofit, it can be used also as a pre-emergence herbicide in nursery beds.

This report describes the characteristics of this new herbicide and summarizes the results obtained in nursery beds in 1984. In Tab. 1 some physical and biological properties of Sofit are given.

Table 1. Some physical and biological properties of pretilachlor and CGA 123'407

	Pretilachlor	CGA 123'407
Trade names	Rifit®, Solnet®	——
Chemical name	2-chloro-2',6'-diethyl- -N-(2-propoxyethyl)- -acetanilide	4,6-dichloro-2-phenyl- pyrimidine
Structural formula		
Characteristics of *a.i.*		
Appearance	colourless liquid	colourless crystals
Boiling point	135° *C* at 0,001 *mm* Hg	
Melting point		96,9° *C*
Vapour pressure	1×10^{-6} *mm* Hg at 20° *C*	9×10^{-5} *mm* Hg at 20° *C*
Solubility	50 *mg/l* in water at 20° *C* soluble in most organic solvents	2,5 *mg/l* in water at 20° *C* slightly soluble in solvents
Acute toxicity of technical materials		
LD_{50} oral (rat)	6099 *mg/kg*	> 5000 *mg/kg*
LD_{50} dermal (rat)	> 3100 *mg/kg*	> 2000 *mg/kg*
LC_{50} inhalation (rat 4h)	> 2800 mg/m^3	2931 mg/m^3
Skin irritation (rabbit)	moderate	slight
Eye irritation (rabbit)	minimal	minimal
	Pretilachlor has a medium acute toxicity to fish	The compound has shown skin sensitizing potential in a guinea pig test

Additional toxicology studies concerning fish tox of EC of formulation are in progress

MATERIALS AND METHODS

Sofit®, a mixture of pretilachlor and CGA 123407, is available in the following formulations:

For nursery beds in tropical/subtropical climates:
EC 300 containing 300 *g/l* pretilachlor and 100 *g/l* CGA 123407

For nursery beds in temperate climates:
EC 240 containing 240 *g/l* pretilachlor and 120 *g/l* CGA 123407

Field trials: Field nursery trials have been conducted at the R&D field Station CIBA-GEIGY in Cikampek in West Java, Indonesia. Soil type was a clay with a pH of 4.7; CEC 14.1 *ml/100 gr;* total N 0.167% and organic carbon 1.63%. Weed species present were *Echinochloa* spp., *Monochoria vag., Fimbristylis mil., Cyperus iria* and *Scirpus juncoides.*

Soil preparation was done manually and puddled twice before levelling.

The plot design was always a randomized complete block with 10 m^2 plots and 3 - 4 replicates.

Two application methods have been tested:
a) Application with a knapsack-sprayer
b) Application with a watering-can

All crop phytotoxicity or weed control evaluations are based on a percentage scale. All herbicide rates are expressed in active ingredient *(a.i.)* per *ha.*

RESULTS

The results reported in Tables 2 - 4 clearly indicate that Sofit is very well tolerated in nursery beds. In the different trials there was some slight stunting (inhibition) just after application in the plots treated with Sofit, which very soon disappeared. At transplanting time, no differences between treated and untreated seedlings were observed with respect to development, stage and vigor.

As reported in Table 2, no reduction of seed germination or number of plants/m^2 has been observed in the plots treated with Sofit.

The control by Sofit of all important weeds, and especially the activity against *Echinochloa* spp., was excellent. The activity of Sofit was independent of the season.

Table 2. Preformance of Sofit (EC formulation) in nursery beds Indonesia 1984 *dry season*

Treatment (Rates in *g ai/ha*)	Application timing	%Seed germination	Phytotoxicity		% Weed control		
			Nr. of plants M^2	% stunt-ing	Monochoria vag.	Sedges	Echinochloa C.G.
Sofit 450*	4 DAS	96	171	10	99	99	95
Sofit 600*	4 DAS	96	183	10	98	98	95
Check	—	97	167	—	—	—	—

Table 3. Performance of Sofit (EC formulation) in nursery beds Indonesia 1984 *dry season* (comparison of application timings)

Treatment (Rates in g *AI/HA*)	Application timing	Phytotoxicity % Stunting	% Weed control Monochoria vag.	Sedges	Echinochloa C. galli
Sofit 400*	0 DAS	6	99	100	95
600*	↓	13	100	100	97
Sofit 400*	4 DAS	5	100	100	95
600*	↓	9	100	100	95
Check	—	—			

* = Rates related to pretilachlor content

Evaluation: Phytotoxicity 10 days after sowing
Weed control 20 days after sowing

Table 4. Performance of Sofit® (EC formulation) in nursery-beds Indonesia, 1984 *wet season* (comparison of application methods)

Treatment (Rates in In g *AI/HA*)	Application timing	Application method	% Phyto-toxicity	% Weed control Monochoria vag.	Sedges	Echinochloa C. galli
Sofit 600*	With spray boom	4 DAS	9	100	100	95
Sofit 600*	With watering can.		9	100	100	96

* = Rates related to pretilachlor content

Evaluation: Phytotoxicity 10 days after sowing
Weed Control 20 days after sowing

Sofit possesses an excellent flexibility concerning application method; as simple technology, a watering-can could be used to apply Sofit onto the nursery beds, with effects very similar to those obtained with a precision sprayer. The results reported in Table 4 clearly indicate that the crop tolerance and weed control of Sofit was independent to the application method.

Based on these results it can be concluded that rice shows an excellent tolerance to Sofit in nursery beds.

With the broad spectrum of Sofit (Table 5) the most important weeds, including *Echinochloa* spp., Sedges, etc. can be controlled.

Table 5. Weed control spectrum of Sofit®

Susceptible
Alisma canaliculatum
Ammania senegalensis
Cyperus difformis
Cyperus iria
Dinebra retroflexa
Dopatrium junceum
Echinochloa colonum
Echinochloa crus-galli
Echinochloa glabrescens
Echinochloa oryzicola
Eclipta alba
Elatine triandra
Eleocharis acicularis
Eleusine indica
Fimbristylis littoralis
Leptochloa chinensis
Lindernia pyxidaria
Ludwigia spp.
Monochoria vaginalis
Rotala indica
Scirpus juncoides

Moderately susceptible
Borreria ssp.
Callitriche verna
Scirpus hotarui

Moderately resistant
Cyperus serotinus
Scirpus maritimus (per.)

Totally resistant
Potamogeton distinctus
Sagittaria pygmaea

The use of Sofit is an important improvement in weed control techniques for nursery beds, which is one of the prerequisites to obtain a high seedling quality, and, due to the excellent weed control of Sofit, the undesirable transplanting of *Echinochloa oryzicola* together with rice can be avoided.

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RESPONSE OF TOMATO CULTIVARS TO BUTACHLOR

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ABSTRACT

The response of different tomato cultivars to butachlor under laboratory and greenhouse conditions was studied. Tolerance of tomato to butachlor varied with cultivar and stage of development. Butachlor did not affect germination of tomato. Root growth appeared more sensitive to butachlor than shoot growth. Under greenhouse conditions, tomato tolerated butachlor applied pre-emergence but was severely injured by post-emergence treatments. Shoot exposure caused greater inhibition than root exposure at the early developmental stages. In 42-day old seedlings, foliar application resulted in the same degree of phytotoxicity as soil or root application.

INTRODUCTION

Butachlor (N-butoxymethyl -2-chloro-2′, 6′-diethyl acetanilide) is a selective herbicide of the chloroacetamide group that controls germinating annual grasses, and certain broadleaf weeds and sedges.

Moosari (1974) reported differences in rice cultivar tolerance to butachlor at normal rates of application. Madrid (1980) showed that rice cultivars tolerant to butachlor have short mesocotyls and long coleoptiles but found it difficult to establish absolute values in order to determine tolerance or susceptibility due to wide variations in the length of these organs within cultivars. Mercado-Noriel (1980) also suggested that cultivar tolerance of rice to butachlor was influenced by stage of development, site of uptake, duration of exposure and soil moisture level. The present study dealt with the response of different cultivars of tomato to butachlor at different stages of development. It aimed to gain further insight into the absorption properties of butachlor.

MATERIALS AND METHODS

A. Laboratory study

Twenty seeds each of selected tomato cultivars were sown in petri dishes lined with filter paper moistened with a 10 *ml* of 0, 10^{-7}, 10^{-6}, 10^{-5} and 10^{-4} *M* of butachlor solution. Percent germination, shoot and root length and morphological characterization were taken after 7 days.

B. Greenhouse studies

Ten seeds each of 16 tomoto cultivars were planted 2 *cm* deep in clay pots with 15 *cm* diameter. Butachlor was applied at 1.5 *kg/ha* on direct-seeded and transplanted tomatoes as a surface blanket spray.

In the study on differential placement on direct seeded tomato, soil treated with butachlor at 1.50 *kg/ha* was placed above the seeds, below the seeds, or both above and below the seeds. A 0.5 *cm* layer of a mixture (1:1,*v/v*) of activated carbon and soil was added as a barrier of herbicide treated zone.

For transplanted tomato butachlor was applied to the shoot, the root, or all parts of the 42-day old plant 4 days after transplanting.

RESULTS AND DISCUSSION

A. Laboratory study

Butachlor did not affect the germination of tomato regardless of cultivar (Fig. 1) as was reported in rice (Mercado et al., 1975) and in Echinochloa, (Chen et al., 1981). Subsequent growth of the root and shoot varied, however, in the different cultivars. Cultivars Cal-J, TNBR and R3030 appeared tolerant whereas Seeda was susceptible. Concentrations up to 10^{-4} *M* did not significantly reduce shoot elongation. Root growth was more sensitive, inhibition being apparent at $10^{-6}M$ in very susceptible cultivars. Quite interesting is the stimulation of root growth at 10^{-7} *M* cultivars TNBR and R3030. Mercado-Noriel (1980) likewise reported stimulation of root growth of rice cv C-168 when butachlor was applied at the second leaf stage.

The general effect of amides is inhibition of protein synthesis and/or nucleic acid synthesis. Noriel (1980) observed reduction in protein content of tolerant and susceptible rice cultivars during the early developmental stages (before emergence up to 1 leaf stage). At the stage that the plant is developing tolerance, butachlor may behave as growth stimulant. In tomato, butachlor appears stimulatory to root growth at very low concentrations in particular cultivars.

B. Greenhouse studies

Among the 16 direct-seeded tomato cultivars, TNBR and VF 145 B 7879 were the most susceptible (Table 1). Most of the cultivars tolerated butachlor better when applied at presowing and at early emergence stages. At 17 and 32 DAS butachlor application caused considerable reductions in shoot dry weight in all cultivars. Foliar absorption of butachlor could be rapid to account for the increased susceptibility or loss of tolerance. Since there were more leaves at 32 days than at 17, plants at 32 days were more susceptible. This possibility is strengthened by the observation that application at 3 days after transplanting is more phytotoxic than that at 2 days before transplanting (Table 2).

At 42 days after transplanting the selected cultivars tolerated butachlor applied to the soil and to the foliage (Table 3). Since the solubility of butachlor in water is only 23 ppm (WSSA, 1979) the herbicide applied to the soil may not have reached the absorbing zones of the root in herbicidal concentration. The same dilution effect might have operated in the foliar application.

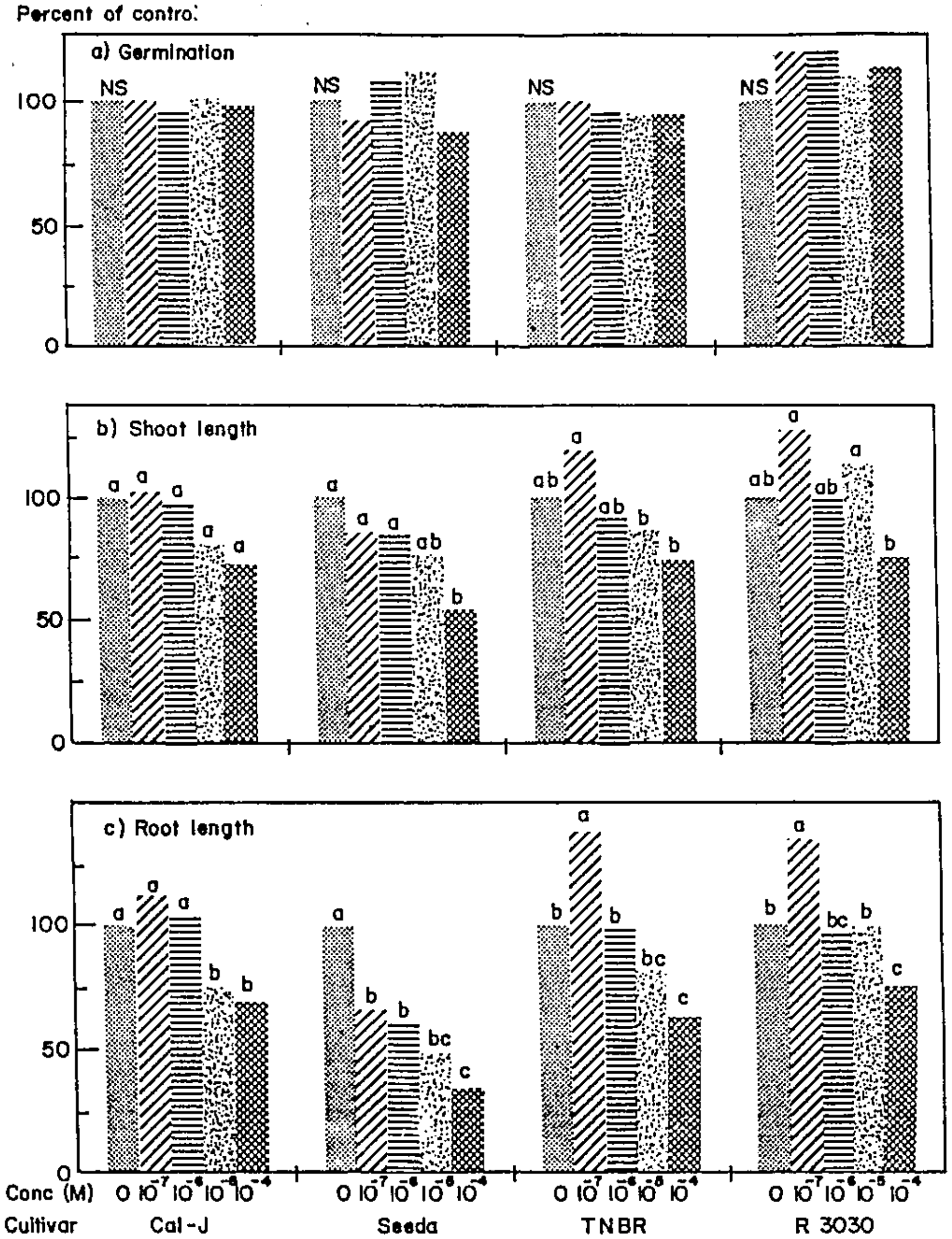

Figure 1. Influence of butachlor on (a) germination, (b) shoot and (c) root length of tomatoes at 7 days after treatment. Mean separation in each cultivar by DMRT at 5%level.

Table 1. Effect of butachlor on shoot dry weight of direct-seeded tomatoes treated at different growth stages.

CULTIVAR	SHOOT DRY WEIGHT (% OF CONTROL)[a]					MEAN
	2 DBS	3 DAS	6 DAS	17 DAS	32 DAS	
1. Cal-J	120.1a	101.2a	102.5a	62.3abc	18.8abc	81.0
2. Calypso	82.8abc	60.9ab	49.0b	61.8abc	11.7abc	53.3
3. Chigo III	75.3abc	58.5ab	52.2b	22.1def	3.2c	42.2
4. Floradel	110.5a	81.2ab	90.3ab	74.4a	15.4abc	74.4
5. Manapal	96.7ab	82.9ab	103.7a	60.1abc	23.7ab	73.4
6. Marglobe	104.3ab	62.3ab	75.5ab	51.5a-d	23.5ab	63.4
7. Modindaeng	77.0abc	88.8ab	103.5a	56.1a-d	18.0abc	68.7
8. Roma VF	108.7a	76.9ab	78.4ab	52.2a-e	8.7abc	65.0
9. Seeda	54.7bc	90.5ab	45.7b	27.8b-f	7.1abc	45.1
10. TNBR	46.5c	47.3b	46.1b	40.1a-e	11.9abc	38.4
11. Ventura	73.3abc	82.3ab	76.6ab	30.2c-f	5.3abc	53.6
12. VF 134	80.3abc	59.4ab	70.4ab	15.7f	18.5abc	48.9
13. VF 145B7879	48.1c	66.9ab	81.3ab	20.3ef	5.4abc	44.4
14. Marikit	96.8ab	88.8ab	69.1ab	31.6b-f	4.0bc	58.1
15. R 3030	113.0a	87.4ab	68.9ab	62.5abc	26.2a	71.6
16. R 3034	130.8a	105.0a	84.0ab	67.4ab	18.7abc	81.2
MEAN	88.7	77.5	74.8	46.0	13.8	

[a]Means followed by a common letter in a column are not significantly different by DMRT at 5% level.

Table 2. Effect of butachlor on shoot and root dry weight (% of control)[a] of transplanted tomatoes.

CULTIVAR	SHOOT		ROOT	
	2 DBT	3 DAT	2 DBT	3 DAT
Cal-J	75.6	84.5	82.1	49.0
Seeda	82.3	61.0	86.2	38.3
TNBR	91.4	74.6	94.1	44.2
R 3030	92.7	75.4	85.0	89.1
MEAN	85.5[ns]	73.9	86.9[ns]	55.2

[a]Average of three replications

[ns]Not significant

Table 3. Influence of site of butachlor application on shoot and root dry weights (% of control)[a] of transplanted tomatoes.

CULTIVAR	SHOOT		ROOT	
	FOLIAGE	SOIL	FOLIAGE	SOIL
Cal-J	70.7	83.9	73.4	87.0
Seeda	109.1	108.1	114.3	146.8
TNBR	102.1	97.1	80.1	105.2
R 3030	89.3	93.8	102.8	121.0
MEAN	92.8[ns]	95.7	92.6[ns]	115.0

[a]Average of three replications

[ns]Not significant

From both laboratory and greenhouse studies, the results indicate that butachlor does not inhibit germination but affects shoot and root elongation at the early developmental stages. At such stages the different cultivars responded differently to butachlor. Hence for direct-seeded tomatoes, selection of the tolerant cultivar is necessary. For the transplanted tomato, however, butachlor application at 2 days before transplanting can be made without differentiating the tolerant from the susceptible cultivars. Application after transplanting is not recommended. No morphological difference could account for differences in cultivar tolerance.

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STUDIES ON SPRINKLER BOTTLE METHOD OF APPLICATION FOR MACHETE® AND ROGUE® HERBICIDES IN TRANSPLANTED AND PUDDLED SOWN RICE IN SOUTHEAST ASIA

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ABSTRACT

An extensive number of trials were conducted in India, Philippines and Thailand to evaluate the performance of Butachlor (Machete®) and Butachlor + 2, 4-D IBE (Rogue®) herbicides when applications were made with the Sprinkler Bottle. The trials were conducted in both transplanted and puddled sown rice from 1980 to 1984.

In the experiments, application of the chemicals were evaluated in different concentrations for direct undiluted application and in different volumes for diluted application through the sprinkler bottle. Moreover, different Machete formulations were also compared with this method.

Both Machete EC and Emulsion formulations applied through the sprinkler bottle showed similar weed control performance when compared to the conventional methods of herbicide application. Machete and Rogue herbicides applied through the sprinkler bottle provided good weed control comparable with that of sprayed or granular applications.

For diluted applications 6 to 12 *litres* of the chemical solution with water *per hectare* was observed to be sufficient for effective weed control. Application in calm weather and uniform distribution with a thin film of standing water in the field were observed to be necessary to obtain best results.

The sprinkler bottle method was found to be an effective, simple, safe and time saving method for applying rice herbicides, specifically Machete and Rogue, in both transplanted and puddled sown rice.

INTRODUCTION

With increased herbicide usage among rice farmers, improved application methods become imperative for better applicator safety and convenience. Several methods of herbicide application are practiced in different countries of Southeast Asia viz., knapsack spraying, granular broadcasting, sandmix and sprinkler bottle application.

The Sprinkler bottle method of application provides an effective, easy and economic alternative to other methods of herbicide application in rice. However, few research publications are available on this method. Gosney (1980) and Lepetit (1983), reported the used of a shaker bottle (synonymous with sprinkler bottle) method for direct undiluted application of oxadiazon formulation in rice. The research conducted at IRRI during 1981 and 1982 revealed that direct application of herbicides without diluting in water would give similar weed control and grain yields to that

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of diluted application. (IRRI, 1982 and IRRI, 1983). Later Migo and De Datta (1983) reported that pre-emergence herbicides viz., butachlor, oxadiazon, thiobencarb and pendimethalin applied directly with sprinkler bottle, controlled weeds as effectively as when applied with knapsack sprayer, in both transplanted and broadcast seeded flooded rice.

Considering the need, effectiveness and advantages of sprinkler bottle for the application of Machete (butachlor) and Rogue (butachlor + 2, 4-D IBE) herbicides in rice, Monsanto conducted a series of experiments from 1980 to 1984 on the sprinkler bottle method of application, with the following objectives:

1. Evaluate the effectiveness of the sprinkler bottle compared to the conventional methods of herbicide application in both transplanted and puddled sown rice.
2. Study the performance of diluted application and assess the optimum carrier volume for effective weed control.

In addition to the above main objectives, the performance of two Machete formulations viz., Emulsifiable Concentrate and Emulsion when applied with the sprinkler bottle or conventional method was also studied.

MATERIALS AND METHODS

The sprinkler bottle trials were conducted in transplanted rice in India, Philippines and Thailand, and in puddled sown rice in Philippines and Thailand. A total number of 50 trials were conducted in either farmer's fields or in co-operation with research institutes from 1980 to 1984. The soil types in these trials ranged from sandy loam soils in India to volcanic clay soils in Philippines, with a pH variation from acidic soils in Central Thailand to saline soils in Northern India. In Philippines and Thailand, Machete EC and EN (EN is referred to as EW in India) were tested at 1.00 *kg* a.i./*ha* and Rogue EC at 0.75 + 0.5 *kg* a.i./*ha* In India, Machete EC and EN were applied at 1.25 *kg* a.i./*ha*. The herbicides were applied 4 days after planting in transplanted rice and 4 days before or 12 days after sowing in puddled sown rice. The carrier columes tested ranged from 4 to 18 *litres/ha*. The plot size in the preliminary trials were about 18 m^2, and in later trials ranged from 200 m^2 to 500 m^2. In all the trials, visual observations were made on weed control by species expressed in percentages compared with an untreated plot 10, 20 and 40 days after transplanting or sowing. Grain yield was determined from a sample area of 10-20 m^2 in small plot trials and three 10 m^2 areas in large plot trials and expressed as *kg/ha*.

RESULTS

The major weed species observed in the trial plots were *Echincholoa colona, E. crusgalli, Cyperus iria, C. difformis, Fimbristylis miliacea, Sphenochlea zeylanica* and *Eclipta alba*. The results obtained are presented below.

Weed control performance by Machete 300 EC was slightly better than that of Machete 50 EC when applied undiluted with the sprinkler bottle in the 1980 trials, but the difference was marginal and in the 1981 trials, both the high and the low concentration formulations performed similarly (Table 1). No significant difference was noticed in the yield. In the 1981 trials, both EC and EN formulations of Machete performed alike when applied directly with sprinkler bottle. The weed control using the sprinkler bottle was as good as with the knapsack sprayer. In general, weed control increased when application volumes increased from 6 to 18 *litres/ha* for the EC formulation, but not with the EW formulation (Table 2). The weed control by Machete EW was reduced at 4 *litres/ha* application volume. The weed control in the sprinkler bottle treatments was comparable to that of the conventional method, i.e., sandmix. The weed control performance of both Machete EC and EN applied with the sprinkler bottle was similar to that of granular application (Table 3). The yields obtained in the treated plots were higher than unweeded and comparable to handweeded plot yields in both transplanted and puddled sown rice. Regarding the application volume, 6 and 8 *litres/ha* provided similar and effective weed control. The performance of Rogue EC applied with the sprinkler bottle was similar to the granular application in transplanted rice, but showed slightly less grass control and similar sedge and broadleaf control in puddled sown rice (Table 4). The grain yields obtained in the treated plots were significantly superior to that of unweeded plot yield, but comparable to handweeded treatment.

Table 1. Effect of different concentrations of Machete Emulsifiable Concentrate (EC) and Emulsion (EN) for undiluted application with sprinkler bottle on weed control in transplanted rice - India and Philippines.

No.	Treatments[1] Chemical & Formulation	Method of Application	Weed control (%) 40 days after planting: Grasses	Sedges	Broadleaves	Grain Yield (*kg/ha*)
	India, 1980 Kharif season (Average of 5 trials)					
1	Machete 50 EC	Sprinkler Bottle	89	83	83	3167
2	Machete 30 EC	Sprinkler Bottle	90	87	87	3000
3	Machete 50 EC	Knapsack	84	82	83	2933
4	Machete 30 EC	Knapsack	86	86	88	2933
5	Unweeded					2800
	India, 1981 Kharif season (Average of 6 trials)					
1	Machete 50 EC	Sprinkler Bottle	88	86	79	-
2	Machete 25 EC	Sprinkler Bottle	86	87	80	-
3	Machete 50 EN	Sprinkler Bottle	87	87	79	-
4	Machete 25 EN	Sprinkler Bottle	87	89	82	-
5	Machete 50 EC	Sandmix	90	88	82	-

[1] The chemicals were applied @ 1.25 *kg* a.i. in all treatments.

Table 2. Comparison of different volumes for diluted application of Machete Emulsifiable Concentrate (EC) and Emulsion (EN) with sprinkler bottle in transplanted rice – India Kharif season.

No.	Treatments[1] Chemical	Method of Application	Total Volume *(Lit/ha)*	Weed control (%) 40 days after planting EC	CD	EA	Average
	1983 Kharif season (Average of 3 trials)						
1	Machete EC	Sprinkler Bottle	6	70	75	64	70
2	Machete EC	Sprinkler Bottle	12	77	85	68	77
3	Machete EC	Sprinkler Bottle	18	83	88	73	81
4	Machete EC	Sandmix		83	65	67	72
	1983 (Average of 5 trials)						
1	Machete EN	Sprinkler Bottle	6	77	88	80	82
2	Machete EN	Sprinkler Bottle	12	81	84	80	82
3	Machete EN	Sprinkler Bottle	18	81	84	80	82
4	Machete EN	Sandmix		79	84	80	81
	1984 (Average of 5 trials)						
1	Machete EN	Sprinkler Bottle	4	85	78	73	79
2	Machete EN	Sprinkler Bottle	6	91	82	78	84
3	Machete EN	Sprinkler Bottle	8	88	83	76	82
4	Machete EN	Sandmix		91	79	81	83

EC = *Echinochloa colona* EA = *Eclipta alba*
CD = *Cyperus difformis*
[1] *The chemicals were applied* @ 1.25 *kg* a.i./*ha* in all treatments

Table 3. Comparison of different volumes for diluted application of Machete Emulsifiable Concentrate (EC) and Emulsion (EN) with sprinkler bottle in transplanted rice (Average of 6 trials), and puddled sown rice (Average of 2 trials). Philippines, 1984 dry season.

No.	Treatments[4] *Chemical & Formulation*	*Method of Applcn*	*Total vol (lit/ha)*	Transplanted Rice: Weed control (%) 40 DAP *G1*	*S2*	*BL3*	*Grain Yield (kg/ha)*	Puddled Sown Rice: Weed control *(%)* 40 DAS *G*	*S*	*BL*	*Grain Yield (kg/ha)*
1	Machete EC	S. B.[5]	6	91	89	86	3369	90	90	90	7700
2	Machete EC	S. B.	8	93	93	87	3497	90	90	90	7600
3	Machete G	Broadcast		91	91	87	3324	90	90	90	6700
4	Unweeded						1808				4000
5	Handweeded						3667				7400
1	Machete EN	S. B.	6	90	90	90	5762	95	93	93	4062
2	Machete EN	S. B.	8	94	91	89	5963	95	91	93	4526
3	Machete G	Broadcast		89	86	91	5860	95	90	93	4232
4	Unweeded						3574				2358
5	Handweeded						5753				4610

[1] Grasses = *Echinochloa* spp
[2] Sedges = *Cyperus* spp, *Scirpus* spp (Annuals)
[3] Broadleaves = *Monochoria vaginalis, Sphenochlea zeylanica*
[4] The chemicals were applied @ 1.00 *kg* a.i./*ha* in all treatments
[5] Sprinkler Bottle

Table 4. Evaluation of different volumes for diluted application of Rogue EC in transplanted rice (One trial), and puddled sown rice (Average of 2 trials) – Thailand, 1984 dry season.

No.	Treatments Chemical & Formulation	Method of Application	Total Volume *(lit/ha)*	Weed control (%) 40 days after planting EC	CD	FM	SZ	Average	Grain Yield *(kg/ha)*
	Transplanted rice								
1	Rogue EC	S. B.[1]	6		100	91	100	97	3896
2	Rogue EC	S. B.	8		99	90	96	95	3794
3	Rogue 6G	Broadcast			100	96	96	97	4089
4	Unweeded								3221
	Puddled sown rice								
1	Rogue EC	S. B.	6	75	98	100	99	93	3683
2	Rogue EC	S. B.	8	77	96	100	100	93	3689
3	Rogue 6G	Broadcast		82	96	95	98	93	3515
4	Unweeded								2082

EC = *Echinochloa colona* FM = *Fimbristylis miliacea*
SZ = *Sphenochlea zeylanica* CD = *Cyperus difformis*
[1] Sprinkler Bottle

DISCUSSION

Direct application of undiluted Machete EC and EN formulations with the sprinkler bottle could be as effective as the conventional method. The slightly increased weed control performance with low concentration Machete (Table 1), may be attributed to the higher solvent and greater volume of application resulting in better herbicide distribution. Similar reasoning has been utilized for direct application of low concentration oxadiazon specially meant for the sprinkler bottle application (Lepetit, 1983). However, when the distribution of the Machete 50 EC formulation was uniform, the performance was observed to be similar to that of low concentration formulation. These finding corroborate the report of Migo and De Datta (1983), that direct application of undiluted butachlor formulation was as effective as knapsack spraying. Hence, by uniform distribution on standing water, one can avoid using low concentration formulations. But the application volume may not be sufficient to cover large areas uniformly, and it will be expensive to use low concentration formulations for this purpose. To make the method easy, effective and economic, diluted applications of standard formulations with the sprinkler bottle were evaluated. It was found that diluted application of Machete EC and EW formulations performed similar to sandmix formulation (Table 2). Nevertheless, the results from EC trials indicated that the higher the application volume, the better the weed control. This might be due to inadequate distribution at lower volumes. However, the EN trial results from a large number of locations indicated that 2 – 12 *litres/ha* volume was sufficient for good weed control, comparable to sandmix application. A practical view of this dilution would be to suggest an optimum range to the farmer and let him choose a convenient volume to cover the fields uniformly with the sprinkler bottle. Machete EC and EN could be applied with the sprinkler bottle even at a lower volume of 6 – 8 *litres/ha,* to provide as effective weed control as granular application (Table 3). Rogue EC also performed similar to granular application, applied in 6 and 8 *litres* application volume/*ha* and applied with the sprinkler bottle (Table 4). The grain yields from the herbicide treated plots were significantly higher than that of unweeded plot due to high weed infestation, and the plots applied with diluted formulations using sprinkler bottle provided comparable yields to that of granular application because of similar weed control performance.

From these studies, it was concluded, that diluted application of Machete EC, EN and Rogue EC with the sprinkler bottle was safer than sandmix application, easier than spraying and less expensive than granules and above all, it was as effective as any conventional method of herbicide application, in both transplanted and puddled sown rice.

ACKNOWLEDGEMENT

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STUDIES ON WEED MANAGEMENT OF DRILLED SOWN RICE WITH BUTACHLOR IN WEST BENGAL INDIA

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ABSTRACT

The suitability of Butachlor (Machete®) as a rice herbicide for drilled sown rice in alluvial lowland soils of the Indo Gangetic Plains of West Bengal India was tested in 1983 and 1984. Trial results in 1983 and 1984. Trial results in 1983 revealed that rates upto 1.00 *kg* ai/*ha* applied after sowing were safer to rice seedlings than applications made before sowing. However, these rates did not provide the necessary grass, sedge and broadleaf weed control.

Results of ten replicated trials in 1984 testing pre-emergence applications of Butachlor at 1.25 and 1.75 *kg* ai/*ha* applied 0, 2, 4 and 6 days after sowing revealed that 1.75 *kg* ai/*ha* gave acceptable grass and sedge control 20 days after sowing and was satisfactory at 1.75 *kg* ai/*ha* 40 days after sowing. Applications made 0, 2, 4 and 6 days after sowing showed marked variation in crop safety and weed control. Treatments made 0 – 2 DAS were found to be safer and provided better weed control than 4 – 6 DAS applications.

INTRODUCTION

Drilled sown rice under upland conditions is being practised on more than a million hectares in West Bengal, India. Ungerminated seeds are directly sown in dry and pulverised soil either by drilling in lines or dibbling behind the country plow. Because of sowing under dry conditions and lack of continuous flooding, unlike transplanted rice, weed infestation is high and is a major factor reducing yields. Kolhe and Mitra (1981) found the first 30 days after sowing were the most critical period for weed competition. Yield losses due to weed infestation ranged from 50 percent to complete crop failure (Negi, 1976). Handweeding is the most common practice of controlling the weeds followed by mechanical weed control. However, manual and mechanical control methods are laborious, expensive and inadequate under such dry direct seeded conditions. Hence, chemical weed control methods must be evaluated for effective weed management. De Datta and Ross (1975), Upadyay and Choudhary (1979), Ahmed and Azizul Islam (1983), have reported butachlor as an effective pre-emergent herbicide in direct seeded upland rice. This paper evaluates the performance of butachlor applied at different rates and times in drilled sown rice in West Bengal.

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MATERIALS AND METHODS

Experiments were conducted in Nadia district of West Bengal during the May to August season in 1983 and 1984. The soil types in the experimental sites varies from sandy loam to heavy clay under the major group of riverine alluvium. The crop was rainfed, irrigated or partly rainfed, but sufficient water was available throughout the crop season in all experiments, resulting in uniform crop stand and normal yield. Three varieties viz., China, IR50 and Moonchi were grown in different experiments.

A replicated trial was conducted in 1983 using butachlor (Machete EC) applied at 0.75 and 1.00 *kg* a.i./*ha* 4 and 2 days before sowing and 0 and 6 days after sowing. In 1984, 8 replicated trials were conducted using Machete EC at 1.25 and 1.75 *kg* a.i./*ha* 0, 2, 4 and 6 days after sowing. Machete EC was sprayed using a knapsack sprayer delivering 250 *litres* of water/*ha*. The treatment size was 15 m^2 and each treatment was replicated three times.

Visual observations were made on crop injury in terms of percent stand reduction and percent growth reduction. Weed control evaluations were made 10, 20 and 40 days after sowing. Grain yield was recorded from a 10 m^2 plot and expressed as *kg/ha*.

RESULTS

The weeds observed in the experimental plots were *Echinochloa colona, E. crusgalli, Cyperus iria, Fimbristylis miliacea, Eclipta alba, Amaranthus* spp and an unidentified broadleaf. Sedges pre-dominated the weed spectrum followed by broadleaves and grasses.

The results of the single replicated trial of 1983 are presented in Table 1. The crop injury observed 10 days after sowing (DAS) was slightly higher when treatments were applied before sowing rather than after sowing.

The grass and sedge control was maximum at 1.00 *kg* a.i./*ha* applied 4 days before sowing followed by 0.75 *kg* a.i./*ha* applied immediately after sowing. The broadleaf control was generally fair to poor. A similar performance trend was observed 40 DAS.

Table 1. Preliminary evaluation of rate and time of Machete application in drilled sown rice in West Bengal, 1981 May season. (Data from a replicated trial).

No.	Treatments			Crop Injury (%)				Weed Control (%)							
	Chemical	Rate (*kg* a.i./*ha*)	Time	10 DAS		20 DAS		20 DAS				40 DAS			
				SR[3]	GR[4]	SR	GR	G[5]	S[6]	BL[7]	O[8]	G	S	BL	O
1	Machete EC	0.75	4 DBS[1]	5	2	2	3	73	79	63	72	73	73	58	68
2	Machete EC	1.00	4 DBS	5	5	3	3	87	86	65	79	87	83	72	81
3	Machete EC	0.75	2 DBS	7	2	5	5	77	84	68	76	80	78	65	74
4	Machete EC	0.75	0 DAS[2]	0	2	0	2	83	86	67	79	80	84	68	77
5	Machete EC	0.75	6 DAS	0	0	0	0	73	76	60	70	73	77	63	71
6	Machete EC	1.00	6 DAS	0	3	2	2	73	78	70	74	77	77	62	72
7	Weeds/*Sqm* in control plot							10	50	22		12	77	48	

[1] Days Before Sowing   [2] Days After Sowing   [3] Stand Reduction
[4] Growth Reduction
[5] Grasses : *Echinochloa colona*
[6] *Sedges* : *Cyperus iria, C. difformis* and *Fimbristylis miliacea*
[7] Broadleaves : *Eclipta alba* and an unidentified broadleaf weed
[8] Overall weed control

Table 2. Varietal response in terms of stand and growth reduction to different rates and times of Machete application in drilled sown rice. West Bengal, 1984 May season.

No.	Treatments			Var 1 China[1]				Var 2 IR–50[2]				Var 3 Moonchi[3]			
	Chemical	Rate	Time	Crop Injury				Crop Injury				Crop Injury			
				10 DAS		20 DAS		10 DAS		20 DAS		10 DAS		20 DAS	
		(*kg* a.i./*ha*)		SR[5]	GR[6]	SR	GR	SR	GR	SR	GR	SR	GR	SR	GR
1	Machete EC	1.25	0 DAS[4]	0	59	0	0	0	60	0	0	0	0	0	0
2	Machete EC	1.25	2 DAS	0	59	0	0	0	60	0	0	0	0	0	0
3	Machete EC	1.25	4 DAS	0	58	0	0	0	60	0	0	0	0	0	0
4	Machete EC	1.25	6 DAS	0	58	0	0	0	60	0	0	0	0	0	0
5	Machete EC	1.75	0 DAS	0	59	0	0	0	55	0	0	0	0	0	0
6	Machete EC	1.75	2 DAS	0	59	0	0	0	60	0	0	0	0	0	0
7	Machete EC	1.75	4 DAS	0	58	0	0	0	55	0	0	0	0	0	0
8	Machete EC	1.75	6 DAS	0	59	0	0	0	60	0	0	0	0	0	0
9	Unweeded			0	59	0	0	0	60	0	0	0	0	0	0
10	Handweeded			0	59	0	0	0	60	0	0	0	0	0	0

[1] Local Variety
[2] High Yielding Variety
[3] Local Variety
[4] Days After Sowing
[5] Stand Reduction
[6] Growth Reduction

Table 3. Performance of Machete EC at different rates and time of application in drilled sown rice in West Bengal, 1984 May season. (Average of 8 replica replicate trials).

No.	Treatments			Weed Control (%)								Grain[6] Yield
	Chemical	Rate	Time	20 DAS				40 DAS				
		(*kg* a.i./*ha*)		G[1]	S[2]	BL[3]	O[4]	G	S	BL	O	(*kg/ha*)
1	Machete EC	1.25	0 DAS[5]	76	83	55	71	72	83	47	77	3244
2	Machete EC	1.25	2 DAS	74	80	52	68	72	79	48	75	3257
3	Machete EC	1.25	4 DAS	67	76	44	62	67	76	44	64	3259
4	Machete EC	1.25	6 DAS	63	67	40	49	62	69	42	66	3217
5	Machete EC	1.75	0 DAS	85	88	61	77	80	85	53	82	3258
6	Machete EC	1.75	2 DAS	78	87	56	73	76	84	50	79	3268
7	Machete EC	1.75	4 DAS	72	81	49	67	70	79	48	74	3279
8	Machete EC	1.75	6 DAS	65	73	38	58	69	74	41	68	3231
9	Unweeded											2205
10	Handweeded											3398
11	Weeds/*Sqm* in control plot			16	36	13		17	34	23		

[1] Grasses : *Echinochloa colona* and *E. crusgalli*
[2] Sedges : *Cyperus iria* and *Fimbristylis miliacea*
[3] Broadleaves : *Eclipta alba, Amaranthus* spp and an unidentified broadleaf weed
[4] Overall control
[5] Days After Sowing
[6] Yield was recorded from only 4 locations

Crop injury observations from the 1984 experiments are presented in Table 2. Severe growth reduction was observed in 10 DAS in all the treatments of the experiments sown with varieties China and IR–50. But it was not a function of butachlor, since handweeded and unweeded treatments were equally affected. However, at 20 DAS, no injury was noticed in any of these treatments in all the experiments. With respect to weed control (Table 3), as the time of application was delayed, the weed control decreased at both 1.25 and 1.75 *kg* a.i./*ha*. Among the rates, 1.75 *kg* a.i./*ha* produced significantly better weed control than 1.25 *kg* a.i./*ha* at all times of observation except 6 DAS. Broadleaf control was poor in all the treatments. Maximum grass and sedge control was obtained with 1.75 *kg* a.i./*ha* applied 0 DAS, followed by the same rate 2 DAS. Grain yields of all the treated areas were higher than the unweeded, but were comparable among them.

DISCUSSION

Though the weed spectrum was dominated by sedges followed by broadleaves and grasses, the effect of the weed population on crop yield was mainly from grasses and sedges and the least from broadleaves due to their growth characteristics, feeding habits and time of germination.

It was observed that applying Machete after sowing the ungerminated seeds could be safer than before sowing. This may be due to the distribution of chemical in the seed germination zone, at the time of sowing. When the chemical was applied on soil surface after sowing, the sowing depth (2 – 5 *cm*) served as physical protection from the chemical. The differences were not marked due to low rates of application, i.e., 0.75 and 1.00 *kg* a.i./*ha*. It was quite obvious that higher rates were required for better weed control due to the high weed intensity.

The growth reduction observed 10 DAS in 1984 in all the treatment plots was due to heavy rain and flooding of the field during the initial period after sowing and was not related to Machete applications. Later the crop recovered and no stand or growth reduction was noticed 20 DAS. This clearly indicated that Machete EC was safe to China, IR-50 and Moonchi varieties, at rates as high as 1.75 *kg* a.i./*ha* applied various days after sowing. The safety of the chemical was also due to sowing of ungerminated dry seeds, at a depth of 2 – 5 *cm*. The delay in the application time of Machete resulted in proportional reduction in weed control because the interval between last tillage and herbicide application prolonged, and weed germination was also increased. Application 6 DAS provided the least weed control due to early germination of weeds. Hence, it is preferable to apply the Machete EC 0 – 2 days after sowing. For effective control of grasses and sedges upto 40 days, 1.75 *kg* a.i./*ha* may be necessary. The broadleaf weed control was poor due to the fact that butachlor was weak on the broadleaves present and the germination of broadleaves was later than grasses and sedges. The higher yield in the treated areas was due to the high level of weed infestation and control. However, the lack of differences among the treatments could not be attributed to any specific reason except that the differences in weed control at early stages might not have had an impact on yield.

CONCLUSIONS

After sowing application was slightly safer to drilled sown rice than before sowing application.

1.75 *kg* a.i./*ha* was required for effective control of grasses and sedges for 40 days.

The broadleaves may be more effectively controlled by a follow up handweeding, herbicide mixtures or post–emergent 2, 4–D.

0 - 2 DAS application was the most favourable time for good weed control in drilled sown rice.

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WEED CONTROL IN AFFORESTED LAND WITH A COMBINATION OF TRICLOPYR AND TETRAPION

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ABSTRACT

A micro-granular formulation containing butoxyethyl ester (BEE) of triclopyr has been widely used in the afforested land planted with cedar or cypress in Japan to control deciduous brush and kudzu vines. However, the formulation is not effective for the control of graminaceous weeds such as *Miscanthus cinensis* and *Sasa* spp. A series of basic studies indicated that one combination of triclopyr with tetrapion broadened the weedicidal spectrum not only by enabling the control of graminaceous weeds but also by enhancing the effects on brush species.

Extensive field trials with micro-granular formulation containing 3% of BEE of triclopyr and 5% of sodium salt of tetrapion at the rate of 80 - 120 *kg/ha*, have proven that the combination can be effectively applied for the control of wide range of unwanted vegetation without giving any serious damage to the planted cedar and cypress.

INTRODUCTION

The most common undesirable plants which is required to be controlled in the Japanese forestry are kudzu vine, *Miscanthus cinensis, Sasa* spp (bamboo) in addition to broad leaved brush species. In most afforested land, two or three of these species form a mixed community, thus control of only one kind of weedy plants will result in vigorous infestation of the other in the following years. For this reason it is desirable and often necessary to control a broad spectrum of undesirable plant species in a forestry management program.

The author and colleagues, therefore have developed a broad spectrum herbicide by combining triclopyr, which had been known to be effective on brush species including kudzu vine (Byrd et al. 1975, Haagsma 1975, Ishikura 1977), and tetrapion, which had been known as a grasskiller (Annon., 1972, Takahashi et al. 1975).

This report is a typical result obtained on the combination from an aerial application experiment and a summary of the results of the field trials laid down between 1979 and 1983 in Japan.

MATERIALS AND METHODS

The herbicide which was field tested was a microgranular formulation (48-150 mesh) containing 3% butoxyethyl ester (BEE) of triclopyr (3, 5, 6-trichloro-2-pyridyloxyacetic acid) and 5% sodium salt (Na) of tetrapion (2, 2, 3, 3-tetrafluoro-propionic acid). The combination product is known as ZYTRON*-FRENOCK++ MG in the Japanese market.

A microgranular fomulation containing 3% BEE of triclopyr, which is known as ZYTRON* 3MG, was also used for comparison purpose.

Aerial application test

Method The experiment was laid down in a forest in Yamaguchi prefecture planted with Japanese cedar *(Cryptomeria japonica)* and Japanese cypress *(Chamaecyparis obtusa)* four years ago.

Triclopyr 3% microgranular was applied to 3.7 *ha* area at the rate of 120 *kg/ha* of the formulation, and triclopyr 3% + tetrapion 5% microgranular was applied to 4.4 *ha* area at the rate of 100 *kg/ha*. Both formulations were applied overall by a Bell-47 KH-4 helicoptor from the hight of 10 - 15 *m* above the planted trees. The application was made on July 15, 1982.

One day before the herbicide application, all the existing plants in nine 1*m* × 1*m* quadrants placed along the approximate diagonal line of each plot at approximately equal intervals were cut at the soil surface and the weight was recorded by species. The similar recordings existing were repeated one, three and 12 months after application. At the final assessment, measurements were taken by weighing the plants cut at 20 *cm* interval vertically from the soil surface.

Results; Figure 1 shows the results of the measurement of the existing weedy plants by categories kind at each assessment. Figure 2 shows the weight of the weedy plants by the hight from the soil surface at the final assessment.

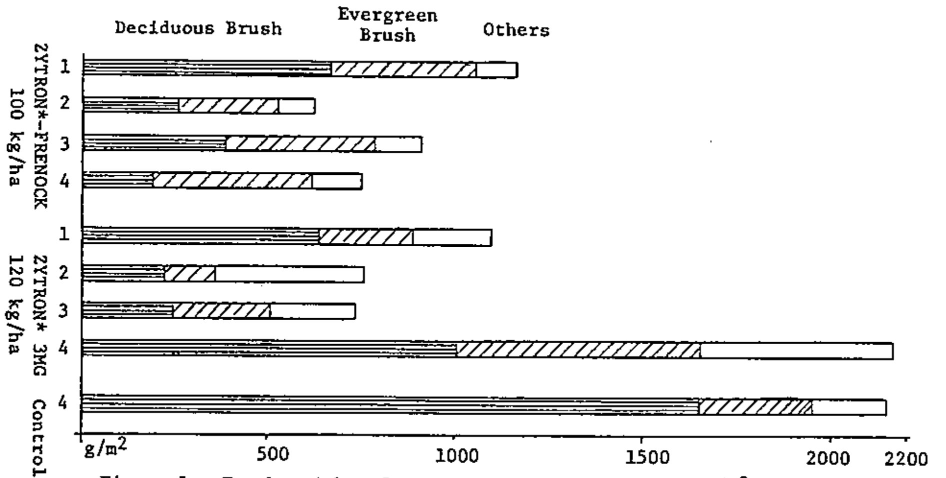

Figure 1 - Fresh weight of existing weedy plants (grams/m²) at pre-treatment (1) one month after treatment (2), three months after treatment (3) and 12 months after treatment (4)

Figure 1 - Fresh weight of existing weedy plants *(grams/m²)* at pre-treatment (1), one month after treatment (2), three months after treatment (3) and 12 months after treatment (4)

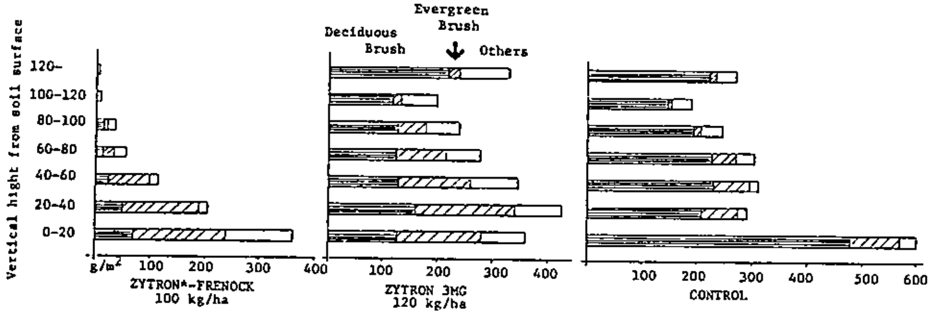

Figure 2: Fresh weight of existing weedy plants (grams/m²) by hight at 12 months after treatment

Figure 2: Fresh weight of existing weedy plants *(grams/m²)* by height at 12 months after treatment

Although the "others" category of the weedy plants in those Figures were not further broken down, it was noteworthy that it consisted mainly of herbacious weeds in the plot for the combined formulation and *Miscanthus cinensis* for the triclopyr single formulation.

Though no numerical data are included in this paper, no phytotoxic symptoms on either species of the transplanted conifer were observed.

Summary of 1979 - 1983 field trials

Methods The triclopyr 3% + tetrapion 5% microgranular formulation was field tested at 56 forest sites planted with either cedar or cypress during the period of 1979 - 1983. The tests were conducted under a uniform experimental design, *i.e.* 10 *m* × 10 *m* plots to be given single manual broadcast of the formulation at the rates of 80 - 120 *kg/ha* between June and August. The assessments of the results were made at appropriate intervals for at least 12 months after application.

Results Based on the results at 12 months after treatment, Table 1 was made to summarize the susceptibility of each plant species to the combined formulation at the designated dose rates. No phytotoxicity to the (planted) conifer was reported from any of the test locations.

DISCUSSION

The original purpose of combining triclopyr and tetrapion was to broaden the weedicidal spectrum by the additive effects for the simultaneous control of brushy and grassy weeds. The results obtained indicated that this was achieved satisfactorily, as apparent in the aerial application test and shown in Table 1.

Table 1: Susceptibility of common forest weeds to ZYTRON*-FRENOCK Micro Granular at indicated dosage

kg/ha	*80*	*90*	*100*	*120*
Castanea crenata	S	S	S	S
Quercus serrata	MS	MS	S	S
Quercus acutissima	S	S	S	S
Benzoin umbellatum	MS	MS	S	S
Deutzia spp	MS	S	S	S
Rubus palmatus	S	S	S	S
Rubus crataegifolius	S	S	S	S
Prunus donarium	R	MR	MR	MS
Lespedega bicolor	MS	MS	S	S
Pueraria thunbergiana	S	S	S	S
Rhus trichocarpa	S	S	S	S
Rhus javanica	S	S	S	S
Ilex crenata	MR	S	S	S
Aralia elata	S	S	S	S
Clethra barbinervis	S	S	S	S
Rhododendron spp	MR	MR	MS	S
Pieris japonica	R	R	MR	MR
Callicarpa japonica	R	R	R	R
Sasa spp	S	S	S	S
Miscanthus sinensis	S	S	S	S

S: Susceptible - 75 - 100% control
MS: Moderately Susceptible - 50 - 75% control
MR: Moderately resistant - Less than 50% control
R: Resistant - little or no control

Furthermore, an additional merit of the combination was found in those field trials. As seen in figures 1 and 2, the suppression of the regrowth of brushy weeds in the following year of the application was much more remarkable with the combined formulation than with the triclopyr single formulation. In fact, as seen in Figure 2, the height of the treated brush was kept so low that the weeding operation for the following year of the treatment was unnecessary. Although no detailed measurement was taken thereafter, visual observation indicated that the brush was still suppressed enough that the weeding operation could be skipped even in the third year after the application.

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EFFECT OF SEED RATE AND NITROGEN LEVEL ON THE YIELD OF DIRECT WET-SEEDED RICE

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ABSTRACT

Direct seeded rice is grown in many countries and becoming increasingly important also in the tropics where rice has traditionally been transplanted. Methods used in direct seeded rice differ from country to country and in particular the seeding rates vary greatly from less than 50 *kg* seed per hectare in some areas to more than 150 *kg* in others. These latter high seeding rates are applied to suppress weed growth, but they are not needed or are even deterimental if high yields are to be obtained under weed free conditions.

Several experiments were carried out to study the effect of seeding rate and fertilizer level in combination with different weeding regimes. Results from these trials clearly indicate, that seeding rates can be lowered significantly without reducing yields, if a fully selective herbicide is applied.

INTRODUCTION

The traditional methods of rice growing in South East Asia (SEA) have undergone some significant changes over the last 10 to 20 years. In a continuing process of improving the economic result of their rice crop, many rice farmers adopted new technologies and increased their inputs. Where the labour cost became a substantial part of the production cost manual soil cultivation and handweeding were substituted by mechanical cultivation with tractors and use of herbicides.

In a next phase transplanting of rice seedling was and is being replaced by sowing pre-germinated seed directly on to muddy soil. Over the last few years this method of direct seeding has become most important in Thailand, but it is also rapidly expanding in the Philippines and in the other SEA countries (De Datta 1981). Even in Indonesia with its abundance of labour force, this rice growing method is seriously being considered for those areas with lower population densities.

Being a new crop growing system for farmers in many areas and lacking the century old tradition of transplanting rice, the details of the crop establishment for direct seeded rice vary greatly from country to country. One of these differences is the seeding rate. Our own investigations in this respect revealed a range from less than 40 *kg* to over 150 *kg* and in some cases up to 180-200 *kg* seed per hectare.

Such a big variation suggests that this input factor may not yet be optimized sufficiently. But it also may indicate that for different conditions and environments the optimum seed rate needs to be adjusted.

In conjunction with the development of Ciba-Geigy's new rice herbicide Sofit® for direct wet sown rice (Quadranti M., Ebner L. 1983), a number of experiments were conducted where seed rate and nitrogen input were varied. The experience gained in these trials allows to establish use recommendations for Sofit® that are not only referring to its herbicidal activity but also to the integration of its use into the production system as a whole.

MATERIAL AND METHODS

Trials were conducted at the Ciba-Geigy Research Station, Cikampek, West Java Indonesia. Soil preparation was done by tractor and final levelling of the individual plots was done manually. Pre-germinated seed of rice (*Oryza sativa* L.),cv. IR-36, which was soaked for 24 hours and incubated for about 40 hours, was broadcast on the saturated mud. Water management during the first 15 days was carefully adjusted to the development stage of the young rice seedlings. A basic fertilization consisting of 100 *kg* triple superphosphate (45%) and 90 *kg* potassium (60%KCL) was applied at seeding time. N was applied as urea (45% N). Urea was applied in 3 split applications with one third of the total rate each at sowing, at 30, and at 50 days after sowing, respectively. Liquid herbicides were applied with a knapsack sprayer equipped with a small spray boom consisting of 3 fan jet nozzles. Spray volume was 500 *l/ha*.

Due to the operations involved (3 nitrogen-input levels, 3 seed rates and 4 weed control regimes) the trial lay out was a split-plot design (see table 1). In this design main plots were the nitrogen-input levels. Within each nitrogen level, every seed rate was present three times replicated. Within the subplots, all weed control regimes were included.

Table 1. Factorial treatments tested and their assignment to experimental plots

Factor	Level	Experimental unit
Nitrogen level	- 150 *kg* urea/*ha* - 225 *kg* urea/*ha* - 300 *kg* urea/*ha*	Main plots
Seed rate	- 40 *kg* seed/*ha* - 80 *kg* seed/*ha* - 120 *kg* seed/*ha*	Subplots
Weed control regime	- Weedy check - Benthiocarb + 2.4-D 1.2 *kg ai/ha* at 6 DAS - Pretilachlor + CGA 123407 = SOFIT® 0.45 *kg ai/ha* at 4 DAS - Butachlor 0,9 *kg ai/ha* at 6 DAS	Subsubplots

Preceeding crop, soil type, soil cultivation, planting time and all maintenance treatments were exactly the same for the three main plots.

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Weed infestation turned out to be uniform throughout all trials sites. However an overall unusually low weed pressure was observed. The weed population was dominated by *Monochoria vaginalis* (Burm.f.) Presl., *Fimbristylis miliacea* (L) Vahl., *Scirpus juncoides* L., *Cyperus iria* L. and *Cyperus difformis* L.. There were only very few *Echinochloa* plants observed in these experiments.

Seedling density was recorded at 15 days after planting. In each plot the number of plants was counted in 4 randomly selected sampling areas of 0.25 *sqm* each. Weed coverage and weed control were assessed visually at regular intervals. Rice grain yields were taken at maturity and data transferred to 13% moisture content.

Statistical calculations were done with the SAS-procedure GLM (SAS Institute 82) (PROC GLM analyzes data within the framework of General Linear Models).

RESULTS

Seedling density at 15 days is presented in figure 1. Since there was no difference in seedling density with respect to various nitrogen levels, the respective values have been pooled.

Figure 1

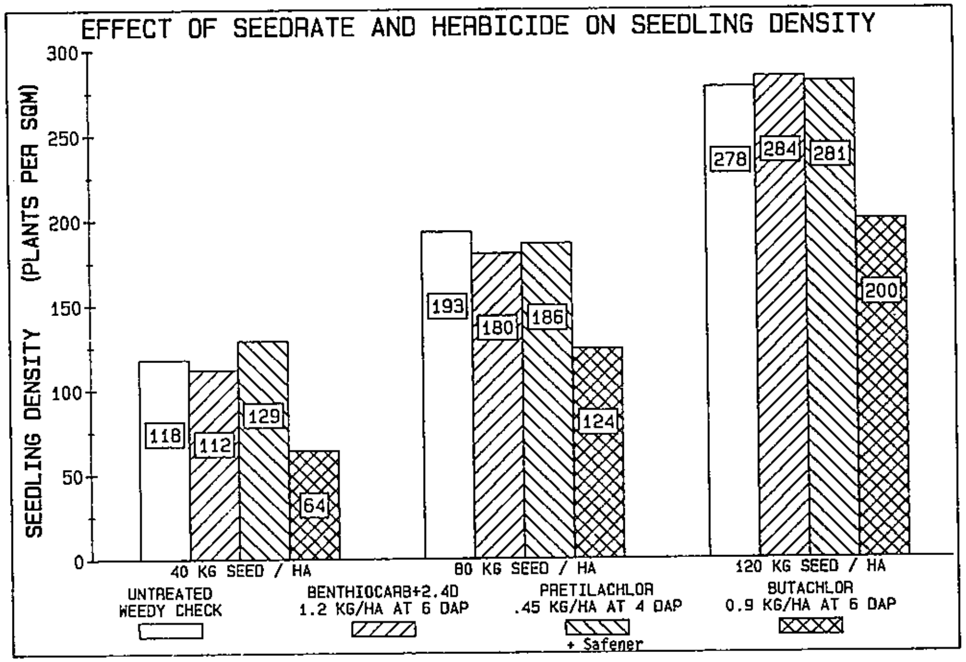

Figure 1 Effect of seedrate and herbicide on seedling density

Benthiocarb + 2.4-D as well as pretilachlor + CGA 123'407 were completely safe to the crop and averaged the same number of seedlings per unit area. With 40 *kg* seed *per hectar* around 120 plants *per sqm* were recorded. The seed rates of 80 and 120 *kg/ha* resulted in a density of about 190 and 280 plants respectively. The herbicide treatment with butachlor reduced crop stand at all three seedling rates by 20-30%.

Weed coverage at 47 days after planting is shown in figure 2. For the two weed control regimes check and butachlor weed coverage clearly decreases with increasing seed rates, whereas the efficiency of benthiocarb + 2.4-D and pretilachlor + CGA 123'407 on weed coverage does not show variation between seed rates. The two latter products controlled weeds effectively and irrespective of the seedling density. These trends subsist in all three main plots with different nitrogen levels. Weed coverage tends to decrease if higher rates of urea are applied, as can be seen with the check and with butachlor.

Figure 2

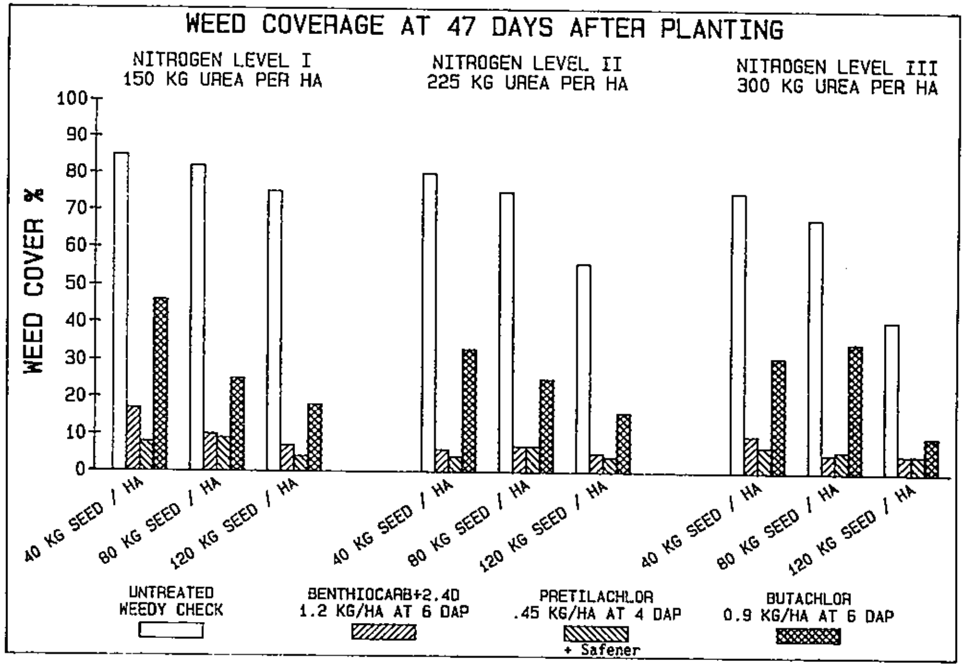

Figure 2 Weed coverage at 47 days after planting

The much higher weed infestation with butachlor is seen as an effect of poor crop establishment due to its phytotoxicity rather than as a poor activity of the product against weeds. In these plots the crop canopy was still open at 20-30 DAP and a second flush of weeds did germinate.

Yield data are presented in table 2. The comparison of the three nitrogen levels shows a general yield optimum at the medium level of 225 *kg* urea/*ha* (table 2,3). The decrease of yields with 300 *kg* urea/*ha* appears to be correlated with the much higher degree of lodging observed in the field.

The influence of the seed rate on yield was not significant. However, there is a tendency of higher yields with higher seeding rates (table 2).

Among the tested weed control regimes, Pretilachlor + CGA 123'407 and Benthiocarb + 2,4-D show the highest yield and they significantly differ from weedy check and Butachlor (table 4).

Table 2: Effect of seed rate, nitrogen level, and weed control regimes on yield of direct weet-seeded rice

Urea Input [kg/ha]	Seed Rate [kg/ha]	Benthiocarb + 2,4.-D [1.2 kg a.i./ha at 6 DAS] N	Yield [t/ha] MEAN	Butachlor [1.2 kg a.i./ha at 6 DAS] N	Yield [t/ha] MEAN	Pretilachlor + Safening agent CGA123407 [0.45 kg a.i./ha at 4 DAS] N	Yield [t/ha] MEAN	Weedy check N	Yield [t/ha] MEAN
150	- 40	3	3.46	3	2.94	3	3.94	3	3.42
	- 80	3	3.78	3	3.32	3	3.83	3	3.46
	-120	3	3.99	3	3.55	3	3.90	3	3.82
225	- 40	3	4.14	3	3.25	3	4.16	3	3.48
	- 80	3	4.22	3	3.83	3	4.45	3	3.94
	-120	3	4.48	3	4.24	3	4.33	3	4.12
300	- 40	3	3.47	3	3.28	3	3.88	3	3.25
	- 80	3	3.72	3	3.37	3	3.75	3	3.22
	-120	3	3.60	3	3.61	3	3.72	3	3.33
Seed Rate [kg/ha]									
- 40	mean	9	3.69	9	3.16	9	3.93	9	3.38
- 80	mean	9	3.91	9	3.51	9	4.01	9	3.54
-120	mean	9	4.02	9	3.80	9	3.98	9	3.76
Treatment mean		27	3.87	37	3.49	27	3.97	27	3.56
urea input [kg/ha]									
150	mean	9	3.74	9	3.27	9	3.82	9	3.57
225	mean	9	4.28	9	3.77	9	4.31	9	3.85
300	mean	9	3.60	9	3.42	9	3.78	9	3.26
Treatment mean		27	3.87	27	3.49	27	3.97	27	3.56

N = Number of observations

Table 3: General influence of the nitrogen level on the yield

Yield *t/ha*	Nitrogen level *kg* urea*/ha*
4.05 a	225
3.60 b	150
3.51 b	300

Table 4: General influence of weed control regime (treatment) on the yield

Yield *t/ha*	Treatment
3,97 a	Pretilachlor + CGA 123'407
3,87 a	Benthicarb + 2,4-D
3,55 b	Weedy check
3,48 b	Butachlor

The results of the interactions between fertilizer level × seed rate, fertilizer level × weed control regime, and seed rate × weed control regime are presented in tables 5,6 and 7 respectively. The results clearly indicate that higher yields will be obtained only when optimal weed control and fertilizer levels are combined.

Table 5: Influence of the interaction between nitrogen level and seed rate on the yield

Yield *t/ha*	Nitrogen level *kg* urea*/ha*		Seed rate *kg/ha*
4,29 a	225	×	120
4,11 a	225	×	80
3,81 b	150	×	120
3,75 bc	225	×	40
3,59 bcd	150	×	80
3,56 bcd	300	×	120
3,51 cd	300	×	80
3,46 d	300	×	40
3,39 d	150	×	40

Table 6: Influence of the interaction between nitrogen level and weed control regime on the yield

Yield *t/ha*	Nitrogen level *kg* urea/*ha* × weed control regime
4,31 a	225 × Pretilachlor + CGA 123407
4,28 a	225 × Benthiocarb + 2,4-D
3,84 b	225 × Weedy check
3,82 b	150 × Pretilachlor + CGA 123407
3,78 b	300 × Pretilachlor + CGA 123407
3,77 b	225 × Butachlor
3,74 bc	150 × Benthiocarb + 2,4-D
3,59 bcd	300 × Benthiocarb + 2, 4-D
3,56 bcd	150 × Weedy check
3,42 cd	300 × Butachlor
3,27 d	150 × Butachlor
3,26 d	300 × Weedy check

Statistics: Yield means not followed by the same letter are significantly different $\alpha = 0{,}05$

Table 7: Influence of the interaction between seed rate and weed control regime.

Yield *t/ha*	Seed rate *kg/ha* × weed control regime
4,02 a	120 × Benthiocarb + 2,4-D
4,00 a	80 × Pretilachlor + CGA 123407
3,98 a	120 × Pretilachlor + CGA 123407
3,92 a	40 × Pretilachlor + CGA 123407
3,90 a	80 × Benthiocarb
3,80 ab	120 × Butachlor
3,75 ab	120 × Weedy check
3,69 abc	40 × Benthiocarb
3,53 bc	80 × Weedy check
3,50 bc	80 × Butachlor
3,38 cd	40 × Weedy check
3,15 d	40 × Butachlor

Statistics: Yield means not followed by the same letter are significantly different $\alpha = 0{,}05$

DISCUSSIONS

The data obtained demonstrate that it is essential to optimize the various input factors if highest yields are to be obtained in direct seeded rice. Nitrogen rates beyond the optimum for a given situation are clearly detrimental due to the increased risk of crop lodging.

Seed rate and weed control regime have to be optimized together since they are interdependent. The results of these experiments suggest that higher seed rates will be beneficial if no weed control is planned (weedy check) or if the envisaged weed control will be only partial. On the other hand there seems to be little benefit in using very high seed rates if the planned weed control practice is fully selective and efficient.

Once again it must be pointed out that the relationship found in these trials have been established in a field with unusually low weed pressure. We expect, that under high weed pressure the use of a selective and active herbicide will be the key to realize high yields in direct seeded rice.

ACKNOWLEDGEMENTS

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NONCOMPETITIVE EFFECTS OF *Digitaria adscendens* ON CROP GROWTH

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ABSTRACT

Weed-crop interaction is composed of competition and allelopathy, although the allelopathic mechanisms has been given little attention. The noncompetitive (allelopathic) effects of *Digitaria adscendens* on the growth of several crops were determined in two weed-stages, young seedlings and mature plants. In the first experiment the weed and a crop species (soybean, lettuce, radish, cucumber of corn) were seeded five rows each in opposite halves of a rectangular soil-filled container. The rows were 5 *cm* apart and the plants were allowed to grow for one month. No adverse effect on the growth of the crops because of weed access was observed, or vice versa, as compared with intraspecific accessions. The growth of soybean, lettuce and cucumber was actually promoted to some degree in the row just adjacent to the weed row. In the second experiment, *D. adscendens* plants were grown on one side of a field plot until they attained full growth. Radish and corn were then seeded, with sufficient water and nutrients, at various distances from the weed plants. Crop growth was markedly reduced in the positions near the weed plants where more weed roots had distributed. These results indicate that although young *D. adscendens* has no phytotoxic activity, mature plant roots may exude substances toxic to certain crop species. Furthermore, ammonium-nitrogen tended to accumulate in the weed root zone soil suggesting the inhibition of nitrification by *D. adscendens*.

INTRODUCTION

Weed interfere with crop plants principally by competition and allelopathy. Although many reports have been made on the weed-crop interaction, most of these have identified competition as being primarily involved.

Digitaria adscendens interference with crop plants was studied in detail by Noguchi (1983).[2] He concluded that the mechanism could be ascribed to light competition in most parts but in the case of corn noncompetitive processes were thought to be involved. The phytotoxic effects of the residue of this weed were found earlier by the authors (1981).[1] The study reported here was conducted to determine if young and mature living plants of *D. adscendens* also have noncompetitive influences through substances released from their roots.

MATERIALS AND METHODS

Effects in early growth stage:

Noncompetitive interaction affecting growth between young seedlings of *D. adscendens* and several crops was assayed in a green house. The crops tested were Japanese radish *(Raphanus sativus)*, lettuce *(Lactuca sativa)*, cucumber *(Cucumis sativus)*, soybean *(Glycine max)* and sweet corn *(Zea mays)*. Plastic boxes (16 *cm* × 50 *cm* × 11 *cm*) filled with sandy-loam soil were prepared. The seeds of *D. adscendens* and one of the crop species, germinated immediately prior in petri dishes; were placed in rows in opposite halves of a box. There were five rows of each type of seeds and the rows were spaced 5 *cm* apart. Fertilizer, N, P, K, at $5 g/m^2$, was mixed with the soil before planting. The boxes were irrigated every day with 1/box of water to maintain moderate soil moisture. Thirty to 42 days after weed planting, the height and fresh weight of all plants were measured. The experiment was replicated three times.

Effects in mature stage:

Noncompetitive effects of mature *D. adscendens* on the growth of crops were assayed in an outdoor condition. Three plots (90 *cm* × 90 *cm*) framed by concrete were used. *D. adscendens* plants 10 to 15 *cm* high were transplanted in one side (90 *cm* × 25 *cm*) of the plots in late June. The above ground part of the plants was allowed to grow only within the originally planted site. The roots, on the other hand, were allowed to grow freely in the plots. Fertilizer was applied in the same manner as in the previous experiment. The plots were kept free from other weeds until early September. Two of the plots were then sown with Japanese radish and sweet corn. The seeds were placed, spaced 1.5 *cm* apart in six rows of various distances from the weed planted site. Urea liquid fertilizer (10-5-8) was applied at 40 *ml*/plot just before seedling, and the plants were sufficiently irrigated. Three weeks after seedling, nine plants per row were harvested and plant length, leaf number, and fresh and dry weight of the top were measured. From the other one plot six soil cylinders per row were sampled, and the weed roots in these samples were separated and weighed to determine whether the root distribution was actually varied along the distance from the originally planted site. Ammonium and nitrate nitrogen of soil samples was quantitatively analized with Orion ion-meter.

RESULTS

Effects in early growth stage:

Results of the experiment in the young seedling stage are indicated in Table 1: the weed and crop growth in fresh weight of each row and the ratio of R-1/R-4. In most weed-crop combinations, the roots mutually entered each other's R-1 and R-2 zones, only cucumber and radish entering up to R-3 of weed. The plants in R-4, therefore, were considered influenced only by intraspecific interaction, while those in R-1 were influenced by interspecific interaction. Consequently, the R-1/R-4 ratio in fresh weight should indicate the mutual effects between the weed and the crops. The ratio in most combinations was more than 1.0, showing that no adverse interaction existed (Table 1). Moreover, cucumber and radish in association with *Digitaria* and *Digitaria* with soybean and lettuce significantly increased their growth.

Effects in mature plant stage:

Results are shown in Table 2. The amount of root distribution declined from R-1 to R-6, as expected.

Table 1. Growth of *D. adscendens* and crop plants in sequential R-1 to R-5[a)] rows from the weed-crop border, and growth ratio of R-1/R-4 as an indicator of weed-crop interaction.

Associated Crop	Fresh weight (g/row) *D. adscendens* R-5	R-4	R-3	R-2	R-1	R-1/R-4	*Crop* R-1	R-2	R-3	R-4	R-5	R-1/R-4
Cucumber	0.97	0.86	1.17	1.07	0.91	1.07	7.34	7.00	5.67	5.71	6.26	1.29*b)
Soybean	1.56	1.87	1.94	2.29	2.71	1.46 *	3.81	3.40	3.13	3.10	3.16	1.23
Sweet corn	1.37	1.49	1.54	1.57	1.59	1.07	1.89	1.96	1.90	2.03	1.57	0.93
Radish	0.70	0.69	0.74	0.84	0.59	0.86	6.00	4.66	4.06	3.16	3.03	1.90 *
Lettuce	1.09	1.37	1.44	1.96	2.16	1.57 *	3.01	3.24	2.67	2.61	2.77	1.16

a) R-1: at the border; R-5: farthest from the border
b) *: Significantly different between R-1 and R-4 at 5% level.

Table 2. Amount of *D. adscendens* roots distributed, test plant growth and soil nitrogen level in sequential rows from the weed planted site.

Rows[a)]	Amount of roots	Test plant fresh weight[b)] Radish	Corn	Nitrogen level NO_3-N	NH_4-N
	(*mg*/sample)	(g/row)		(*ppm*, dry wt.)	
R-1	31.17	0.40	1.67	6.71	5.65
R-2	26.58	0.39	1.80	8.80	7.62
R-3	15.68	0.41	2.00	8.16	5.82
R-4	7.00	0.78	2.25	11.38	4.97
R-5	2.71	1.11	2.66	17.27	4.58
R-6	2.17	1.66	3.51	-	-
LSD at P = 0.05	7.33	0.21	0.33	3.08	1.07

a) R-1: nearest; R-6: farthest from the weed planted stie.
b) Measured three weeks after seeding.

The test plants germinated and grew normally during the first week, but thereafter growth was gradually reduced in the rows nearer ther site where *Digitaria* was originally planted. Radish was more inhibited than corn.

Soil nitrogen level varied according to the root distribution of *Digitaria*. Soil which contained a greater quantity of roots, in the rows nearer to the weed planted site, had a tendency to show lower NO_3-N level but higher NH_4-N level. If the weed had absorbed NH_4-N, or if NH_4-N had not been utilized by the weed but had been nitrified at the same rate at every position in the plot, the content should decline as the roots decreased or should not differ, respectively. Since the results showed neither condition, however, inhibition of nitrification by *D. adscendens* was suggested.

DISCUSSION

The rusults of these two experiments showed that *D. adscendens* affects on the crop growth through the roots inhibitively in the mature stage but ineffectively or, rather, promotively in the young stage. In the first experiment, water and nutrient supply was sufficient and the light condition resulting from the both intra-specific and weed-crop competition was almost the same for every row. In the second experiment, test plants were supplied sufficient water, nutrients and sun light. In this connection, the soil inorganic nitrogen level of all rows traced at the radish harvesting was almost the same, varying only 11.8 to 12.6 *ppm*. Therefore, the effects observed here were considered mainly attributable to the noncompetitive (allelopathic) mechanisms caused by the root exudate of *D. adscendens*.

Phytotoxic activity of the root exudate of *Digitaria sanguinalis,* a species closely related to *D. adscendens,* was reported by Parenti and Rice (1969).[3)] This species is found to be inhibitory also to nitrifying bacteria.[4)] *Rice* (1974)[5)] identified chlorogenic, isochlorogenic and sulfosalicylic acids as the phytotoxin of this weeds. Such phenolic compounds might also be contained in the root exudate and act as allelochemics in *D. adscendens.* To what extent allelopathy could be involved in crop loss by this weed should be determined.

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UPTAKE AND TRANSLOCATION OF ^{15}N IN WATER HYACINTH

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ABSTRACT

Nitrogen uptake and translocation in water hyacinth, *Eichhornia crassipes* (Mart.) Solms, were examined during a 96-hour exposure to NH_4NO_3 solution labelled with NH_4- ^{15}N or NO_3- ^{15}N (at 2 *mg* N l^{-1}). The ^{15}N from $NH_4{}^+$ was distributed more in the roots than that from $NO_3{}^-$ during a 96-hour period. The amount of ^{15}N from $NO_3{}^-$ was less in the aerial parts than that of $NH_4{}^+$ during the initial 48-hour period, and then increased rapidly during the 48- to 96-hour period.

These results indicate that water hyacinth plants exhibit a preferential uptake of $NH_4{}^+$ over $NO_3{}^-$, when both ions are present at equal concentration in the same nutrient solution.

In another experiment, a 3-day exposure to the $^{15}NH_4Cl$ solution containing 20 *mg* N l^{-1}, followed by a 25-day exposure to $^{14}NH_4Cl$ solution containing 2 *mg* N l^{-1} revealed that 44-46% of absorbed ^{15}N by one plant for initial 3 days was directly translocated to new ramets, and 15-18% of the absorbed ^{15}N was translocated to the secondary new ramets via stolons.

INTRODUCTION

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) is recognized as a serious aquatic weed throughout world. At present, however, utilization of this weed is considered an important part of the weed management. Especially this weed has received attention as water purifier. As a result, much research dealing with the characteristics of nitrogen and phosphorus uptake of water hyacinth has been conducted (Gopal and Sharma, 1981; Pieterse, 1978).

Shiralipour et al. (1981), Reddy and Tucker (1983) and Oki et al. (1978) have already evaluated the effect of nitrogen source on the growth and nutrients uptake of water hyacinth. However information on uptake rate of ammonium and nitrate, and translocation from roots to shoots during the initial period of exposure are lacking. Also the translocation patterns of the absorbed N within water hyacinths population via stolons has not been observed. The objectives of this study were to determine (a) the N uptake and translocation during a short-term using ^{15}N as tracer when both ammonium and nitrate ions are present in the same medium, and (b) the transloca-tion of the initially absorbed ^{15}N by one plant within growing water hyacinth population.

MATERIALS AND METHODS

Experiment 1

Water hyacinths were cultured outdoors in tanks at the Okayama University campus for several months. Uniform plants of six leaf stage (ca. 60*g* wet wt) were collected and acclimated in tap water for 4 days before initiation of experiment. Experiment was conducted in a phytotron at 25°*C* under natural light for 4 days (96 *hr*). One plant was placed in each of one polyethylene containers with 3 *liters* of 5% Hoagland's solution minus N, and adjusted to N concentration of 2 *ppm*. $^{15}NH_4NO_3$ or $NH_4{}^{15}NO_3$ with 99 atom % ^{15}N were added to two different series of containers. Initial pH of solution was 7.02. The solution was not changed during experiment. At 14*h*00 on August 9, 1983, the experiment was started and three plants of each treatment were harvested at 6, 24, 48, 72 and 96 *hr* after initiation of experiment. At each harvest, plants were washed, separated into aerial parts and root and oven-dried at 70°*C* for 48 *hr*. Total nitrogen was determined by Kjeldahl digestion and subsequent distillation method. ^{15}N content in Kjeldahl digest of plant tissues was determined by emission spectroscopic method.

Experiment 2

Nineteen clones of water hyacinth plants were collected during summer of 1984 from different freshwater habitats of Florida. One plant from each collection was cultured in a 60 *l* tub containing 5% modified Hoagland's solution for 40 days at Central Florida Research and Education Center, Sanford, Florida. New ramets produced from 4 original clones were examined; Clone No.1: collected from Tampa in West-Central Florida, No.2: from Ft. Lauderdale in South Florida, No.3: from Tallahassee in North Florida, No.4: from Zellwood in Central Florida. Clone No. 2 is the long styled form and other three are the mid-styled forms.

On October 4, 1984, one new ramet (3 replications/clone) was placed in a 12 *l* container containing 10% modified Hoagland's solution minus N. $^{15}NH_4Cl$ with 5.317 atom % ^{15}N (20 ppm N) was used as N source. After 3 day's culture in a green house, all plants were taken out from the $^{15}NH_4Cl$ solution and washed, and subsequently transferred into a 12 *l* container with a solution containing 2 ppm N as natural NH_4Cl and 1% modified Hoagland's medium minus N, and cultured for 25 days. At harvest, the water hyacinth population per container were separated into 4 components, namely initial plant (mother plant), ramet I (new ramets produced from initial plant during culture), ramet II (new ramets produced from ramet 1 during culture) and stolons. During the experimental period, stolons were found to be intact connecting mother plant and ramets. All plant samples were dried in an oven at 70°C for 48 *hr*, and analyzed for total N and ^{15}N by the same technique as in Experiment 1. ^{15}N content was analyzed using an isotope radio mass spectrometer.

RESULTS AND DISCUSSION

Experiment 1

Figure 1 shows the time course of ^{15}N uptake by roots from solutions containing $^{15}NH_4NO_3$ and $NH_4{}^{15}NO_3$. In the case of $^{15}NH_4NO_3$ solution, the uptake rate of $^{15}NH_4{}^+$ was increased during the 72-hour period, and then declined. While in the case of $NH_4{}^{15}NO_3$ solution, the $^{15}NO_3^-$ was taken up more slowly during the initial 48-hour than the $^{15}NH_4{}^+$. Though the $^{15}NO_3{}^-$ was rapidly taken up during the 48- to 72-hour period, the difference between two forms in uptake was significant over a period of 96 hours.

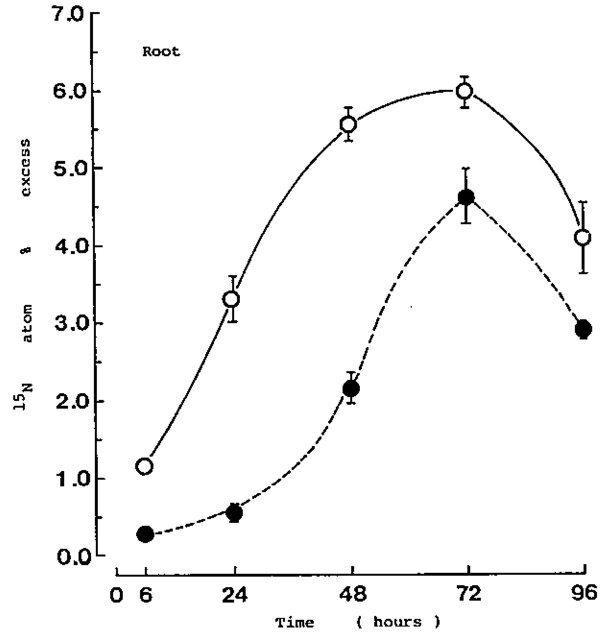

Figure 1. Time course of ^{15}N abundance in the root treated with $^{15}NH_4NO_3$ solution (—O—) and $NH_4{}^{15}NO_3$ solution (--●--). The vertical bars represent S.D. of mean of three replicates.

The changes in the ^{15}N atom % excess in the aerial parts is presented in Figure 2. In the case of ^{15}N-labelled ammonium, ^{15}N was translocated from the roots to the aerial parts rapidly, and the value showed higher than that of ^{15}N-labelled nitrate over period of 96 hours. In the case of ^{15}N-labelled nitrate, it was noted that the amount of ^{15}N was very low during the first 48-hour due to slow uptake by roots, but during the 48- to 96-hour a marked increase was observed. Hence there was no difference significantly between two forms at the 72– and the 96-hour. These results showed that ammonium ion seemed to inhibit the uptake of nitrate ion by roots when ammonium and nitrate nitrogen were co-existing in the same nutrient solution. It is suggested that N from ammonium nitrogen was absorbed preferentially during first specific period and followed by the uptake N from nitrate nitrogen due to reduction of ammonium ion in solution. In the case of exposure to 2 *mg* N/*l* solution, such a change occurred during the 48– to 72-hour period. Yasuda et al. (1985) investigated nitrogen uptake under the influence of ammonium ion by water hyacinth and reported that ammonium assimilation for 4 days at 20 *mg* N/*l* solution was by about five times greater than nitrate nitrogen assimilation. When plants were supplied

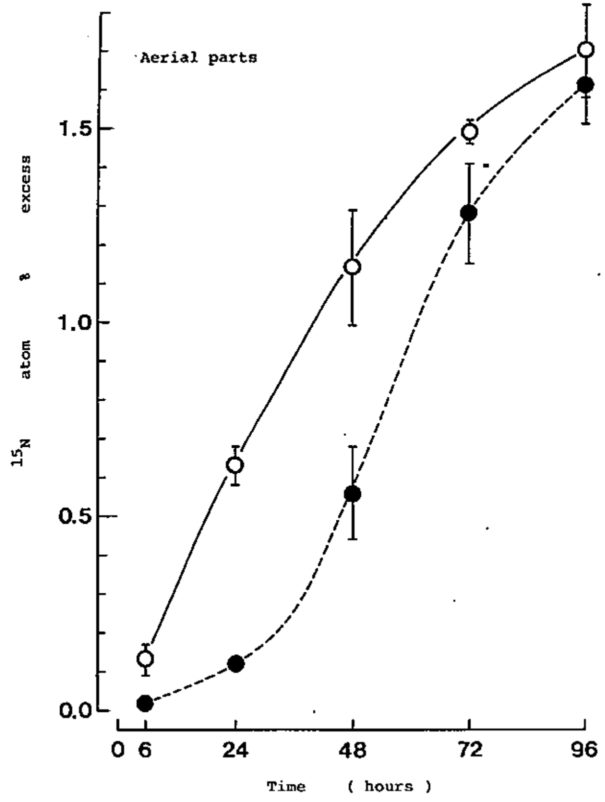

Figure 2. Time course of ^{15}N abundance in the aerial parts treated with $^{15}NH_4NO_3$ solution (—O—) and $NH_4{}^{15}NO_3$ solution (--●--). The vertical bars represent S.D. of mean of three replicates.

with both ammonium and nitrate in the same medium, ammonium was reported to inhibit nitrate uptake by many plants (Frith and Nichols, 1975; Haynes, 1978; Orebamjo and Stewart, 1975).

Potentially ammonium has two sites of inhibition, (a) on the actual uptake of nitrate and (b) on the activity of nitrate reductase, but the mode of inhibition was not demonstrated in this study. Research on other plants indicates that ammonium nitrogen was rapidly transformed to amino acids and amides in the roots, while in the case of nitrate nutrition, the plants can be divided into three groups according to whether nitrate reduction takes place in roots or shoots (Yoneyama et al., 1975; 1976). In rice which appears to grow equally well in ammonium or nitrate media as like water hyacinth, the nitrate is absorbed by the roots and is then translocated to the leaves where reduction takes place (Haynes and Goh, 1978).

Table 1 shows the time courses of increase in the absorption percentage of labelled nitrogen from nutrient solutions containing ammonium nitrate by water hyacinth. The absorption percentage was obtained as follows:

$$\frac{^{15}N \text{ content in tissue of one plant } (mg)}{\text{Initial application amount as N per pot } (mg)} \times 100\,(\%)$$

Table 1. Change in the absorption percentage of labelled nitrogen by water hyacinth. The concentration of nitrogen in the initial solution was 2 *ppm*, containing ^{15}N of each form at 98.6 atom % excess. Each value is the mean ± S.D. of three replicates.

Time after treatment (*hr*)	Treatment solution	
	$^{15}NH_4NO_3$	$NH_4H_4O^3$
6	4.19 ± 1.06	0.84 ± 0.17
24	16.72 ± 2.40	3.11 ± 1.01
48	32.82 ± 6.83	15.17 ± 5.07
72	42.47 ± 2.62	36.91 ± 4.59
96	55.15 ± 5.66	48.95 ± 0.84

When water hyacinths were supplied with both ammonium and nitrate, the plants absorbed ammonium at a faster rate than nitrate. However, about 55% of the initial application amount derived from $NH_4{}^+$ and about 49% of them derived from $NO_3{}^-$ were recovered in the plant tissue at the 96-hour after treatment. No significant differences were found between two forms at the 72-hour and the 96-hour, implying that ammonium ion in solution was reduced after the 72-hour.

The pH of the solutions containing ammonium nitrate ranged from 7.2 at the beginning to 6.0 at the end of the experiment.

Experiment 2

Figure 3 shows the distribution of ^{15}N present in water hyacinth population per pot during exposure to $^{15}NH_4Cl$ for 3 days followed by $^{14}NH_4Cl$ for 25 days. When all plants were taken out from the $^{15}NH_4Cl$ solution after 3 day's culture and transferred into the $^{14}NH_4CL$ solution, they did not produce new ramets yet. All new ramets had been produced during exposure of the plants to $^{14}NH_4Cl$ solution, and stolons connecting the mother and daughter plants had not broken till the end of experiment. About 44-46% of absorbed ^{15}N by one plant for initial 3 days was translocated to the ramet I (the primary new ramet) via stolons, and 15-18% of them to the ramet II (the secondary new ramet) via the ramet I, and only about 34-37% of ^{15}N had remained in the initial plant after a 25 day period. No significant differences were found between clones. These results indicate the significance of initial plant in regulating the growth of new generation with respect to translocation of N.

Differences in ^{15}N abundance with in each segment of water hyacinth population between clones was observed (Figure 4). These data show that ramet II has the highest ^{15}N content in all clones, implying that much of the N is transferred to the

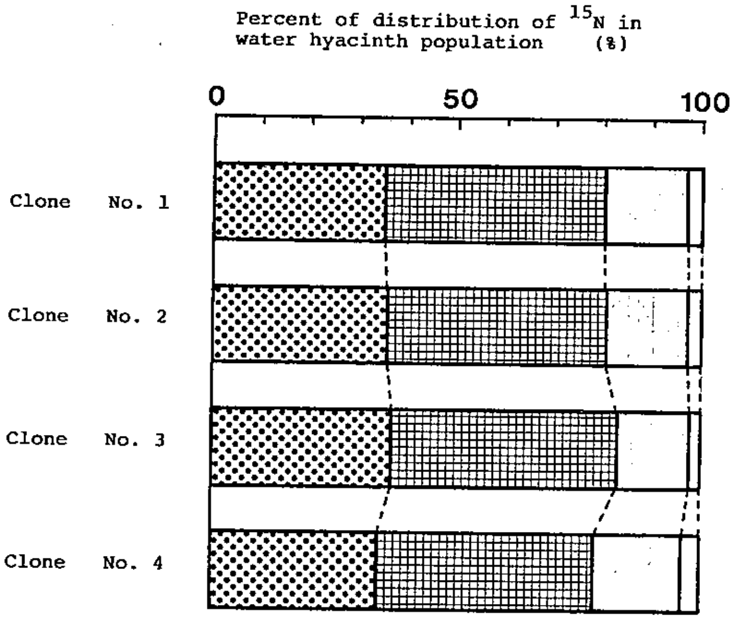

Figure 3. Percentage distribution of ^{15}N present in water hyacinth population per pot during exposure to $^{15}NH_4Cl$ for 3 days followed by $^{14}NH_4Cl$ for 25 days. , , and represent Initial plant, Ramet I, Ramet II and Stolon, respectively.

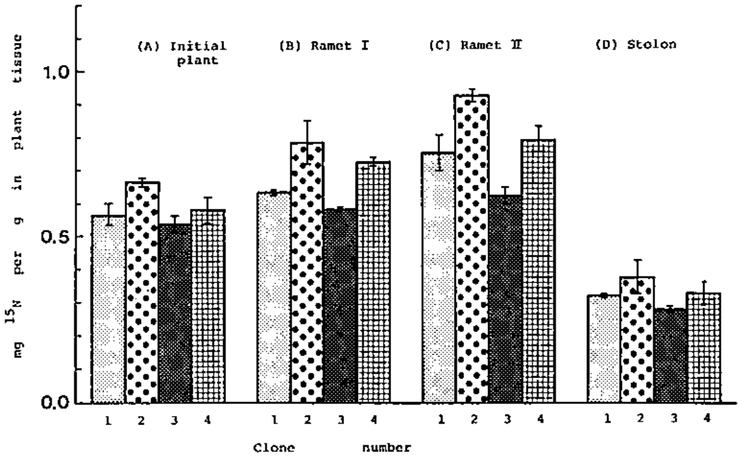

Figure 4. Distribution of ^{15}N in Initial plant (A), Ramet I (B), Ramet II (C) and Stolon (D) of each clone during exposure to $^{15}NH_4Cl$ for 3 days followed by $^{14}NH_4Cl$ for 25 days. The $^{15}NH_4Cl$ contained 5.317 atom % ^{15}N. The vertical bars represent S.D. of mean of three replicates.

Table 2. Growth of and nitrogen uptake by each clone of water hyacinth during exposure to $^{15}NH_4Cl$ for 3 days followed by $^{14}NH_4Cl$ for 25 days. Values are the means ± S.D. of three replicates.

Clone No.	Initial dry weight (g/pot)	Dry weight at harvest (g/pot)	Relative growth rate (day^{-1})	TKN in tissue (A) (mg/pot)	Total ^{15}N in tissue (B) (mg/pot)	B/A × 100 (%)
1	0.26 ± 0.03 c	12.51 ± 0.69 c	0.139 ± 0.007 a	148.16 ± 9.25 c	7.49 ± 0.49 b	5.05 ± 0.01 c
2	0.35 ± 0.02 b	17.21 ± 0.49 b	0.139 ± 0.003 a	197.54 ± 5.03 a	12.20 ± 0.29 a	6.18 ± 0.01 a
3	0.33 ± 0.03 b	16.19 ± 2.05 bc	0.139 ± 0.003 a	176.34 ± 21.54 bc	8.89 ± 1.10 b	5.04 ± 0.01 c
4	0.49 ± 0.06 a	22.21 ± 4.10 a	0.136 ± 0.005 b	237.39 ± 40.00 a	13.99 ± 2.26 a	5.89 ± 0.01 b

Values with same letter are not significant at 5% level.

young developing ramets. Comparing the amount of ^{15}N incorporated in each segment between the four clones, clone 2 contained the highest amount of ^{15}N in the initial plant, ramet I and ramet II significantly. Generally it appears that the increase in accumulation of nitrogen is closely related to the increase in biomass (Oki et al., 1981), it is necessary, therefore, to compare growth and nitrogen uptake between the four clones. Data on growth and nitrogen uptake of each clone are presented in Table 2. At the starting of the experiment, initial ramets still had the same morphological features as their original plants for 40 day's culture prior to this experiment, so that initial dry weight of each clone was different. Though the biomass per pot at harvest time was affected by dry weight of initial plants, the relative growth rate was similar except clone 4. The amount of total Kjeldahl nitrogen (TKN) in tissue per pot was found to be related to the biomass at harvest time, while those of total ^{15}N was not so closely related. As a result, the total ^{15}N/TKN ratio in tissue showed significant difference without relation to the biomass. Comparing with phosphorus which indicated that 21-50% of the absorbed ^{32}P was mobile and leached from plants in 6 days (Haller et al., 1970), the amount of leaching ^{15}N absorbed by initial plant during exposure to $^{14}NH_4Cl$ for 25 days was 0% in clone 1, 11.61% in clone 2, 19.43% in clone 3 and 20.47% in clone 4, respectively. From these results, it is suggested that in clone 2 with the long-styled form, nitrogen was more rapidly absorbed and transported to the next generation. However, further work is necessary to confirm whether the difference of nitrogen uptake pattern among biotypes of water hyacinth occur or not.

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CHEMICAL CONTROL OF *Mimosa pigra* L. IN (NORTHERN) THAILAND BY AERIAL SPRAYING

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ABSTRACT

Aerial applications of promising herbicides for controlling giant mimosa (*Mimosa pigra* L.) were conducted at Kew–Lom reservoir, Lampang province during the 1981 wet season and dry season of 1982. This plant has become a serious pest of irrigation ditches, reservoirs and roadside ditches in Northern Thailand and is begun to spread to the Central region. Result from the 1981 experiment indicated that when sprayed by helicopter glyphosate (N-(phosphonomethyl) glycine) at 12.5 and 25.0 *liters* (product)/*ha* in 125, 250 and 375 *liters* of water/*ha* gave the best control of *Mimosa pigra* L. throughout 365 days experimental period while application of forsamine (ammonium ethyl carbomoyl-phosphonate) at 18.75 and 31.25 *liters* (product)/*ha* in the same amount of spray solution did not provide satisfactory control. Results from the 1982 experiment suggested that foliar application of glyphosate, picloram (4–animo–3, 5, 6–trichloropicolinic acid) and triclopyr [(3, 5, 6–trichloro–2–pyridinyl) oxy] acetic acid at the rate of 6.25 and 12.5 *liters* (product)/*ha* and dicamba (3, 6–dichloro–o–anisic acid) at rates of 12.5 and 25.0 *liters* (product)/*ha* in 62.5 and 125 *liters* of spray volume provided good control of *Mimosa pigra* L. throughout 120 days. Regrowth from lower part of the weeds was found after 120 days from treatments applied at low spray volume. Deep flooding at the end of the rainy season provided complete control of the regrowth.

INTRODUCTION

Giant mimosa (*Mimosa pigra* L.) was introduced to Thailand from Indonesia as a green manure crop in 1952 (9). Because of its high adaptability of Thai conditions, this plant has become a noxious weed along rivers, streams and swamp areas in the northern part of the country. Control measures involving both mechanical and hand methods have given poor results (9, 12). Chemical control was first introduced in 1975 in an effort to improve efficiency. Foliar application of several systemic and nonsystemic herbicides on giant mimosa were evaluated under field conditions in Chiengmai and Lampoon provinces. Systemic herbicides such as 2, 4–D (2, 4–dichlorophenoxy acetic acid) and 2, 4, 5–TP showed a higher efficacy for controlling giant mimosa and some woody species than contact herbicides such as paraquat (1, 1 'dimethyl–4, 4' dipyridinium ion) (9, 10).

Adequate coverage of foliage is a prime requisite for an effective spray system. For example, it was found that 11 droplets per square centimeter was optimum in order to maintain effectiveness of 2, 4, 5–T on honey mesquite (*Prosopis juliflora* (Swartz) DC.) (2).

Herbicide combinations can often broaden the spectrum of effectiveness where resistant species occur in mixed stands of brush. Combinations of pricloram + 2, 4-D or 2, 4, 5-T improved control of some woody species which were resistant to phenoxy herbicide alone (8). The uptake and transport of 2, 4, 5-T in woody species was decreased in the presence of picloram, but the uptake and transport of picloram itself was increased in the presence of 2, 4, 5-T (4). Air temperature had a greater effect than relative humidity on absorption of 2,4, 5-T by honey mesquite (10).

The objective of this study was to evaluate the effectiveness of promising herbicides applied to control giant mimosa on a large scale by aerial means.

MATERIALS AND METHODS

The test site was located in Kew Lom Reservoir, Lampang province 642 *Kilometers* North of Bangkok whose elevation is 241 *meters* above sea level. Average annual rainfall within the area is 1,079 *mm*. The maximum and minimum temperatures are approximately 32.6°*C* and 20.2°*C* respectively. Sunshine averages approximately 8.0 hours per day.

Water depth in the test area reaches a maximum of 3.5–4.0 *meters* in December or January but the reservoir is completely dry in May and remains in this state for about 4 months before the monsoon flooding begins.

Herbicides used in 1981 were glyphosate 41% (N-phosphonomethyl) glycine at 12.5 and 25.0 *liters* (product)/*ha* and fosamine 42% (ammonium ethyl carbo-moylphosphonate) at 18.75 and 31.25 *liters* (product)/*ha* with 125, 250 and 375 *liters* of spray solution/*ha*. In 1982, test herbicides included glyphosate, picloram 49.8% (4-amino-3, 5, 6-trichloropicolinic acid) and triclopyr 48% [(3,5, 6-trichloro-2-pyridinyl) oxy] acetic acid at 6.25 and 12.5 *liters* (product)/*ha* and dicamba 40.6% (3, 6-dichloro-o-amisic acid) at 12.5 and 25.0 *liters* (product)/*ha* in 62.5 and 125 *liters/ha* of spray volume.

Age of the natural growth of giant mimosa within the test area was estimated to be 4–5 years old with heights ranging mostly from 4.0–4.5 *meters*.

Spraying was conducted with a "Hiller 305" helicopter travelling at 20 knots equipped with a 160 *liter* spray tank and 59 nozzles on a 9.7 *meter* spray boom which covered 10 *meters* each swath. All applications were made near plant-top level. Time of application was between 8*A.M.* to 4 *P.M.* in 1981 and between 8.00–11.00 *A.M.* in 1982.

A randomized block design with two replications was used in this test. Plot size measured 20 × 320 *meters* or 6,400 Square *meters*. Data were collected from the middle of each plot. Visual observations were made at 30 day intervals using a 0–10 point scale throughout the 12 months study.

RESULTS AND DISCUSSION

Data collected in the 1981 wet season are summarized in Table 1. Results show that within the first month after application of "forsamine" and "glyphosate" on a natural growth of mimosa in "Kew Lom" reservoir more than 90 *percent* of the giant mimosa was defoliated. Glyphosate showed more effect than "forsamine".

Table 1. Performance of glyphosate and forsamine for giant mimosa control by aerial application at "Kew Lom" reservoir, Lampang 1981.

Treatments	Rate *Lts (mat)/ha*	Spray Vol. *Lts/ha*	Performance (d.a.t.) 30	100	120	180	240	365
1. forsamine	18.75	375	7.0	4.0	2.0	0	0	0
2. forsamine	31.25	375	9.0	6.0	5.0	3.0	0	0
3. glyphosate	12.5	375	10.0	9.5	10.0	10.0	10.0	10.0
4. glyphosate	25.0	375	10.0	10.0	10.0	10.0	10.0	10.0
5. glyphosate	12.5	125	10.0	9.5	9.5	9.5	9.0	9.0
6. glyphosate	25.0	125	10.0	10.0	10.0	10.0	10.0	10.0
7. forsamine	18.75	125	7.0	4.0	3.0	0	0	0
8. forsamine	31.25	125	8.0	6.0	4.0	3.0	2.0	0
9. forsamine	18.75	250	7.0	4.0	2.0	0	0	0
10. forsamine	31.25	250	8.0	6.0	5.0	3.0	0	0
11. glyphosate	12.5	250	9.0	9.5	7.5	5.0	4.0	4.0
12. glyphosate	25.0	250	10.0	10.0	8.0	7.0	4.0	4.0

Remarks :
Performance : visual observation using a 0 to 10 scale with 10 being 100% defoliation
d.a.t. : days after treatment

At the end of the first 30 days after treatment, "glyphosate" at 12.5, 25.0 *liters* (product)/*ha* in 125, 250 and 375 *liters* of spray solution provided approximately 90–100 *percent* defoliation when compared with "forsamine" at 18.75 and 31.25 *liters* (product)/*ha* in the same amount of spraying volume which resulted in 70 to 90 *percent* defoliation.

At 100 days after treatment, the killing action of "glyphosate" appeared to be at a satisfactory level with complete defoliation noted on plants treated at both rates at all three levels of spraying solutions. The killing action of "forsamine" declined with time.

Regrowth from stems was observed on plants treated with "forsamine". The chemical apparently was not mobile within the plants because the tops of the plants were defoliated but the lower branches remained green. Similar results were observed at 120 days following application of "forsamine".

At 180 days following treatment continued regrowth was found on forsamine treatments with the lower rate showing almost complete regrowth.

Application of "glyphosate" at both low and high rates with 125 and 375 *liters* of water/*ha* provided satisfactory results but application of the same concentrations in 250 *liters* of water showed approximately 50 and 30 *percent* regrowth. Similar results were recorded at 240 days after treatment.

At the final checking, or at 365 days after chemical application, results showed that "glyphosate" at 12.5 and 25.0 *liters* (product)/*ha* in 125 and 375 *liters* of spray volume gave 90–100 *percent* control of giant mimosa but application of the same rates in 250 *liter/ha* of spraying solution resulted in 60 percent regrowth. All spray treatments with forsamine showed complete regrowth one year after spraying was done.

Results from the 1982 dry season are listed in Table 2. Data indicate that herbicides such as dicamba, glyphosate, picloram and triclopyr showed fast top killing action within 30 days after application under dry condition of "Kew Lom" area. Complete defoliation of the leaves and complete killing of the top plant parts was noted 60 days after treatment. Visual observations indicated no differences among treatments during the 60 day after spraying.

Table 2. Performance of dicamba, glyphosate, picloram and triclopyr for giant mimosa control by aerial application at "Kew Lom" reservoir, Lampang 1982.

Treatments	Rate *Lts (mat)/Rai*	Spray Vol. *Lts/ha*	Performance (d.a.t.) 60	120	180	240	365
1. dicamba	12.5	62.5	10.0	9.5	8.0	10.0	10.0
2. dicamba	12.5	125.0	10.0	10.0	10.0	10.0	10.0
3. dicamba	25.0	62.5	10.0	10.0	10.0	10.0	10.0
4. dicamba	25.0	125.0	10.0	10.0	10.0	10.0	10.0
5. glyphosate	6.25	62.5	10.0	10.0	8.0	10.0	10.0
6. glyphosate	6.25	125.0	10.0	10.0	10.0	10.0	10.0
7. glyphosate	12.5	62.5	10.0	9.5	8.5	10.0	10.0
8. glyphosate	12.5	125.0	10.0	10.0	10.0	10.0	10.0
9. picloram	6.25	62.5	10.0	8.5	8.0	10.0	10.0
10. picloram	6.25	125.0	10.0	10.0	9.0	10.0	10.0
11. picloram	12.5	62.5	10.0	8.5	8.0	10.0	10.0
12. picloram	12.5	125.0	10.0	10.0	9.0	10.0	10.0
13. triclopyr	6.25	62.5	10.0	9.0	7.0	10.0	10.0
14. triclopyr	6.25	125.0	10.0	10.0	8.0	10.0	10.0
15. triclopyr	12.5	62.5	10.0	9.5	7.5	10.0	10.0
16. triclopyr	12.5	125.0	10.0	9.5	8.5	10.0	10.0

Remarks : performance : visual observation using a 0 to 10 scale with 10 being 100% defoliation
d.a.t. : days after treatment

Records at 120 days after application showed slight differences in the degree of efficacy for all four tested compounds compared to 60 days following spraying.

Observations made at 180 days after application indicated that dicamba at 12.5 and 25.0 *liters* (product)/*ha* and glyphosate at 6.25 and 12.5 *liters* (product)/*ha* in 125 *liters* of spraying volume gave complete control similar to the first 30 day checking but application of both herbicides at the same rates using 62.5 *liters* spray volume gave less control with time and regrowth was observed on the lower parts of the stems. Regrowth was also recorded from plots treated with picloram and triclopyr at 6.25 and 12.5 *liters* (product)/*ha* in 62.5 and 125 *liters* of spraying solution.

A better degree of control was detected from all treatments at 240 days after application and absolute control was obtained after 240 days and up to 360 days after application due to the increasing water level in the reservoir at the end of the rainy season.

Visible toxicity to near-by vegetation indicated that glyphosate was highly selective on many broadleaf species other than grasses. Dicamba on the other hand should high selectivity for grasses while the rest of the tested compounds did not show any selectivity for grasses or broadleaf plants.

Forsamine and glyphosate showed similar defoliation action on natural growth of giant mimosa at 30 days after application but the effectiveness of glyphosate increased with time and a high water level in the "Kew Lom" reservoir. This suggests that high moisture conditions speeded up glyphosate activities (7). The increase in glyphosate action might relate to its classification as an ambimobile rather than a specific phloem-mobile herbicide (5).

The visible toxicity obtained from application of forsamine indicated that it did not translocate within the plant and its activities decreased with time. Good coverage of all the leaves and green plant parts is important for effectiveness of forsamine. A spray volume less than 200 *liters/ha* is not sufficient for forsamine to control plants taller than 1.5 *m* in height (11).

Time of application is also critical for aerial control of giant mimosa. Treatments applied in the morning allowed plants to absorb more chemical than when applied later in the afternoon of the same day.

Data collected from the dry season experiment indicated that foliar application under dry conditions stimulated absorption and translocation of all four tested compounds. Deep penetration through both apoplast and symplast portions of the plants by dicamba and glyphosate resulted in better control of giant mimosa when compared with picloram and triclopyr in the first 6 months. The minimum spraying volume for aerial control of natural growth giant mimosa is 125 *liters/ha* or more (11). Suitable spraying time for best control is from morning up until noon.

The results presented in this paper suggest that *Mimosa pigra* can be controlled if the proper herbicides, spray volume and timing are used. Economics of using the aerial spray procudure have not yet been worked out.

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HERBICIDAL ACTIVITIES OF CHLORINATED ISOPROPYLPHENOXYACETIC ACIDS AND THEIR DERIVATIVES

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ABSTRACT

Four compounds were prepared from isopropylphenol derivatives and monochloroacetic acid, and investigated the inhibition of elongation for root and shoot at the germination stage (in vitro test), and also herbicidal activity on young plants (in vivo test).

The results of these tests were as follow:

(a) 2–Chloro–4–isopropylphenoxyacetic acid showed strong activity by germination test for inhibiting elongation of root, and inhibiting shoot elongation of radish and lettuce.

(b) 2, 6–Dichloro–4–isopropylphenoxyacetic acid and 4–isopropylphenoxyacetic acid were no–effective in these tests.

(c) 3–Isopropylphenoxyacetic acid showed activity by germination test and small activity by spray test without reference to having chlorine atom.

INTRODUCTION

Some isopropylphenoxyacetic acids and their halogenated derivatives were synthesized, and investigated their herbicidal activities. Authors described and discussed herein their herbicidal activities on three kinds of test plants by the germination test *(in vitro),* and on six kinds of plants by spray test *(in vivo).*

MATERIALS AND METHODS

The compounds of isopropylphenoxyacetic acids and their derivatives were prepared by the reaction of corresponding phenol derivatives and monochloroacetic acid.

The compounds prepared were as follow:

Compound	Chemical name
(I)	4–isopropylphenoxyacetic acid
(II)	3–isopropylphenoxyacetic acid
(III)	2–chloro–4–isopropylphenoxyacetic acid
(IV)	2, 6–dichloro–4–isopropylphenoxyacetic acid

The structure of these compounds were confirmed by G.C. IR and NMR spectrometer.

Herbicidal activity was investigated by germination test *(in vitro)* using rice, radish and lettuce, at the concentration 0.1, 1, 10, 100 *ppm*, and also by spray test in green house using the plants of 2–3 stage of leaves of two monocotyledonous, and four dicotyledonous species at the concentration of 100 *ppm*.

Herbicidal activities were determined 5 days after treatment by germination test and 10 days by spray test. The activities were indicated by dividing the damage of test plants into six ranks of visual standard, from non–effect (0) to complete–kill (5).

RESULTS AND DISCUSSION

The results of these tests were summarized in Table 1 and 2. Major points to note are:

(a) 2–Chloro–4–isopropylphenoxyacetic acid (Comp. III) showed strong activity by germination test to inhibition of elongation of root, and the activity of inhibiting shoot elongation was strong against radish and lettuce.

(b) 2, 6–Dichloro–4–isopropylphenoxyacetic acid (Comp. IV), and 4–isopropylphenoxyacetic acid (Comp. I) were no–effective by germination test.

(c) 3–Isopropylphenoxyacetic acid (Comp. II) showed activity by germination test and also activity by spray test without reference to having chlorine atom in chemical structure.

(d) 2, 4–D (reference sample) showed the most strong activity except the elongation test on rice.

(e) In case of spraying test, the concentration of 100 *ppm* of compound (III) showed good activity to dicotyledonous plants, and weak activity to monocotyledonous plants.

(f) It is necessary that one ortho position of OH group must be unoccupied as 2, 4–D for the activity.

Having investigated herbicidal activities of isopropylphenoxyacetic acids and their derivatives, we would like to report of some results.

Table 1. Germination test (Examined 5 days after treatment)

		Root									Shoot								
		Rice			Radish			Lettuce			Rice			Radish			Lettuce		
Compound	*ppm*	100	10	1	100	10	1	100	10	1	100	10	1	100	10	1	100	10	1
I		0	0	Es	1	Es	0	1	0	0	0	0	0	Es	0	0	1	0	0
II		4	3	1	4	3	2	3	2	1	0	0	0	3	2	0	3	2	1
III		4	4	2	4	4	3	4	3	2	Es	0	0	4	3	1	4	3	2
IV		1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0
2, 4–D (Ref.)		5	5	4	5	4	4	5	4	2	El	Em	0	5	4	3	5	4	2

Remarks: El: large elongation, Em: middle elongation
Es: small elongstion

Table 2. Spray test (Pot test)
(Concentration: 100 *ppm*)
2–3 leaves stage of plant

No. of Compound	Days after treatment	Rice	Barnyard grass	Radish	Lettuce	Tomato	Cucumber
I	2	0	2	0	0	0	2
	10	0	2	0	0	0	1
II	2	0	2	0	0	1	2
	10	0	0	0	1	1	2
III	2	0	1	1	3	4	2
	10	0	1	5	4	4	3
IV	2	0	1	2	0	0	2
	10	0	0	0	0	0	0
2, 4–D (Ref.)	2	0	3	2	3	4	3
	10	4	4	5	5	5	4
MCP (Ref.)	2	1	1	4	3	3	2
	10	1	0	5	4	4	2

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