as a source of feed for pigs or as a handicraft materials has been practiced among farmers.

Table 4. The most abundant aquatic plant present in Thailand (Thamasara, 1983).

Plant Species	Part	Aquatic Systems
1. *Eichhornia crassipes*	C, NE, N, S	canals, rivers, lakes
2. *Mimosa pigra*	N, C	canals, lakes, rivers
3. *Hydrilla verticillata*	N, NE, S	lakes, canals
4. *Potamogeton malaianus*	NE, S, C	canals, lakes
5. *Coix aquatica*	C	canals, rivers
6. *Salvinia cucullata*	NE, C	lakes
7. *Najas graminea*	N, NE	canals, lakes
8. *Eleocharis dulcis*	NE	lakes
9. *Pistia stratiotes*	N, C	lakes
10. *Colocacia esculentum*	C, NE	rivers, lakes
11. *Nymphaea lotus*	C, NE	rivers, lakes

N.B. C = Central Region N = Northern Region
NE = Northeastern Region S = Southern Region

CONCLUSION

Though possible utilization of aquatic weeds is considered in various countries, studies in Japan have focussed on water hyacinth's use as water purifier, animal feed and in biogas production. Also the cultivation of water hyacinth like a crop under near-optium condition has been practiced to obtain a specific amount of production. However, the cost of harvesting, drying up and processing the plants by present techniques prohibits commercial exploitation. Also as water hyacinth is cold sensitive, the use of this plant is limited seasonally and geographically in Japan. Currently in Japan, the interest of the public, the Government and private industries to utilizing water hyacinth is increasing, and this has resulted in establishing the Waterhyacinth Society of Japan in 1982. In the near future, the most appropriate system for water hyacinth utilization will be established.

Nowadays, in the U.S.A., studies refer to utilization of aquatic weeds have focussed on only wastewater treatment and gasification system. Reddy (1983) reported that data bases will need to be developed in the following areas for better understanding of the biological, nutritional, and cultural aspects of the aquatic weeds before aquatic weeds are cultured in large scale energy farms ;

(1) Search, select and identify genetic variability of plants for their potential high biomass yields and nutrient removal.
(2) Develop methods of propagation, planting and seed collection.
(3) Establish photosynthetic rates of aquatic weeds under a variety of nutrient, pH, light, and temperature regimes.

(4) Determine growth rate of selected aquatic weeds.
(5) Plant nutrition - characterize different sources of water medium, and identify the limiting plant nutrient. Determine seasonal variations in plant uptake.
(6) Develop cultural methods for maximum yields (plant density, frequency of harvesting in mono and polyoculture systems).
(7) Develop suitable harvesting methods.
(8) Determine evapo-transpiration losses of water.
(9) Develop techniques to reduce phosphorus levels of wastewater leaving biomass production systems.
(10) Develop methods to store surplus biomass.
(11) Develop integrated pest management schemes.

Concerning economic considerations, it's considered that harvesting is the only major cost involved in aquatic plant biomass production, however, at this time, economical harvesting method are not available and further research should aid in developing low cost harvesters.

While in Thailand, most aquatic weeds has grown through the year. so that Thailand seems to be an ideal location to establish energy farms with aquatic weeds and to get the production of high biomass yields year around compared with Japan. In near future it is hoped that Thailand will be successful in establishing an effective aquatic weed management included utilization.

REFERENCES

Oki, Y. (1983): Potential utilization of water hyacinth in Japan. Proc. of the 9th APWSS Conf. (Suppl) 588-593.

Reddy, K.R. et al. (1983) : Freshwater aquatic plant biomass production in Florida. Soil and Crop Sci. Soc. of Florida Proc. Vol. 42, 28-40.

Thamasara, S. (1983) : Aquatic weed problem in Thailand. The First Tropical Weed Sci. Conf., Vol. 1, 149-161.

WEED CONTROL IN RICE

Prasan Vongsaroj, Sombat Chinawong
Ausvin Notaya and Jamrus Lekkum

1. INTRODUCTION

Weed is a main problem for rice production improvement in all method of plantings which can frequently be seen from the requests of farmers pass through the government for solving weed problem in various places for example Potamogeton sp. at Lumphun province, Dactyloctenium aegyptium, Ageratum conyzoides at Chiang Mai province, Chara zeylanica at Nakhon Ratchasima, Sukhothai and Surat Thaini province, Sphenoclea zeylanica, Marsilea crenata, Cyperus difformis at Suphanburi, Ratchaburi, Chachoengsao province, Echinochloa crus-galli at Suphanburi, Chachoengsao, Samut Sakhon province, Oryza ridleyi at Prachin Buri, Songkhla and Nakhon Si Thammarat and Ischaemum rugosum; Echinochloa colona at Ayutthaya province. The variation of land preparation of each method of planting which has different moisture content, creat more weeds problem than other crops and lead to lower yield. Although the government is trying to improve rice production per area but it can not prevent yield from lossing by weeds and degree of losses will depend on method of plantings. So it is necessary to reduce the losses due to weeds to be minimal or nons. There is a possibility to make such target by all means from every step of rice growing, must be raised to serious consideration. The efficacy of each method of weed control should be emphasized as well as trained farmers. Therefore, factors concerned on weed control should be strong consideration namely : land for rice growing, kind of weeds, well trained farmer; advantage and disadvantage of weed control method to get the most effective management method in term of practical term to farmers. And then yield losses due to weeds will be minimized, which will partly influence the improvement of rice production to be on the target.

2. WEEDS AND METHODS OF PLANTING

In Thailand, rice generally grows in several methods which depend on limiting factors namely topography, soil moisture and weeds problem that cause development the method of growing. The method of planting are :

2.1 Upland rice is a method of growing in a field crop condition either lowland or highland. This method of planting is done for family consumption in the Northern and Southern part of Thailand by direct seeding. The maximum yield is not more than 1.87 ton/ha, it is low because of weeds and lack of proper land preparation for stimulating weed germination for control. The main weeds found in upland are similar to weeds of field crops, consisted of grasses (2.1.1-2.1.8) broadleaves (2.1.9-2.1.16) and sedges (2.1.17):

2.1.1 Dactyloctenium aegyptium (L.) P. Beauv.
2.1.2 Digitaria adcendens (HBK.) Henr.
2.1.3 Eleusine indica (L.) Gaertn.
2.1.4 Eragrostis tenella (L.) Beau.
2.1.5 Panicum repens Linn
2.1.6 Cynodon dactylon Pers.

2.1.7 Chloris barbata SW.
2.1.8 Brachiaria repens L.
2.1.9 Ageratum conyzoides Linn.
2.1.10 Amaranthus viridis Linn.
2.1.11 Commelina banghalensis Linn.
2.1.12 Eurphobia hirta Linn.
2.1.13 Gomphrena celosiodes Mart.
2.1.14 Heliotropium indicum Linn.
2.1.15 Mollugo pentaphylla Linn.
2.1.16 Phyllanthus nururai Linn.
2.1.17 Cyperus rotundus Linn.

2.2. Dry seeded rice is method that rice seeds are broadcasted in a plowed land without or with harrowing and wait for the moisture from the rain to promote germination, normally do in the Central Plain and the South. This method of planting generally seed in the early of rainy season because it is lowland condition and will be flooded quickly later in this season (deepwater rice) otherwise rice seedling can not be survived. It is an economic method, the yield is generally as high as 3.25 ton/ha. Weeds germinate at the same time with rice seeds that cause severe competition between rice and weeds especially grasses and at last reduce rice yield production. The infestation of weeds is not so severe as upland rice because it is flooded at the middle of rainy season which kill some weed such as Echinochloa colona. Main weeds are grasses (2.2.1-2.2.9), broadleaves (2.2.10-2.2.16), sedges (2.2.18) and fern (2.2.17) :

2.2.1 Echinochloa colona (L.) Link
2.2.2 Hymenachne pseudointerrupta C. Muel.
2.2.3 Ischaemum rugosum Salisb.
2.2.4 I. barbatum Retz.
2.2.5 Leersia haxandra SW.
2.2.6 Oryza ridleyi Hook. S.
2.2.7 Setaria geniculata Lamk.
2.2.8 Panicum cambogiense Balansa
2.2.9 Echinochloa picta (Koen) Michael.
2.2.10 Cyanotis axillaris Roem. & Schult
2.2.11 Aeschynomene indica Linn.
2.2.12 Ipomoea aquatica Forsk.
2.2.13 Melochia corchorifolia Linn.
2.2.14 Pentapetes phoenicea Linn.
2.2.15 Utricularia aurea Lour.
2.2.16 Nymphaea nouchari Burm. S.
2.2.17 Marsilea crenata Presl.
2.2.18 Cyperus rotundus Linn.

2.3 Transplanted rice is a method of growing rice from seedling which can be prepared in a nursury bed after plowing; puddling and divided into a small plot for seeding. Twenty to thirty days after seeding, seedling will be hand-pulled and transplanted in well prepared land with plowing, harrowing and puddling. Transplanting will be made in muddy condition. Weeds problem is less than other method of growings because the height of rice seedling is about 20-30 cm at the time of transplanting which can compete with weeds. Main weeds in transplanted rice are grasses (2.3.1-2.2.2), broadleaves (2.3.4-2.3.6), sedges (2.3.7-2.3.9), fern (2.3.10) and algae (2.3.11) :

2.3.1 Echinochloa crus-galli L. Beauv.
2.3.2 Leptochloa chinesis (L.) Nees.
2.3.3 Echinochloa colona (L.) Link
2.3.4 Sphenoclea zeylanica Gaertn.
2.3.5 Mimulus orbicularis Benth
2.3.6 Monochoria vaginalis Burm. f. Presl.
2.3.7 Cyperus difformis Linn.
2.3.8 Fimbristylis miliacea (L.) Vahl.
2.3.9 Eleocharis dulcis (Burm f.) Henschel
2.3.10 Marsilae crenata Presl.
2.3.11 Chara zeylanica KL. ex. Willd

2.4 Pre-germinated direct-seeded rice is similar to transplanted method in stage of seed bed nursury but it does in bigger area and the seed rate is reduced. Weeds are also similar to transplanted method but an infestation is more severe than transplanting. Therefore the achievement of pre-germinated direct-seeded rice is to control weeds otherwise yield of this method will be limited by weeds.

It is shown the list of weeds in each method of planting are mostly different except between transplanted rice and pre-germinated direct-seeded rice. By mean of unequal infestation of weeds in each method of planting, it has been developed for loss infestation of weeds which it is shown from first year of growing in upland condition with no weeds; but the second or third year, heavy weed infestation will be started because of distribution of weeds from other places. The farmers solve weeds problem by moving to a new deforestation for growing rice. In the same way, in lowland rice that dry seeded rice method is always done but the infestation of weeds is severe so transplanted rice is found for loss weed problem. Although, transplanted rice faces with less weeds problems but nursury bed preparation, hand pulled seedling, transplanting consume labour and higher investment, then transplanted rice has been developed to pre-germinated direct-seeded rice. The last developed method also faces weeds problem as well as dry-seeded rice but this bottle neck can be solved by our new adopt technology which is the policy of the Thai Government at present time.

3. METHOD OF CONTROL

A single method of weed control in rice will not be achieved, so every step in growing rice in each method should be considered as below :

3.1 Upland rice and dry-seeded rice

Treatment	Time of application	Target weeds	Remarks
1. Land preparation	Two times : at the present of weeds and when new weeds come up.	Most of weeds	Adequate plowing for land preparation, and harrowing after seedling is very effective to reduce weed population.
2. Manual weeding	30 days after emergence of rice	All weed species	

Treatment	Time of application	Target weeds	Remarks
3. Herbicide application			
Bifenox 2 kg a.i./ha	After seeding and harrowing	Grasses and broadleaves, i.e.(2.2.1, 2.2.2) in lowland and deepwater rice and (2.1.1) in upland rice.	Mix with water and spray
Pendimethalin 2 kg a.i./ha	(ditto)	Grasses (i.e. 2.2.1) and broadleaves (2.1.15)	
Oxidiazon 1 kg a.i./ha	(ditto)	Grasses (i.e. 2.2.1, 2.2.3) and broadleaves (2.1.15)	
2,4-D 1 kg a.i./ha	15-20 days after the emergence of rice seeds or 3-4 leaved stages of weeds	Broadleaves and sedges, i.e. (2.2.11,2.2.12, 2.2.13) in lowland and deepwater rice and (2.2.15) upland rice	Amine and sodium salt give better control than does ester one. Water should be drained out before spraying in lowland and deepwater rice.
Propanil 2 kg a.i./ha	(ditto)	Grasses weeds, i.e.(2.2.1, 2.2.3) in lowland and deepwater rice and (2.2.1) in upland rice	Do not use carbamate and organophosphate pesticides during 1-2 weeks after propanil usage. Water should be drained out before spraying in lowland and deepwater rice.
Propanil+2,4-D (1.50+0.75)2.25 kg a.i./ha	(ditto)	Grasses, broadleaves and sedges i.e. (2.2.1,2.2.7, 2.2.13,2.2.14) in lowland and deepwater rice and (2.1.1,2.1.9) upland rice	See "propanil"

Treatment	Time of application	Target weeds	Remarks
Ioxynil+2,4-D (0.14+0.86) 1 kg a.i./ha	15-20 days after the emergence of rice seeds or 3-4 leaved stages of weeds	Broadleaves and sedges, i.e. (2.2.12,2.2.13, 2.2.14) in lowland and deepeater rice	
Propanil+ thiobencarb, (0.67+1.33) 2 kg a.i./ha	(ditto)	Grasses and broadleaves, i.e.(2.2.1, 2.2.3,2.2.13) in lowland and (2.1.1,2.1.16) in upland rice	See "propanil"
Propanil+ molinate (1+1) 2 kg a.i./ha	(ditto)	Grasses weeds, i.e.(2.2.1) in lowland and deepwater rice and (2.1.1,2.1.2, 2.1.3) in upland rice	See "Propanil"

3.2. Transplanted rice

Treatment	Time of application	Target weeds	Remarks
1. Land preparation	Before transplanting	Perrenial weeds	Remove perennial weeds by plowing harrowing
2. Water management	After transplanting	Weed species germinated under a dry or moist condition	Ten cm. of water depth prevents weed emergence, Especially some of annual grasses and some sedges
3. Manual weeding, hand weeding, footing, hand rotivating	30 days after transplanting	All weed species	-
4. Herbicides application			
2,4-D 1 kg a.i./ha	5-8 days after transplanting	Broadleaves and sedges, i.e. (2.3.4,2.3.8)	Any formulation of 2,4-D can be used, but water should maintain 5-10 cm. depth at the

Treatment	Time of application	Target weeds	Remarks
			time of application and other 7 days
Thiobencarb 2 kg a.i./ha	5 days after transplanting	Grasses, broad-leaves and sedges i.e.(2.3.1,2.2.4, 2.3.7)	Water depth at the time of application should be maintained 5-10 cm depth and other 7 days
Bifenox 2 kg a.i./ha	(ditto)	The same as "thiobencarb"	See "thioben-carb"
Butachlor 1 kg a.i./ha	(ditto)	Grasses, i.e. (2.3.1,2.3.2)	See "thiobencarb"
CNP 2 kg a.i./ha	(ditto)	The same as "thiobencarb"	See "thiobencarb"
Molinate 2 kg a.i./ha	(ditto)	Grasses (2.3.1, 2.3.2)	See "thiobencarb"
Oxadiazon 1 kg a.i./ha	(ditto)	Grasses, broad-leaves, sedges and algae, i.e. (2.3.1,2.3.4, 2.3.7,2.3.11)	See "thiobencarb"
Oxadiazon+ 2,4-D (0.5+ 0.5) 1 kg a.i./ha	(ditto)	The same as "thiobencarb" and 2.3.10	See "thiobencarb"
Piperophos+ dimethametryn (0.60+0.15) 0.75 kg a.i./ha	(ditto)	The same as "oxadiazon+ 2.4-D"	See "thiobencarb"
2,4-D 1 kg a.i./ha	15-20 days after transplanting or 3-4 leaved stages of weeds	Broadleaves and sedges i.e. (2.3.6,2.3.8)	Amine and Sodium salt formulation give better control than does ester one
Propanil 2 kg a.i./ha	(ditto)	Grassy weeds	Do not use car-bamate, organo-phosphate pesti-cide at 1-2 weeks before and after propanil usage

Treatment	Time of application	Target weeds	Remarks
Propanil+ 2,4-D (1.5+ 0.75) 2.25 kg a.i./ha	15-20 days after transplanting or 3-4 leaved stages of weeds	Grasses, broad-leaves and sedges, i.e.(2.3.1,2.3.4, 2.3.7)	See "propanil"
Ioxynil+ 2,4-D (0.14+ 0.86) 1 kg a.i./ha	(ditto)	Broadleaves and sedges i.e. (2.3.4,2.3.7)	
Propanil+ thiobencarb (0.67+1.33) 2 kg a.i./ha	(ditto)	Grasses, broad-leaves and sedges, i.e.(2.3.1,2.3.4, 2.3.7)	See "propanil"
Propanil+ molinate, (1+1) 2 kg a.i./ha	(ditto)	Grasses, i.e. (2.3.1,2.3.2)	See "propanil"

3.3. Pre-germinated direct-seeded rice

Treatment	Time of application	Target weeds	Remarks
1. Land preparation	Before seeding	Most of weeds	Even land leveling after plowing and harrowing is important for weed control
2. Water management	From the 4th day ater seeding		The water level gradually, increases to the certain depth, 5-10 cm.
3. Herbicide application			
Thiobencarb 2 kg a.i./ha	8-10 days after seeding	Grasses, broad-leaves and sedges, i.e. (2.3.1,2.3.4, 2.3.7)	Water depth at the time of application should be maintained 5-10 cm.
Bifenox 2 kg a.i./ha	(ditto)	The same as "thiobencarb"	See "thiobencarb"
Butachlor 1 kg a.i./ha	(ditto)	Grasses and sedges, i.e. (s.3.1,2.37)	See "thiobencarb"
CNP 2 kg a.i./ha	(ditto)	The same as "thiobencarb"	See "thiobencarb"

Treatment	Time of application	Target weeds	Remarks
Oxadiazon 2 kg a.i./ha	8-10 days after seeding	The same as "thiobencarb"	See "thiobencarb"
DPX 5384 25 gm a.i./ha	(ditto)	The same as "thiobencarb"	See "thiobencarb"
Pretialachlor 0.75 kg a.i./ha	(ditto)	The same as "thiobencarb"	See "thiobencarb"
Oxadiazon+ (1+1) 2 kg a.i./ha	(ditto)	Grasses, broadleaves, sedges and fern, i.e. (2.3.2,2.3.4, 2.3.7,2.3.10)	See "thiobencarb"
Piperophos+ dimethametryn (0.65+0.15) 0.75 kg a.i./ha	(ditto)	Grasses, broadleaves, sedges and fern, i.e. (2.3.2,3.2.4, 2.3.7,2.3.10)	See "thiobencarb"
2,4-D 1 kg a.i./ha	15-20 days after seeding or 3-4 leaved stages of weeds	Broadleaves and sedges i.e. (2.3.1,2.3.2)	Amine and Sodium salt formulations give better control than does ester one
Propanil 2 kg a.i./ha	(ditto)	Grasses, i.e. (2.3.1,2.3.2)	Do not use carbamate pesticides at 1-2 weeks before and after propanil usage
Propanil+ 2,4-D (1.50+ 0.75) 2.25 kg a.i./ha	(ditto)	Grasses, broadleaves, sedges and fern, i.e. (2.3.1,2.3.4, 2.3.7,2.3.10)	See "propanil"
Ioxynil+ 2,4-D (0.14+ 0.86) 1 kg a.i./ha	(ditto)	Broadleaves, sedges and fern, i.e. (2.3.4,2.3.8, 2.3.10)	
Propanil+ benthiocarb (0.67+1.33) 2.10 kg a.i./ha	(ditto)	Grasses, broadleaves and sedges, i.e. (2.3.1,2.3.4, 2.3.7)	See "propanil"

Treatment	Time of application	Target weeds	Remarks
Propanil+ molinate (1+1) 2 kg a.i./ha	15-20 days after seeding or 3-4 leaved stages of weeds	Grasses	See "propanil"

4. CONCLUSION

Rice in Thailand can be grown in various method of plantings namely upland rice, dry seede rice uder lowland and deepwater; transplanting and pre-germinated direct-seeded rice. In each method will have specific habitat which suit to the occurence of a particular weed such as upland weeds and lowland weeds are different. Any environment which is similar to each other, weed species are the same as transplanted rice and pre-germinatinated direct-seeded rice.

Weed control in rice must be done in every step of growing rice, from seeding until harvesting which depend on kind of weeds and mtthod of plantings. Single method does not completely control weeds even herbicides usage. So it needs learning how to use properly as a recommendation and an integration of agricultural system such as land preparation, water management and herbicides usage, is emphasized in each method of plantings, then weed control in rice will be idially effective.

WEED CONTROL IN FIELD CROPS

Maneesa Teerawatsakul

In Thailand, there are usually various possible practices of weed control in field crops. The main factor involving weed problems is the kind of crops. Approximately 20 kinds of field crops can be grown obtionally on monotonously in more than 30 million rais of upland growing area of the country.

The type of weed control is also quite variable to growing seasons of respective crops. Mungbean is one of the field crops growing more than one time a year. Dry season growing mungbean requires less control of weeds than those of early in the season and late in the season.

Vigourousness of crop is an importance role, it allows crops to be able to compete with weeds. Sorghum, rosell, black gram are sown without weed control. On the contrary, cotton, tobacco etc. need very intensive control of weeds more than 2 times within one season.

Most of the field crops are grown under natural rainfall. The unpredictable rainfall is one of the major causes that restricts improvement of weed control practice as well as cropping system. Heavy rainfall frequently limits all of mechanical control methods in every kind of field crops. Many available measures of control are not utilized because of the irratic rainfall. Preemergence herbicides is not widely used because of lacking of rainfall for a long period after spraying. Multiple cropping pattern does not allow farmers to apply residual herbicides which may be toxic to susceptible crops followed by.

Increasing of labor cost is occured in Thailand since oil price crisis. However, hand weeding is the most common practice in all of field crops inspite of resulting yield losses to some extent . The data present in this paper are from many sources including a survey on the weeding status of farmers.

Table 1. Average times, labor requirement per rai for weeding and yield losses of some field crops with no weeding.

Crops	Weeding time	man-days/time/rai	Yield losses (%)
Sorghum	0-1	3.5	28
Muangbean	0-1	4.5	25
Soybean	0-1	4.5	30
Peanut	2-3	6.5	92
Corn	1-2	4.0	60
Tabacco	3-4	8.5	98
Cassava	2-3	4.5	85
Kenaf	0-1	3.0	30
Roselle	0-1	3.0	25
Jute	0-1	3.0	14
Cotton	3-4	6.5	98
Black gram	0-1	3.5	40
Job's tear	2-3	5.5	40

From 1960 up to the present time, changes in agricultural technology for production affect the weed control of Thai farmers. Traditional methods of control are still practical and economical for small farm. Modification of many weeding equipment to be efficient to local economic sitution is the most common practices such as

Rotary cultivator
Traditional wooden plow
Sprayers
Sprayer shield
Spray gun
Spray boom
Etc.

Limitation of an individual controlling method causes the farmers try to apply all possible means to minimize the competition with weeds. The following table shows the application of weed control methods available in some field crops in Thailand.

Table 2. Weed control practice and herbicide application in some field crops in Thailand.

Crops	Native plow	Hoe weeding	Sickle	Spraying	Herbicides
Corn	+	+	+	+	+ 2,4-D, paraquat, alachlor, metolachlor and atrazine
Cassava	+	+	+	+	+ paraquat, oxyfluorfen, alachlor and metolachlor
Tobacco	-	+	-	-	-
Peanut	-	+	-	+	+ alachlor, metolachlor
Sorghum	-	+	+	+	+ 2,4-D. paraquat
Job's tear	+	+	-	-	-
Soybean	+	+	+	+	+ paraquat, alachlor, metolachlor, oxyfluorfen, fluazifop-butyl, Dow 453
Mungbean	-	+	+	+	+ alachlor and metolachlor
Kenaf	-	+	+	-	-
Jute	-	+	+	-	-
Cotton	+	+	+	+	+ paraquat, alachlor and metolachlor
Roselle	-	+	+	-	-

WEED CONTROL IN INTEGRATED PEST CONTROL

Somchai Khomvilai and Chaiyot Supatanakul

I. INTRODUCTION

In 1982, a working comittee on IPC rice project was set up in the Department of Agriculture in Consequence of the FAO inter-Country IPC Rice Programme agreement. The members of the committee are from Entomology and Zoology Division, Pathalogy and Microbiology Division, Botany and Weed Science Division, Agricultural Toxic substance Division, and Planning Division. The representalives of The Plant Protection Service Division, Department of Agricultural Extension are also invited to be the committee. There are six major areas of activities in the committee, which are insect, disease, weed, rodent, Pesticide application technique and environmental impact.

II. THE IMPLEMENTATION OF FIELD AND DEMONSTRATION

The objective of the field trial and demonstration is to prove the feasibility of the technology obtained from various components of supporting researches in the proper way of the IPC concept, and to get the response of farmers to the new technology, as well as the feed back from the extension workers.

A farmer irrigated paddy field of about 80 ha. at Pathum Thani Province which is about 45 km from the north-east of Bangkhen was selected for the IPC field trial and demonstration for three years from 1982-1984.

The field was heavily destroyed by many pests causing tremendous economic loss to the farmers for about 2 to 3 years before the starting of the project. The major pests were BPH, RSB, raged stunt, and rodent.

To start the IPC project on the first crop in 1982, the basic line study was recorded and the agreements with the farmers on the condition of the project assistance were made. Some important points of the agreement are as follows;

1. In the first year, the farmers will get full supply of pesticide free of charge and the spraying equipments will be loaned as needed.
2. The supply of pesticide will be reduced to 50% in the second year and no supply in the third year.
3. The farmers must do their own insect scouting and strictly follow the recommendation of the field manager.

This field trial and demonstration is also served as the area for technology transfer to the plant protection officers (PPO). Every monthly farmer meeting, the PPO of DOAE are also invited to observe the on going activities and join the discussion during the meeting.

III. WEED CONTROL

A. In 1982

1. Weed Survey

Weeds in the paddy field of the IPC demonstration plot are divided into four groups:

A. Grasses, there were six species of grasses which were counted

half of the total weeds in the area. The most noxious weeds are Echinochloa sp. and Leptochloa chinensis (Linn.) Nees. which are distributed in the upland area.

B. Broadleaf, there were seven species of broadleaf weed and counted about 10% of the total weeds.

C. Sedges were about 34% of the total weeds. Cyperus difformiss Linn. and Fimbristylis miliacea Vahl. were noxious weeds in low and area.

D. Aquatic weeds were counted about 5% and no trouble to farmers.

2. Weed Control Method

In the wet season, we received 500 kgs of oxadiazon from Department of Agricultural Extension. We recommended farmers to use oxadiazon at the rate of 120 gm. (a.i.)/rai when rice was 10-12 days after germination. The phytotoxic to rice was about 25%

There was one study trial for selection of the good method for weed control in this project. There were five treatments:

a. no weed control
b. hand weeding
c. weed control by cultivation method
d. 2,4-D at 240-400 gm. (a.i.)/rai
e. oxadiazon at 120 gm. (a.i.)/rai

In oxadiazon plot, yield at 14% moisture content obtained 609 kgs. and had the most effective control of weeds. The land slopes from west to east, this have an influence on weed distribution. In upland, grasses were noxious weeds and yield was low. In lowland, weeds were controlled by herbicides effectively. However, hand weeding plot gave the highest yield which was 650 kgs. Land leveling is necessary for good control of water level and increasing efficiency of using herbicides.

B. In 1983, Dry Season

There are three herbicides that use in the project.

1. saturn-G. 160 kgs. were used at the rate of 2 kg/rai, 5-6 days after germination. The cost of herbicide is 40 ฿/rai.

2. ronstar-G, 500 kgs were used at the same recommendation of last year.

3. 2,4-D. The cost of 2,4-D is very cheap, about 10 ฿/rai. There were widely used in the low land area.

A field trail was set up to compare the effective of herbicides in farmer field. There were 10 treatment, plot size about 2-3 rais.

1. hand weeding
2. 2,4-D plus hand weeding
3. saturn G at 2 kg/rai
4. saturn G at 3 "
5. ronstar G at 4 "
6. machete EC at 4 "
7. machete G at 4 "
8. rouge EC at 3.2 "
9. rouge G at 3.2 "
10. ordram plus.

Yield was not different between treatments. Weeds were collected at 60 day after planting in 1 m^2, identified, counted and dried for weight. Rouge G, gave a good weed control that other herbicides in this trial, In 2,4-D plus hand weeding treatment, there were only Echinochloa sp. in the field because it look like rice at younger stage. Ordam plus were use where there are high population of weeds for test the effective-

ness. It gave a good control againt broadleaf weeds.

C. In 1983, Wet Season

In wet season, water supply from irrigation canal was sulficient, weeds distribution were low when compare with dry season. Farmers used 2,4-D plus hand weeding in the lowland area and oxadiazon in the higher slope. Yields were rangs from 733 to 743 kg/rai when used herbicides and 565 kg/rai from without herbicides field. Weeds population were about 36.8 plants/m^2 in no weed control field and reduce to 3-9 plants/m^2 after used herbicides.

D. In 1984, Dry Season

One field trail was set up for test commercial herbicides that farmer can buy in the market. There were seven treatments.

1. bifenox at 320 g(ai)/rai
2. benthiocarb at 320 "
3. butachlor at 160 "
4. benthiocarb + butachlor at 160 + 80 g(ai)/rai
5. benthiocarb + oxadiazon ar 160 + 120 "
6. butachlor + oxadiazon at 160 + 120 "
7. Check

Weeds were checked at 50 days after germination. All of herbicides treatments showed better control of weeds compared to check.

Weed survey in farmers field was checked at harvested. Average weeds population was 38 plant/m^2. Tha main weeds were Fimbristylis milicea 26%, Echinochloa sp. 21%, Cyperus diffomis 15% and Jussiaea linifolia 14%. An average yield was 634 kg/rai.

E. In 1984, Wet Season

The last crop of this profect, most of farmers use 2,4-D plus hand weeding. Weeds survey were made at 50 days and harvested. At harvested, the major weeds were Echinochloa sp. 49%, Scripus juncoides 22% and Monochoria vaginalis 7% . Weed population about 12.5 plants/m^2 and yields ranges from 584 to 736 kg/rai.

WEED CONTROL IN INDUSTRIAL CROPS AND HORTICULTURE

Kleopan Suwannarak and Sermsiri Kongsaengdow

In Thailand, farm holding lands for planting economic crops are approximately 38% of total areas. The most important crops are rice, sugarcane, corn, pineapple, fruit crops and others. Sugarcane and pineapple are justified as industrial crops. During 1978-1985, the planting areas of sugarcane is 0.5-0.6 million hectares, the average yield of 29.5-48.8 tons/ha. Several fruit crops and vegetables are being promoted for exporting, especially pineapple which has been the most favourable taste. At present, there are 128,000 hectares planted in the area of this crops. The main objective of growing pineapple is for canning factory. Most of pineapple porducts has been exported, its value exceeded 2,000 million Baht in 1986.

The factors that affect the growth and yield of all crops are climate, soils, nutrient, diseases, pest insects and weeds. Generally, weeds differ from other pests because they are found every time of growing crops, though some other pests can be found in certain occasions. In the rainy season, weeds are quite troblesome throughout the area of planting because they reproduce rapidly. Thus, this situation, weed control programme should be made for reduced costs of weeding and increased yield production per unit area. However, in some case, particularly in vegetables or ornamental crops, weeds are overlooked by growers because it is the integral part of planting and then they do it always. Nowadays, weeds are a persistent problem to all of growers. It has been concerned that economic losses due to the lack of weed control may be more than 40-60%. However, the impact of weeds on crop losses varies with control methods and agricultural practices. The purpose of this paper is to mention the weeds and weed control in sugarcane, pineapple, orchards and vegetable crops which was written from research works in Thailand, during 1974-1986.

SUGARCANE

Sugarcane is usually planting for sugar mills. The average sugar recovery is about 80-90 kg white sugar from a tonnage of cane which is very low when compared to Taiwan and Australia. Weeds are accepted as one of the major confinements to high yield in sugarcane production. The main planting areas are located in the West Central and the Eastern regions. Most of noxious weeds in sugarcane fields could be classified as Gramineae and Cyperaceae, namely, Dactyloctenium aegyptium Willd., Eleusine indica (L.) Gaertn. Brachiaria reptans (L.) Gard. et Hubb., Echinochloa colonum (L.) Link., Digitaria adscendens (HBK) Henr, and Cyperus rotundus L. Other common broadleaf weeds which are also difficul to control are Amaranthus spinosus L., Trianthema portulacastrum L., Tribulus terrestris L., Sida acuta Burm. f., Portulaca oleraceae L., Mimosa pudica Mill., Ageratum conyzoides L., Ipomoea gracillis R.Br., Alternanthera frutescens R.Br., Hyptis souveolens Polt., etc.

Most troublesome weeds are annuals which have been distributed by seeds. In general, the major weeds such as I. portulacastrum and A. conyzoides are able to complete 1-3 generations in one cane

cropping season. Actually, in a favourable condition, weeds will emerge 1-2 weeks after planting cane-setts and start flowering within 3-8 weeks later. Growers prefer to apply pre-emergence herbicides which can not control purple nutsedge. In near future, purple nutsedge will be a noxious weed, because it stands alone in many cane fields.

Weeds are estimated to reduce the yield of sugarcane in the world as a whole by 15%. In Thailand, it seems to be more losses. The critical period of weed competition is the first 3 to 4 months of crop growth. For instance, studies conducted in various regions revealed that competition with weeds during the entire period of crop caused the yield reduction of 89.2%, but little yield reduction caused by delaying the first weeding until 2 months after planting. When the duration of weed competition lasted for 3 and 4 months, the yield was reduced to 73.6 and 80.8%, respectively. However, the yield of plot where weeds were removed 3 months after crop planting was almost the same with the weed free plot. As the young cane grows very slowly and are easily covered by fast growing weeds, tiller growth and development was greatly retarded. The first weeding should be made as early as possible. If cane fields could be kept clean for this critical period, the weeds which will germinate later are suppressed by shading.

Planting season of sugarcane in Thailand generally is 2 periods as follows :

1. Dry season planting : Acutally, this method has been done for a long time by the growers in the non-irrigated area of the Eastern and the North-Eastern. At present, it has been spread to the North Central and West Central. Planting is started in November to January, even though this method needs many techniques and more experience, particularly land preparation and the mechanization of planting. However, sugarcane which is planted during this period would be escaped from weed infestation at the early stage of cane growth. Furthermore, the usefullness of this method is to minimize weeding labour and herbicide application. Moreover, the main purpose is to reduce expenditure and increase yield production.

2. Rainy season planting : This method is started at the early rainy season from April to June. As this period has quite heavy rain, the weed problem is very serious and it is difficult to made weeding by either mechanical and cultural means. Therefore, growers have to use chemicals to control weeds. For herbicide application, most of growers have to improve technique for successful use.

METHODS OF WEED CONTROL

1. Preplant-land preparation. The first objective of land preparation is to eliminate weeds and provide an environment favourable for sugarcane growing. Usually, the most important practices in land management that give an influence on the efficacy of herbicides which will be applied later. Before preparation of weed beds, the land is first ploughed by disc plow and then it is subsoiled in order to promote water retention, root penetration and uprooting some perennials. Lastly, it should be harrowed to make soil surface into a good tilth.

2. Interrow cultivation. It is mainly done with animal drawn or weeding machine which can control weeds in the interrows, but growers have to do weeding in the cane rows by hoeing. In a wet condition, as

weeds regrow rapidly, cultivation is needed to do around 2-3 times in the first 3-4 months. The hilling-up should be operated before cane canopy are closed-in.

3. Manual weeding. Actually, manual weeding is very effective and still the most feasible in controlling young weeds, but it seems to be time-consuming and labourious, particularly for perennials which reproduce from underground organs that are rather difficul to control by this operation. Furthermore, delay of cane growing or longer competition with weeds due to the lack of labour in critical times or heavy rain fall will not let do weeding by this way.

4. Mulching. In the ratoon cane, some growers in the West Central normally prefer to use cane leaves for mulching. It not only preserve soil moisture but also prevent weed seed germination and suppress re-growth of perennials.

5. Burning. In ratooning, before new shoot of cane stubbs are emerged, most of growers in the Eastern part use flame for killing weed seeds near soil surface and perennial weeds.

6. Intercropping. The aim of intercropping in sugarcane is maximum utilization of lands, especially to minimize weed infestation, reduce weeding costs and increase income per unit area. Though there is a limited research on this subject, it would be expected that corn, soybean or mungbean could be intercropped between the rows of sugarcane, and they must be harvested and ploughed before tillering phase are closed-in. On the other hand, this practice might increase the organic matter of the soil.

7. Chemicals. Chemicals are used in the case of increase of labour cost, labour lacking, unfavorable weather conditions for weeding by traditional means. Recently, growers seem to interest more in chemical control. Even though it is, only some of growers can be able to use chemical properly, and most of growers are required to have improved technique of application. However, many herbicides are widely recommended for more effective weed control in the sugarcane fields. Promising herbicides are described in Table 1.

Table 1. Chemical weed control in sugarcane.

Herbicide	Time of application	Target weeds	Remarks
Asulam 2.5 kg a.i./ha + dalapon 3.0 kg a.i./ha	Post-emergence at 5-7 weeks after planting	Broadleaf and grassy weeds, especially perennials such as Imperata and nutsedge	Apply directly to weeds. Do not mix with surfactant. Avoid spray drift on cane foliage.
Atrazine 2.5-3.75 kg a.i./ha	After planting or ratooning but before weeds and sugarcane emerge	Broadleaf and grassy weeds, including Amaranthus and crabgrass	Do not apply more than 9-10 kg a.i./ha. Application under a sufficient moisture condition is more effective. Apply the second application for continuing control of germinating weeds.
Diuron 1.5-3.0 kg a.i./ha	Pre-emergence and early post-emergence	Annual weed seeds and seedling less than 1 inch tall	Apply before weed emerage immediately after planting or ratooning, and also just after weeds emerged. When apply after weed emergence, add a surfactant at rate of 0.3% v/v and directly spray to weed seedlings.
Metribuzin/2, 4-D Na. 2.5-3.25 kg.a.i./ha	Pre-emergence and early post-emergence	Grasses and broadleaf weeds particularly jungle rice, spiny amaranth, spurge weed and alligator weed	In irrigated cane or wet season, apply just after planting or ratooning and before weed emerge. Make the 2nd application before "close-in" if necessary. Apply as early post-emergence, to weeds taller than 3-4 inches or at 4-5 weeks after planting cane-setts.
Alachlor 2.0-3.5 kg a.i./ha	Pre-emergence just after planting under adequate molsture	Most annual weeds especially crabgrass and jungle rice	Should be applies just after planting and may make the 2nd-3rd application if necessary.
Ametryn 2.25-3.0 kg a.i./ha	Pre-emergence, early post-emergence or post-emergence	Most annual weeds including crowfoot grass, jungle rice and goosegrass	In irrigated cane, the 1st application as post emergence is make not later than 3-4 weeks after weeds emerge. The 2nd application may make before "close-in" if necessary. In dry season, usually apply as post emergence at 7-9 weeks after planting. Should not be applied directly to cane foliage.

Herbicide	Time of application	Target weeds	Remarks
Ametryn 2.5 kg a.i./ha + Atrazine 2.5 kg a.i./ha	Post-emergence	Most of annual weeds and nutsedge	Apply directly to weeds taller than 6 inches or at 7 weeks after planting. Should not be applied directly to cane foliage.
2,4-D 1-2 kg a.i./ha	Post-emergence	Most annual and perennial broad leaf weeds; Trianthema iron weed, Euphorbia and Amaranthus	Apply as foliage spray at less than 4-6 inches tall. Re-treat as necessary, and may use as spot treatment to kill some of noxious weeds such as Euphorbia and Amaranthus.
Paraquat 1-1.5 kg a.i./ha	Pre-emergence or Post-emergence	Annual broad-leaf and grassy weeds emerged, and perenials (top kill)	Broadcast spray for clearing land. Shield is necessary to avoid contact with cane foliage when apply inter-row as past emergence. Make the 2nd or 3rd application if necessary when weed regrowth is 4-6 inches high. Do not apply after cane rows have closed-in.
Asulam 2.5 kg a.i./ha plus (Ioxynil 10% 2,4-D est.60%) 1.7 kg a.i./ha	Early post-emergence	Broadleaf and grassy weeds such as horse purslane, iron weed, brachiaria and spiny amaranth	Apply directly to weeds at 3-4 weeks after planting or when weeds are actively growing, but less than 4 inches tall. Made the 2nd application before "close-in" without surfactant.

PINEAPPLE

The pineapple (Ananas comosa) is a monocotyledonous plant which belongs to the family Bromiliaceae. Most of the species in this family are epiphytes which objects for support and derive their moisture and nutrients from the air. The pineapple is one of the few terrestrial species of this family which grow with their roots in the soil. It is able to strore quantities of water in its leaf axils and in special water storage tissues in its leaves, its also successfully grown in some relatively low rainfall areas without irrigation. Fruit development can continue for up to 3 months without soil water.

The centre production areas are in the Eastern and West Central, on an area currently totaling 128,000 hectares. Thailand is one of the major pineapple producing countries. Actually, they can grow in a wide range of soil types but can not tolerate a wet condition. Therefore, pineapple can be grown successfully only in well drainaged and aerated soils. Moreover, improper cultivation and frequent weeding may cause diseases infected and decreasing in yield will be occured.

Planting materials such as sucker, slip and crown are normally used in starting new crops. Suckers are generally recognized as being the best. The planting material makedly affects the time to harvest and to do weeding. For instance, sucker will mature into fruit in about 14-16 months and crown in 18-24 months. Crop cycle extends over a period of 3-4 years since the crop is planted until the same land is again planted for a new crop..

At present, pineapple growers aim at producting very high standard quality and fruit size for canning. Actually, yields vary according to husbandry, fertilization, climate, pest management and time of harvesting particularly in regard to weed control. Weeds are still being the major problems causing yield reductions. The results from our experiments were concluded that competition between pineapple and weeds for the first 4 months gave yield losses more than 50%. Crops which were planting in the early rainy season and dry season, critical time was appeared at the first 2 and 4 months of planting respectively.

Based on the weed survey in pineapple fields, the common narrowleaf weeds are Digitaria adscendens (HBK) Henr., Datyloctenium aegyptium willd., Elausine indica (L.) Gaertn., Echinochloa colonum (L.) Link., Brachiaria reptans (L.) Gard. et Hubb., Chloris barbata Sw., Rhynchelytrum repens (willd) C.R. Hubb., Pennisetum spp., Cyperus rotundus L. and Imperata cylindrica (L.) Beauv. etc. Some of broadleaves are Amaranthus spinous L., Scorparia dulcis Linn., Commelina spp., Euphorbia geniculata Orteg., Mimosa pudica Mill, Eupatorium odoratum L. and Paederia foetida L. etc. Plant crops are usually competed with annual weeds but perennials such as cogongrass, E. odoratum and P. foetida are found in ratoon crops along field boundaries and new lands which will be opened for growing. Land preparation is more exacting mechanization in order to provide adequate drainage and better result of herbicide application. Generally, most of perennials should be eradicated by either deep plowing followed by harrowing or digging out and chemical operations. Most of annual weeds as goosegrass and spiny amaranth normally having

of great number of seeds which are able to dormant and continue viable for long time of germination. Those are easily controlled by many promising herbicides.

Due to slow growing of pineapple shoots at beginning stage and quite limiting on critical time, furthermore, close spacing around 50,000-75,000 plants/ha. is planted to increase yields and produce small fruits for canning. For these reasons, cultural weeding is seem more difficult to operate. At this moment, growers prefer to use chemical weed control.

In previous time, atrazine, ametryn and diuron have widely used for controlling general annual weeds. At present, bromacil has been become more popularily, due to better weed control, particulary its quite effective against some noxious weeds. The use of hormonal herbicids such as 2,4-D should be avoid because of the influential effect on flowering. However, some interesting new chemicals also have been tested in various locations. The promising herbicides that gave satisfactory weed control without causing crop damage are described in Table 2.

Table 2. Weed Control in Pineapple.

Herbicide	Treatment and time	Target weeds	Remarks
Atrazine 2.5-4.5 kg a.i./ha	Pre-orearly post-emergence	Annual broadleaf and grassy weeds, especially Ageratum, Eupatorium, and spiny amaranth	Apply as a blanket spray after planting and could be repeated at 2 months intervals up to flowering if necessary. Do not apply at fruiting period or within 45-60 days of fruit harvest.
Ametryn 2.5-4.5 kg a.i./ha	Early post- or post-emergence	Broadleaf and grassy weeds, especially Brachiaria and Jungle rice	Apply as early post emergence to weed seedlings just after emerged and as post-emergence to weeds not more than 4-6 inches tall at higher rates. Do not apply more than 3 times a cycle. The last application should not be after flowering.
Bromacil 2.5-3.0 kg a.i./ha	Early post- or post-emergence	Annual and perennial weeds such as Ageratum, Eupatorium, Imperata, finger weed Rhynchyrytrum, most of climbing weeds and nutsedge	Apply directly to weeds 3-5 weeks or 2-3 months after planting as broadcast spray. Some perennials are effectively controlled with 2-3 times applications. Do not apply during the flowering period until fruit harvest. Do not apply in pineapple that are grown as intercropping of rubber trees.
Diuron 2.25-4.5 kg a.i./ha	Pre-and early post-emergence	Most of annual weeds, especially annual grasses	Should be applied immediately after planting as blanklet spray. The second or third application could be done if necessary. When applying early post-emergence, use a surfactant to increase efficiency

Herbicide	Treatment and time	Target weeds	Remarks
Bromacil 1.5-2.5 kg a.i./ha + Diuron 1.5-2.5 kg a.i./ha	Pre, early post and post-emergence	Most annual weeds and some perennials such as Panicum, nutsedge, Imperata and Eupatorium	Pre-emergence should be applied when soils have sufficient moisture and overhead irrigation or rain can be anticipated within 5-7 days. Post-emergence can be made 2-3 months after planting. The best control will be obtained when apply directly to weeds just after emerged or not more than 3-4 inches tall.
Bromacil 2.0-2.5 + Atrazine 2.5-3.0 kg a.i./ha	Early post or post emergence	Most of grasses and broadleaf weeds especially Euphorbiaceae	Post-emergence should be tank mixed with surfactant for better control
Bromacil 3.0 + Ametryn 3.0 kg a.i./ha	Post emergence	Perennial weeds especially Cogongrass and Paederia sp.	Spot treatment for controlling most noxious perennial weeds or broadcast spray to eradicate weeds before land preparation. Avoid spray on pineapple leaves. Do not apply during the flowering period until fruit harvest.
Fluazifop-butyl 0.5-0.75 kg a.i./ha	Post-emergence	Most of grasses especially crabgrass, crowfoot grass and finger grass	Good control on grasses but could not control broadleaf weeds. Use a surfactant 0.1-0.3% to increase efficiency.
Fluazifop-butyl 0.5+ Ametryn 2.0 kg a.i./ha	Post-emergence	Grasses and broadleaves	Tank mix application to control both grasses and broadleave, use surfactant to increase efficiency.

ORCHARD

Most of troublesome weeds in orchards are perennials like Imperata cylindrica (L.) Beauv., Borreria latifolia, Panicum repens L. and Eupatorium odoratum L. At present, Pennisetum setosum (Swartz) L.C. Rich. become to be a problem weed. Weed control in rochards may be carried out by many ways. Mechanical and cultural methods such as mowing, mulching, hand weeding and cover crops are normally practiced for controlling weeds. Actually, orchardists tend to favour chemicals which offer many advantages.

In young orchards, the need for weeding is greatly increased, the growing of leguminous cover plants is done in the North and the South, inter-cropping with catch crops are extensively planted in the Central and the East Central.

Mowing by simple tool or small cutting machine and slashing by weeding knife are commonly practiced in the areas where labours are available, but manual weeding is becoming increasingly expensive, and tend to encourage perennials as dominant weeds. This method is only effective when it is done in time. At present, hand weeding or hoeing then followed by herbicide application around the tree bases and interrow slashing by mechanical tools are widely practiced.

Mulching with slashed weeds, rice straw, lalang leaves etc. has been found to supress weed infestation, preserve soil moisture and also increase soil organic matter.

In mature orchards, the shading effect of the crops themselves greatly reduces weed competition. Therefore, weed control is not needed frequently, and may be minimized production costs.

At some occasions, cultural methods are difficult to practice due to labour shortage and higher wages etc. So, there is an increasing tendency to use chemical weed control. Many herbicides are evaluated at the area of fruit crops in the North and the Central. Some orchardists tend to do on new application technique as it has been practiced popularity in rubber and oil palm plantations. The result was obtained form field trial on using ultra low volume (ULV) was given better weed control than high volume application. By the technique, chemical dosage could be reduced around 40%.

Appropriate use of herbicides in orchards should be concerned, particularly the method of application that needs more techniques and experience. Most growers can not do it, only some of them can do successfully. For instance, misuse of herbicides such as using of 2,4-D, dalapon and other systemic chemicals has been often found in the orchards and then cause crop damage. In order to solve this problem, growers have to get more knowledge to improve their techniques for better result of herbicide application.

A list of herbicides which have been found to be promising in fruit crops is shown in Table 3.

Table 3. Chemical weed control in rochards.

Crops	Herbicide	Treatment and Time	Target Weeds	Remarks
Citrus	Bromocil, 2.0-4.0 kg a.i./ha	Pre-and post-emergence in citrus established 4-5 years or more	Annual and perennial weeds	Preferably control annual weeds before or just after emerged. Do not apply more than 2 times per year. Do not graze treated areas.
Citrus, Rambutan, Durian, Mango, Lychee, Banana, Papaya, Longan	Diuron, 2.0-4.0 kg a.i./ha	Pre-emergence when irrigation or rain can be anticipated in 1 week.	Annual weeds	Apply as directed spray to orchard established at least 1-2 years. Use only under fruit trees and do not use more than 2 times a year.
	Paraquat 1-1.5 kg a.i./ha	Post-emergence	Annual and perennial (top kill and suppression)	Should be applied just after emerged or re-established not more than 4 inches tall. Repeat application is neccessary.
	Glyphosate 2.25-4.0 kg a.i./ha	Pre-plant, Post-emergence	Most annual and perenial weeds	Apply when weeds are actively growing. Avoid drift on green foliage of fruit trees.
	Paraquat+ atrazine (0.5-0.75)+ (1.5-2.5) kg a.i./ha	Post-emergence	Annual grassy and broadleaf weeds	Tank-mixed spray to kill established weeds and to control weed seed. For better control, may by applied repeatedly at 3-4 months intervals. Avoid drift on Green foliage of fruit trees.
	MCPA + diuron + paraquat (0.6-0.9)+ (0.9-1.4)+ (1.8-2.7)+ (0.5-0.75) kg a.i./ha	Post-emergence	Annual and perennial weeds	Do not apply to fruit trees of less than 3 years after establishment.
	Paraquat + diuron (0.5-0.75) +(1.5-2.5) kg a.i./ha	Post-emergence	Annual grassy and broad-leaf weeds	Should be avoid spray drift on foliage of fruit tree. Apply repeatedly 3-4 months intervals.
Banana, Guava	Ametryn 2.25-4.5 kg a.i./ha	Early post- or post-emergence and pre-emergence	Annual grassy and broadleaf weeds	Apply early post-emergence at low rates. Pre-emergence application for controlling weed seeds. Post-emergence at high rates for killing weeds which more than 6 inches tall. Avoid spray drift on foliage of fruit trees.

VEGETABLE CROPS

Vegetables are considered as a part of horticultural crops. The growing processes need frequent and careful attention. They are usually grown in the areas when irrigation water is available. Most of them have short durationed growing which can be planted many times, at least 3-4 croppings a year. In Thailand, there are different methods of growing such as direct seeding and transplanting. Weed infestation is the major problem, especially in the lowland near Bangkok, where growing on raised bed surrounding by small canals that is full of water all year round. Most growers are mainly weeded by cultural practices and also use chemical weed control.

Vegetables which grow as upland crops are normally found in the North, the North East and the South. This type is watered by sprinkling system. Weeds are more serious in the first type of growing above-mentioned. Weed control has been carried out by either cultural or chemical means.

Crops and weed competition varies with the types of growing. Yield losses of crops caused by weeds were estimated from the minimum weed control which hardly cause yield losses. Some results from the experiments revealed that 30 days competition between purple nutsedge and cabbage caused the yield loss of 35%. In the area which was infested by general weeds, the critial period of cabbage was found in the first 3-4 weeks after transplanting, and then weeding should be done during the first 4 to 6 weeks for the purpose of higher yield production.

In tomato growing in the area infested by common grassy weeds like D. adscendens and E. colonum, it was found that nearly 40% yield loss occured when competed with weeds during the first 4 weeks after transplanting. It may be condluded that tomato needed a weed free condition at least 6-8 weeks, and had to do weeding every 2 weeks.

Weed control methods can be made by several ways such as cultural and chemical means. Cultural methods consist of soil preparation, hand pulling, mowing, hoeing, mulching and intercropping.

Proper soil preparation before planting should be considered to reduce subsequent weed problems. Proper plowing and harrowing just prior to seeding or transplanting will prevent germinating of weed seeds and reduce early competition with some perennial weeds like purple nutsedge and Panicum spp. In general growing of vegetable crops, weeds which grow near crops can not be controlled by any small weeding machines. They can be eradicated by hand pulling only. This operation is commonly practiced by growers in the Central area near Bangkok. It may be noted that this method is quited labourious, more expensive and unpractical in large areas.

Mowing by weeding knife usually give effective control in the early stage of growing. Hoeing by hand tool is used for weeding along the interrows. Hand hoeing is still more practical than mowing and hand pulling. Its also effective in control of perennials by means of digging out and uprooting the under ground stems and rhizomes.

Mulching with rice straw and weed leaves etc. has been used successfully in suppressing weeds and reduced weeding costs. Moreover, it can preserve soil moisture, especially in the dry season growing.

Manual weed control should be made regularly at intervals of 10 to 20 days in order to get highest yield production. Besides this operation, cropping system by integrating with some of vegetables can reduce weed

competition and also increase grower's income. For example, cauliflower interplanted with onion, chilli and cabbage. Actually, each crop can be harvested at different times and then leaving space for longer duration crops.

Herbicides have been used in order to reduce weeding cost and replace the lack of labour. In large scale growing for vegetable seed production, season-long weed control is required to prevent late season weed growth. For this purpose, weed control practices should be based on the use of promising selective herbicides combined with proper cultivation. Herbicides selected to apply in each vegetable crops are shown in Table 4.

Table 4. Weed control in vegetable crops.

Crops	Herbicide	Time of application	Target weeds	Remarks
Onion, Garlic, Chilli	DCPA 5.6-7.8 kg a.i./ha	Pre-emergence at seeding or after transplanting	Annual grassy weeds and some broadleaf weeds	Apply to soil surface before weed emergence irrigation before or after application is necessary.
	Oxyfluorfen 0.3-0.375 kg a.i./ha	(ditto)	(ditto)	(ditto)
	Metolachlor 1.5-2.25 kg a.i./ha	(ditto)	(ditto)	(ditto)
Chinese Kale, Long bean, Chinese redish Chinese cabbage	DCPA 6.25-7.8 kg a.i./ha	Pre-emergence before or after seeding or sowing before mulching	Annual grassy and broadleaf weeds	Irrigation is necessary after application. High rate should be applied in heavy soils.
	Metolachor 1.0-2.0 kg a.i./ha	Pre-emergence at 3-7 days before seeding or sowing	Annual grassy and broadleaf weeds	Irrigation is necessary after application. High rate should be applied in heavy soils.
Cabbage	Oxyfluorfen 0.3-0.375 kg a.i./ha	Re emergence before transplanting	Annual grassy and broadleaf weeds excepted Commelina spp. and purple nutsedge	Soil application at 1 day before transplanting Irrigation is necessary for Activated the chemical.
	Oxadiazon 1.125-1.5 kg a.i./ha	(ditto)	(ditto)	(ditto)
	Pendimethalin 1.25-1.5 kg a.i./ha	(ditto)	(ditto)	(ditto)
	Fluazifop-butyl 0.25-0.5 kg a.i./ha	Early post emergence	Annual grassy weeds especially crabgrass and crowfoot grass	Foliar application at 3-5 leaf stage weeds. For better control should be tank mixed with surfactant 0.15% v/v
	Haloxyfop-methyl 0.1-0.2 kg a.i./ha	(ditto)	(ditto)	(ditto)

Crops	Herbicide	Time of application	Target weeds	Remarks
Cabbage	Fenoxaprop-ethyl	Early post emergence	Annual grassy weeds especially crabgrass and crowfoot grass	Foliar application at 3-5 leaf stage weeds. For better control should be tank mixed with surfactant 0.25% v/v/
Tomato, Cabbage, Chilli	Glyphosate 1.5-2.5 kg a.i./ha	Pre-planting	Perennial weeds such as purple nutsedge	Apply directly to weeds before land preparation 10-15 days or more.
	paraquat 0.75-1.0 kg a.i./ha	(ditto)	Annual grassy and broad-leaf weeds	(ditto)
Tomato	Metribuzin 0.25-0.5 kg a.i./ha	Pre-emergence	Annual grassy weeds and some broad-leaves	Soil application at 1-3 days before transplanting or soil application after transplanting in inter-row space which showed be avoid spray drift injury to the crops.
	Diphenamid 1.0-2.0 kg a.i./ha	(ditto)	(ditto)	(ditto)
	Oxadiazon 1.0-1.5 kg a.i./ha	(ditto)	(ditto)	(ditto)
	Metribuzin+ pendimethalin (0.375-0.525) +(1.0-1.5) kg a.i./ha	(ditto)	(ditto)	(ditto)
	Bifenox + pendimethalin (0.75-1.0)+ (1.0-1.5) kg a.i./ha	(ditto)	(ditto)	(ditto)
	Metribuzin + diphenamid (0.375-0.525) + (1.5-2.25)	(ditto)	(ditto)	(ditto)

WEED CONTROL IN PLANTATION CROPS

Prateep Krasaesindhu and Chanya Maneechote

Weeds are capable of causing enormous crop production losses by depriving the crops of water, mineral nutrients and light which would otherwise be available and so prevent it from achieving potential. Weeds may act also as a host to insect pests and diseases and may interfere with the passage of machines used for tillering the soil, applying fertilizers and pesticides, and for harvesting the crops. Losses of crop production from weeds can be very high. On the other hand, the longer plantation is kept free from weeds the higher is the yield it produces. For weed control, highly effective treatments with no detrimental effects on the crops and soil must be applied.

Weeds generally found in plantation crops are Imperata cylindrica (L.) P. Beauv., Paspalum conjugatum Berg., Rhynchelytrum repens (Willd.) C.E. Hubb., Eleusine indica (L.) Gaertn., Digitaria adscendens (HBK) Henr., Dactyloctenium aegyptium (L.) P. Beauv., Echinochloa colona (L.) Link., Brachiaria distachya (L.) Stapf., Brachiaria mutica, (Forsk.) Stapf., Panicum cambogiense Balansa, Choris barbata Sw., Cyperus rotundus Linn.,Ageratum coryzoides Linn., Eupatorium odoratum Linn., Euphorbia heterophylla Linn., Tridax procumbens Linn., Crassocephalum crepidioides (Benth) Moore, Commelina benghalensis Linn., Boerhavia erecta Linn., Euphorbia hirta Linn., Melastoma malabathricum Linn., Mikania micrantha H.B.K., Scoparia dulcis Linn., Passiflora foetida Linn., Lantana camara Linn., Borreria laevis (Lamk.) Griseb., Borreria alata (Aubl.) DC., Mitracarpus villosus (Sw.) DC., Bidens pilosa L. var minor (Bl.) Sherff., Hyptis sauveolens Poit., Xyris indica (Linn.), Pennisetum pedicellatum Trin., Pennisetum polystachyon Schult., Pennisetum setosum (Swartz) L.C. Rich. (in southern part only) and Eupatorium adenophorum Spreng. (highland in the northern part only).

There are various methods for controlling weeds, each suitable to the period of the year, infestation conditions, plantation age, crop spacing, terrain and available equipment.

1. Hand weeding or mechanical weeding to cut above ground plant parts. Their success depend largely upon the stage of weed growth at the time it is carried out, and it must be done scrupulously if it is to produce satisfactory results. Hand weeding is suitable to perform on terrain where it is difficult to use machines.

2. Mulching. The material for mulching can be rice straw, cut weeds from nearby area etc. Mulching is not only prevent weed seed germination but also help to prevent leaching, preserve soil moisture and increase organic matter. The problem for this type of weed control is in difficulty of finding mulching materials.

3. Cover crops. Weed plants can be prevented by growing leguminous plants to cover the soil surface instead of using plant parts only. The problem for this method is to require much labour to manage the cover crops.

4. Weed control with herbicides. Chemical weed control is now becoming increasingly popular, mainly for the fact that it is more effective. It is the most economical method and it can be employed both in large and small plantations.

Table 1. Weed Control in Oil Palm and Coconut

Herbicide	Time of Application	Target weeds	Remarks
Diuron 2.0-4.0 kg a.i./ha	Before weed emergence.	Most germinating annual, broadleaf and grassy weeds.	Use only in plantation which have been established for at least two years. Repeat as needed. Avoid spray drift to damage the crop.
Paraquat 0.5-1.0 kg a.i./ha	When weeds are succenlent and new growth is within 15 cm tall.	Annual broadleaf weeds and grasses (top kill) and perennials around the base of tree (suppression)	Apply as a coarse direct spray to avoid drift injury. Do not allow spray to contact green stem or foliage. Retreament or spot treatment is necessary for mature woody and perennial weeds.
Glufosinate-ammonium 1.5-2.0 kg a.i./ha	(ditto)	(ditto)	(ditto)
Glyphosate 2.0-3.0 kg a.i./ha	When weeds are actively growing.	Annual and perennial broadleaf and grassy weeds.	Apply as a direct spray in established palm. Avoid spray drift on green foliage.
Dalapon 5.0-10.0 kg a.i./ha	At the growth of grass foliage.	Most annual and some perennial grasses.	Apply as a direct spray. Apply at lower rate for younger palm. Do not use to the palm less than two years old.
Paraquat + Diuron (0.5-0.75)+ (0.5-1.0) kg a.i./ha	When weeds are in active growth and new growth not over 15 cm tall.	Annual, broadleaf and grass-weeds (top kill or long-term control) and perennials (suppression)	Use to palm of two years old or above. Avoid contact injury on foliage.
Paraquat + Oxyfluorfen (0.5-0.75)+ (0.25-0.5) kg a.i./ha	(ditto)	(ditto)	(ditto)
Paraquat + MCPA+ Diuron + Amitrole (0.5-0.75)+ (1.0-2.0)+ (1.5-3.0)+ (2.96-5.94) kg a.i./ha	When weeds are in active growth and new growth not over 15 cm tall.	Annual, broadleaf and grassy weeds (top kill) or longterm control) and perennials (suppression).	Use to palm of two years old or above. Avoid contact injury on foliage.

Table 2. Weed Control in Coffee, Cocoa, Tea, Macadamia and Cashew

Herbicide	Time of application	Target weeds	Remarks
Atrazine 2.0-4.0 kg a.i./ha	Before weed emergence or at growing stages of weeds	Broadleaf and grassy weeds.	Apply at lower rates before weed emergence or at younger stages. Apply at higher rates for longterm control. Repeat at 3-4 months interval as needed. Avoid injury to crop foliage.
Ametryn 2.0-4.0 kg a.i./ha	At the active growth of weeds but before 15 cm tall.	Broadleaf and grassy weeds.	Do not apply to trees less than 2 years. Avoid injury on foliage. Apply as a blanket spray before weed emergence, and make additional spray at 1-2 months interval.
Metribuzin 0.75-1.0 kg a.i./ha	Before weed seeds germination.	Broadleaf and grassy weeds.	Rainfall or irrigation helps to activate the chemical. Apply only in plantation of more than two years after establishment. Repeat as needed. Avoid spray contact on crop foliage.
Diuron 2.0-4.0 kg a.i./ha	Before weeds emergence.	Most germinating annual broadleaf weeds and glasses.	Rainfall or irrigation helps to activate the chemical. Apply only in plantation of more than two years after establishment. Repeat as needed. Avoid spray contact on crop foliage.
Paraquat 0.5-1.0 kg a.i./ha	At the young and succulent stages of weeds within 15 cm high.	Annual broadleaf and grasses weeds (kill) and perennials around the base of tree (suppression).	Apply as a coarse spray to avoid drift injury. Do not allow spray to contact green stems or foliage. Retreatment or spot treatment is necessary for mature woody and perennial weeds.
Glufosinate-ammonium 1.5-2.0 kg a.i./ha	(ditto)	(ditto)	(ditto)

Table 3. Weed Control in Mulberry

Herbicide	Time of application	Target weeds	Remarks
Diuron 1.5-2.0 kg a.i./ha	Right after mulberry planting and before weeds emergence.	Most germinating annual broadleaf and grasses.	Rainfall or irrigation helps to activate the chemical.
Metribuzin 0.5-1.0 kg a.i./ha	(ditto)	(ditto)	(ditto)
Paraquat 0.5-1.0 kg a.i./ha	When weeds are succulent and new growth is within 15 cm tall.	Annual broadleaf weeds and grasses (top kill) and suppression of perennials	Apply as a coarse direct spray to avoid drift injury. Do not allow spray to contact green stem or foliage of crop. Retreatment or spot treatment is necessary for mature woody and perennial weeds.
Glufosinate-ammonium 1.5-2.0 kg a.i./ha	(ditto)	(ditto)	(ditto)
Glyphosate 2.0-3.0 kg a.i./ha	When weeds are actively growing	Annual and perennial broadleaf and grassy weeds.	Apply as a direct spray in established mulberry plants. Avoid spray drift on green foliage.

Table 4. Weed Control in Linseed

Herbicide	Time of application	Target weeds	Remarks
Alachlor 2.0-3.0 kg a.i./ha	After seeding of linseed and before weed seeds germinations.	Most germinating annual broadleaf and grasses.	Rainfall or irrigation help to activate the chemical. Best results are obtained when rainfall occurs within 10 days after application.
Pendimethalin 2.0-4.0 kg a.i./ha	After seeding of linseed and before weed seeds germination	Most germinating annual broadleaf and grasses	Rainfall or irrigation help to activate the chemical.

(Continued)

Herbicide	Time of application	Target weeds	Remarks
Glyphosate 2.0-3.0 kg a.i./ha	At active growing of weeds in established crops	Annual and perennial broad-leaf and grass weed	Apply as a direct spray. Do not apply when green shoot or foliage is in spray zone. Avoid spray drift on green foliage.
Paraquat+ Diuron (0.5-0.75)+ (0.5-1.0) kg a.i./ha	At young and active growing of weeds	Annual broad-leaf and grasses (top kill and longterm control) and perennials (suppression)	Do not apply to the trees less than 2 years old. Avoid injury on crop foliage.
Paraquat+ Oxyfluorfen (0.5-0.75)+ (0.25-0.5) kg a.i./ha	(ditto)	(ditto)	(ditto)
Paraquat+ Metribuzin (0.5-0.75)+ (0.25-0.5) kg a.i./ha	(ditto)	(ditto)	(ditto)

WEED CONTROL IN RUBBER

Charuck Boonsrirat
(Rubber Research Centre, Department of Agriculture)

The main area of rubber plantation in Thailand is located in the South and the East, covering 1.5 million ha. Large-scaled estate plantation with good weed management accounts for only 20 percent of the total, and a 80 percent is small-scaled farming where severer weed problems exist due to bad weed management.

Generally, weed infestation is severer at earlier stages of rubber plants including intercropping. Main weed species can be listed as follows:

Heavily infested weeds - Imperata cylindrica, Pennisetum setosum, Brachiaria reptans, Borreria latifolia, Eupatorium odoratum, Ageratum conyzoides, Paspalum conjugatum, Ottochloa nodosa

Moderately infested weeds - Axonopus compressus, Cyperus rotundus, Dactyloctenium oagyptium, Digitaria adscendens, Echinochloa colonum, Eragrostis tenella, Euphorbia geniculata, Euphorbia hirta, Elesine indica, Mikania cordata, Caladium spp.

Weed control in rubber is very important to raise high latex yielding and that by use of chemicals is increasingly employed, probably due to the labour shortage and higher wage. Application of herbicides is different according to the field conditions or target weeds as shown in Table 1 .

In the case of budwood nurseries and newly planted rubber, weed population and growth increase gradually in the open. Band application, below 2 m wide, should be made along the rubber rows.

Cover crops are also effective to suppress weed infestation between rubber rows. Pueraria phaseoloides, Centrosema pubescens and Calopogonium mucunoides are the main species, usually be planted at the same time of rubber planting. Intercropping in rubber is by upland rice which accounts for 90% of all intercropping. The remainer is by pineapple, 10%.

In mature rubber plants, weed control is mainly carried out against small number of weeds. However, when weed species such as Axonopus compressus and Ottochloa nodosa survive under a shading condition, herbicide combination as indicated in Table 1 should be applied.

Table 1. Recommended Herbicides in Rubber

Field Condition	Herbicide	Dosage kg a.i./ha	Time and/or treatment	Remarks
Rubber-Stock nurseries (early age seedlings)	Linuron	1.56	Pre-emergence Soil treat	Apply 1-2 days after seeding for early age seedlings 6 to 8 weeks control of weeds is available. Linuron is more selective than diuron.
	Diuron	0.75	(ditto)	
(established seedlings)	Diuron	0.75	Pre-emergence Soil treat	For established seedling in 1.5-2 months after previous application. Apply in 50 cm band along the rubber rows after hand-weeding.
	Paraquat	0.375	Post-emergence Foliage t.	Apply at a volume rate 313 l/ha when established weeds are not removed.
	Paraquat + Diuron	0.375+0.75	(ditto)	
Budwood nurseries and newly planted rubber	Paraquat	0.5	Post-emergence Foliage t.	When the plants are in 2 months age or more.
	MSMA+Diuron	1.56+0.375	Post-emergence	For grass control. Apply when the plants are in 8 months to 2 years age.
	Dalapon	5.0	Post-emergence	Apply when the plants are in more than one year old.
	Paraquat	0.25	Post-emergence Foliage t.	Apply after Dalapon application.
	MCPA+Amitrol+ Diuron	0.35+1.03+ 0.52	Post-emergence Foliage t.	Apply in rows of the plants more than one year old. (single appl.
	MCPA+Amitrol+ Diuron	0.8+2.37+ 1.2	Post-emergence Foliage t.	Apply in rows of the plants more than one year old. (split appl.)
	Paraquat+ 2,4-D (aime)	0.375+0.49	Post-emergence Foliage t.	For broadleaves and cover crops in rubber rows.
	MSMA+2,4-D (amine)+Diuron	1.56+0.94+ 0.375	Post-emergence	For control of broadleaves and grasses in the plants more than 2 years old.
	MSMA+2,4-D+ Dalapon	2.5+0.94+ 2.5	Post-emergence Foliage t.	For control of weeds tolerant to herbicides

Field Condition	Herbicide	Dosage kg a.i./ha	Time and/or treatment	Remarks
	Imazapyr	0.125+0.25 (a.e.)	Foliage t.	Apply when the plants are in more than one year old.
	Glyphosate	0.5-1.25	Post-emergence Foliage t.	Apply at a volume rate 313 l/ha. Apply to one year old plants without residuality in the soil.
Mature rubber plants	MSMA+2,4-D (amine)	2.5+0.94.	Post-emergence	For control of broad-leaves and grasses for 5-7 months.
	Sodium chlorate +2,4-D (amine)	6.0+0.94	Post-emergence	(ditto) Do not give spray droplets on plants
Alang alang control	Dalapon	10+10	Split appli. Foliage t.	Spray two times at 3 weeks intervals with volume rate 625 l/ha.
	Dalapon/ Paraquat	10/0.5	Split appli. Foliage t.	Use plants less than 2 years old. Apply paraquat 3 weeks after dalapon application.
	Glyphosate	2.5	Foliage t.	Best control but costly.
	Imazapyr	0.5-0.75 (a.e.)	Foliage t.	Apply when the plants are in more than one year old.
Intercropping (upland rice)	Oxadiazon+ 2,4-D(ester)	1.0+0.75	Pre-emergence	Apply about 25 days after rice seed germination.
	Propanil+ 2,4-D(ester)	3.0+0.75	Post-emergence	
Intercropping (pineapple)	Bromacil+ Diuron	2.35+2.25	Pre-and Post-emergence	Spray 1 m apart from the rubber rows.
Cover crops	Alachlor	1.6	Pre-emergence	Good control for 2 months after application.
	Oxyfluorfen	0.225	Pre-emergence	(ditto)
	Fluazifophutyl	0.375-0.5	Post-emergence	Top spray, plus surfactant 0.25%

PROPERTIES OF HERBICIDES AS AFFECTED WITH CROPS AND WEEDS

Cha-um Premasthira
Weed Science Branch, Botany and Weed Science Division,
Department of Agriculture

INTRODUCTION

Herbicides have played an important role in Agriculture since 1896. In previous times, salts were used as weed killing chemicals. Organic chemicals were first used as herbicides in 1932. Later, an extensive array of herbicides with widely different chemical types which influence the metabolism and behaviour of plants developed and introduced to the field. The different mechanism of chemicals in plants is according to the physical and chemical properties of them as well as the aspects of crops and/or weeds.

According to the chemical structure and its biochemical behaviour of herbicides are generally divided into inorganic and organic. In-organic chemicals are the compounds of salts or acids. Organic chemicals are oils and organic compounds. Presently, organic compounds are classified base on the chemical structure of about 30 groups.

APPLICATION OF HERBICIDES

To get the achievement of weed control by herbicides, the chemical must get into the site of action in/on the plant. Hence, the method of herbicide applications, timing of application and physiological characteristics of weeds and crops, selectivity of herbicide to crops and so on, has to be considered very carefully, otherwise weeds will not be controlled and herbicides will damage crops. After many years of discovering and using various kinds of herbicides that can be used for killing weeds, they have been much developed to be very successful to control weeds.

Herbicides can be applied as pre-emergence or post-emergence depended on its mechanical properties to effect on weeds. Pre-emergence herbicides will be applied before or at weed seed emergence. To get effective control, chemicals must reach and get into the germinated seeds by the uptake of root or plumule. Post-emergence herbicides can be applied by the soil application or band spray on weeds and/or crops.

The chemicals can be uptaked into the plant by root or upper parts of the plant and come to the site of action. However, there are many factors concerned the biological or physiological properties of target weeds and/or crops, natural or environmental factors on the herbicidal properties themselves can limit the use and efficiency of the chemicals.

MECHANISM OF HERBICIDAL ACTION

The mechanism of herbicides in plants depends on various aspects, types of herbicides and the absorption and translocation of chemicals in plants, that is, the biological, physiological and biochemical properties of chemicals on plants.

Inorganic compound herbicides (salts or acids groups) cause nonsystemic action on plants. These groups of chemicals will effect in plants by the destruction of protoplasmic structure of cells with osmotic concentration. Chemicals of oil groups will destroy the living cell membrane by breaking down cell bonding with the interpolating of oil molecules in protein layer and chemicals of oil groups also reduce rate of photosynthesis as well. Herbicidal activity of organic compounds are mostly concerned with the mechanism of physiological and biochemical processes in the plants. Physiological processes as affected by herbicides involve cell division, cell elongation, abnormal growth, chlorophyll and plastid formation. Biochemical processes by herbicides are the inhibition of photosynthesis, respiration, ATP formation, protein synthesis, seed germination and so on.

Herbicidal reactions occur in all parts of a plant after passing through the cell membrance and their activities may disturb directly or indirectly depending on the types of herbicides which are Aliphatics, Amides, Arsinicals, Benzoics acids, Chlorophenoxy, Carbamates and Dinitroanilines that affect protein synthesis in the nucleus of plant cell. While Triazines, Bipyridiliums, Uracils and Ureas affect photoxynthesis activities in the chloroplast in the cells. ATP formation along with Hill reaction in photosynthesis system of the plant will be inhibited by Diazines. Respiration inhibitors are Nitrils and phenoxy which affect mitochondria. Shoot and root growth is inhibited by Thiocarbamate compounds.

HERBICIDAL EFFECT ON CROPS AND WEEDS

Phytotoxicity against crops and weeds refers to the degree to selectivity of herbicides as associated with biochemical factors like the metabolism of compounds within the plants, ecological and morphological factors,concerning the chemical structure of herbicides. Application techniques, dosages, ages of plant and cultural practices might create indirect selectivity action to weeds and crops.

Propanil and 2,4-DB are different compounds, their selectivities on crops and weeds are different. Propanil has been used as a contact herbicide at post-emergence. A 2 kg/ha of active ingredient is required to kill annual broadleaf and grass weeds, especially Echinochloa crusgalli in paddy fields, when the rice and weeds have 3rd leaf stage suitable to use propanil. The action of propanil is the growth inhibition of plants, being most effective in controlling grass species, but relatively less toxic to rice plants though both belong to gramineae; this is because Propanil can be degraded within 24 hrs after application by arylacylamidase enzyme which contains in rice. Both 2,4-D and 2,4-DB are phenoxy compounds. Their activities give abnormal growth and respiration inhibition of broadleaf weeds. 2,4-D is quite toxic to soybean but 2,4-DB formulation is not harmful to this crop. This phenomenon can be understood by the reason why soybean does not have ability to change 2,4-DB back to 2,4-D formulation. Som selectivity of 2,4-DB to soybean can be detected but broadleaf weed such as cockleber (Xanthium sp.) can be degraded by 2,4-DB to 2,4-D formulation which is toxic to cocklebur. As shown in the above examples, each of herbicides has different mechanism of action in or on plant, therefore, it is necessary and important to learn the exact properties of herbicides thoroughly before actual use in Agriculture.

CONCLUSION

For safety use of herbicides both in croplands and in the environment to control weeds, it is necessary to know the properties of action of herbicides in plants and its efficiency in controlling weeds before actual application. Regarding the above consideration, Table 1 indicates some of informations of principal herbicides in Thailand for technical persons who interest in effective use of herbicides.

LITERATURE CITED

Anderson, W.P. 1977. Weed Science Principles, West Publishing Co.

Ashton, F.M. and Crafts, A.S. 1973. Mode of Action Herbicides. A Wiley-Interscience Publication.

Audus, L.S. 1976. Herbicides, Physiology, Biochemistry, Ecology Vol. I, II. 2nd edition. Academic Press.

Crafts, A.S. 1975. Modern Weed Control. University of California Press.

Hadogaya Chemical Co.,Ltd. 1986. Short Review of Herbicides. 5th edition. Zenkoku Noson Kyokai Publishing Co.,Ltd.

Herbicide Handbook of the Weed Science Society of America. 1983. Fifth edition.

National Weed Science Research Institute Project. 1984. Suggested Guide for Weed Control in Thailand. Project Technical Bulletin No. 1.

Moreland, D.E. and K.L. Hill (1962). Influence of Herbicides with the Hill Reaction of Isolated Chloroplast. Weeds 10 : 229-236.

Moreland, D.E. 1967. Mechanism of Action of Herbicides. Ann. Rev. Plant Physiol. 18 : 365-386.

Overbeek, J. Van and R. Blondeau. 1954. Mode of Action of Phytotoxic Oils. Weeds 3 : 55-56.

Table 1 Chemical Structure Classification

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50)ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
1	Aliphatics *						
	dalapon	2,2-dichloropropionic acid (sodium)	pre-post emergence 1- 5	3,860 - 9,000 2 - 4	annual & perennial grass	potato, sweet potato, asparagus, orchards.	growth inhibition (translocate from foliage to root)
	TCA	trichloroacetic acid (sodium)	pre-post emergence 5 - 20	3,200 - 5,000 2 - 8	annual & perennial grass	cotton, clover, tomato, onion, sugarbeet, fruit trees.	translocate
2	Amides & Acetamides *						
	propanil	3',4'-dichloropropion anilide	post-emergence 3 - 6	1,285 - 1,483 1/2	annual broadleaf & grass	rice, turf, tomato, sweet potato.	growth inhibition (Selective contact)
	alachlor	N-methoxymethyl-2',6'-diethyl-2-chloro-acetanilide	pre-emergence 2 - 4	> 2,000 6 - 12	broadleaf & annual grass	corn, soybean, cotton, radish, sugar cane, rape seeds.	inhibition of protien synthesis
	butachlor	2,chloro-2',6'-diethyl-N-(butoxymethyl)-acetanilide	pre-emergence 1 - 3	3,300 6 - 10	annual broadleaf & grass	rice, wheat, sugarbeet, cotton, peanuts.	inhibition of protien synthesis
	metolachlor	2-chloro-2'-ethyl-6'-methyl-N-(2-methoxy-1-methylethyl)acetanilide	pre-emergence & incorporated 0.75 - 2	3,170 1.5 - 3	grasses	corn, soybean, peanuts, sunflower.	inhibition of germination

(continuous)

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50);ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
3	Arsenicals *						
	MSMA	monosodium methane-arsonate	post-emergence 2 - 4	700 inactive	broadleaf & grass	cotton, sugar cane & non-cropland.	contact
	DSMA	disodium methane-arsonate	post-emergence 2 - 4	1,800 inactive	annual & perennial, broad-leaf & grass	cotton, turf, rye and non-cropland.	
4	Benzoics *						
	dicamba	3,6-dichloro-2-methoxy benzoic acid	pre&post emergence basal application 0.5 - 3	2,900 ± 800 2 - 4	annual & perennial & brush	small grain, sugar cane,corn, sorghum,orchard-crops and grass-pasture.	translocate (horomone type)
	chloramben	2,5-dichloro-3-amino benzoic acid	pre-emergence post transplanting 2 - 4	5,620 6 - 8	annual broadleaf & grass	corn, soybean, pumpkin,squash, peper,tomato and sweet potato	translocate (hormone type) inhibition of root development of seedling weed
5	Carbamates *						
	chloropropham	isopropyl-N-(3-chloro-phenyl) carbamate	pre-emergence & early post-emergence 2 - 4	5,000 - 7,000 3 - 5	annual grass & some broadleaf	corn,wheat, sugarbeet, bean, onion, vegetable	inhibition of growth (intact plant) inhibition of RNA & protein synthesis at cell
	swep	methyl-N-(3,4-dichloro-phenyl) carbamate	pre-emergence & early post-emergence 4 - 6	4,197 4 - 8	annual grass & some broadleaf	rice and large seeded legume.	

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50;ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
6	Diazines *						
	bentazone	3-isopropyl-1H-2,1,3-benzothiadiazin-(4)-3H-one-2,2-dioxide	post-emergence 1 - 6	850 5 - 6	annual & perennial, broadleaf & sedge	soybean, corn, peanut, rice.	inhibition of Hill reaction & photo-synthesis
	methazole	2-(3',4'-dichlorophenyl) tetrahydro-1,2,4-oxadiazol-3,5-dione	pre & post emergence 1.5 - 10	1,350 6 - 8	many broadleaf & some grass	cotton, potato, citrus, garlic, onion, tea.	inhibition of RNA & protein biosynthesis reduce ATP content
	oxadiazon	3-(2,4-dichloro-5-isopropoxyphenyl)-5-tert-butyl-1-3,4-oxadiazol-2(3H)-one	pre & post emergence 0.6 - 1.2	>8,000 12 - 24	broadleaf & grass	rice.	inhibition of young shoot growth
7	Dinitroanilines*						
	trifluralin	2,6-dinitro-N,N-dipropyl-4-trifluoro methylaniline	pre-emergence & incorporated 0.5 - 1.0	10,000 12 - 24	annual grass & broadleaf	cotton, soybean, carrot, okra, potato, vegetable.	inhibition of seed germination
	oryzalin	3,5-dinitro-N,N-dipropyl sulphanilamide	pre-emergence 0.5 - 3	10,000 1 - 2	annual grass & some broadleaf Cyperus spp.	rice, cotton, soybean.	inhibition of seed germination
	nitralin	4-(methylsulphonyl)-2,6-dinitro-N,N-dipropyleniline	pre-emergence 0.5 - 2	2,000 4 - 5	annual grass & broadleaf	cotton, soybean, peanut, tobacco, brassicas, ornamental plants.	
8	Diphenylether *						
	nitrofen	2,4-dichlorophenyl-4-nitrophenyl ether	pre-emergence & early post-emergence 2 - 6	3,050 ± 500 1 - 2	annual broadleaf & grass	rice, soybean, peanut, water melon, cabbage, lettuce, strawberry carrot.	contact

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50/ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
	fluorodifen	4-nitrophenyl 2-nitro-4-trifluoromethyl phenyl ether	pre&post emergence 2 - 5	> 9,000 1 - 2	annual broadleaf & grass	rice, soybean, peanut, alfalfa.	
	oxyfluorofen	2-chloro-4-trifluoro-methylphenyl-3-ethoxy-4-nitrophenyl ether	pre-emergence & incorporated 0.1 - 1.0	5,000 4 - 6	annual broadleaf & grass	cotton, peanut, soybean, corn, ornamental.	Contact Light require for herbicidal activity
9	Bipyridiliums * diquat	1,1'-ethylene-2,2'-bipyridylium dibromide	post-emergence 0.5 - 2	400 - 440 inactive	grass and broad-leaf pre-planting weeds	aquatics, potato, seed crops.	
	paraquat	1,1'-dimethyl-4,4'-bipyridylium dichloride or dimethylsufate	post-emergence 0.5 - 3.0	150 inactive	grass and broad-leaf	non-cropland, orchard, and plantation.	Contact
10	Nitriles * ioxynil	3,5-diiode-4-hydroxy benzonitrile	post-emergence 0.5 - 1.0	110 - 210 nil	annual broadleaf	wheat, barley, corn, rice.	inhibition of Photosynthesis and Respiration
	dichlorobenil	2,6-dichlorobenzo-nitrile	pre&post emergence 2 - 6	3,160 8 - 24	annual & perennial, broadleaf & grass	transplanted rice wheat, bush, aquatics.	inhibition of growth
	buctril	4-octanoyloxy-3,5-dibromobenzonitrile	post-emergence 0.3 - 1.5	250 1 - 2	annual broadleaf	wheat, barley.	inhibition of Photo-synthesis and respiration
11	Phenols * PCP	pentachlorophenol (sodium)	pre-post emergence 10 - 30	210 2 - 4	annual broadleaf & grass	rice, wheat, soybean, corn, sugarcane.	
	dinoseb	2,sec-butyl-4,6-dinitro phenol	pre-post emergence 0.75 - 12	40 - 200 2 - 4	annual grass & broadleaf	bean, pea, cereal, potato.	cell necrosis

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50)ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
	dinoterbacetate	2-tert-butyl-4,6-dinitrophenyl acetate	pre-post emergence 0.5 - 1.0	> 2,000 2 - 3	annual broadleaf & grass	cereals, cotton, legume (maize, sorghum, alfalfa-post-em.)	
12	Phenoxys * 2,4-D	2,4-dichlorophenoxy a acetic acid	post-emergence & some pre-emergence 0.4 - 4.5	375 2 - 3	annual & perennial broadleaf	rice, wheat, barley pasture, non-cropland.	translocate(hormone) abnormal growth respone and affect on respiration
	2,4,5-T	2,4,5-trichlorophenoxy acetic acid	post-emergence & some pre-emergence 4 - 10	500 3 - 6	annual & perennial broadleaf and deep-rooted brush.	basal application of woody plants forestry & non-cropland.	effect on cell differentiation
	2,4-D B.	4-(2,4-dichlorophenoxy) butyric acid, salt; amine salts mixed sodium & potassium salts	post-emergence 0.3 - 3.5	700 nil	broadleaf	rice, cereals, peas, grassland, soybean, peanut.	effect on cell differentiation
13	Phosphorous * piperophos	S-(2-methylpiperidin-1-yl) carbonylmethyl-O, O-dipropylphosphorodithioate	pre-emergence eary post - emergence 2 - 3	2,150	annual grass & broadleaf, Cyperus spp.	rice, maize, cotton, soybean, peanut.	inhibition of photosynthesis
	glyphosine	N,N-bis(phosphonomethyl glycine	post-emergence 2.4 - 4.5	3,925 brief		bean.	inhibition of growth, chlorosis
	glyphosate	N-(phosphonomethyl) glycine	post-emergence 0.5 - 3.0	4,320 brief	annual & perennial broadleaf & grass	bean, citrus orchard, non-cropland	inhibition of aromatic amino acid biosynthesis pathway

(continuous)

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50)ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
14	Pyridines * picloram	4-amino-3,5,6-trichloro-picolinic acid	pre-post emergence and injection 0.5 - 3	8,200 12 - 69 (4 - 48)	wide range of annual & perennial broadleaf woody plant	non-cropland.	translocate (hormone type)
	triclopyr	[(3,5,6-trichloro-2-pyridyl)-oxy] acetic acid	post-emergence 1 - 3	713 12 - 16	annual & perennial broadleaf &brush	non-cropland & forestry.	translocate (hormone type)
	xyloxadine	2-[1-(2,5-dimethyl-phenyl)ethyl] sulfonyl pyridine-1-oxide	pre-emergence & incorporated 0.56 - 1.68	5,200	grass & Cyperus rotundus.	cotton, soybean, sugarbeet, potato.	
15	Sulfonyl * chlorosulfuron	2-chloro-N-(4-methoxy-6-methyl-1,3,5-triazin-2-yl-aminocarbonyl) benzenesulfonamide	pre&post emergence 0.01 - 0.06	5,545 8 - 12	broadleaf & grass	wheat, barley, oat, rye.	inhibition of cell division
	DPX-F 5384	methyl-2-[3-(4,6-dimethylpyrimidin-2-yl)ureidosulfonylimethyl] benzoate	pre-emergence & early post - emergence 0.0075 - 0.01	11,000 8 - 12	annual & perennial broadleaf & sedge	rice.	inhibition of cell division
	sulfometuron-methyl	methyl-2-[3-(4,6-dimethylpyrimidin-2-yl)ureidosulfonyl] benzoate	pre-post emergence 0.3 - 0.6	- 8 - 12	annual & perennial grass & weed	orchard, pasture, forestry, non-cropland.	
16	Thiocarbamates * EPTC	S-ethyl-N,N-di-n-propyl thiolcarbamate	pre-emergence & incorporated 2 - 6	3,160 4	annual grass & some broadleaf & Cyperus spp.	corn, cotton, flax, potato, bean, carrot, asparagus, & ornamental.	inhibition of growth in meristematic region

(continuous)

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50)ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
	molinate	S-ethyl-N,N-hexamethylene thiolcarbamate	pre-emergence 2 - 4	500 - 700 3 - 6	annual grass particular Echinochloa spp.	rice.	inhibition of growth and leaf development
	benthiocarb	S-(4-chlorobenzyl)-N, N-diethyl. thiolcarbamate	pre-emergence & early post-emergence 2 - 4	1,903 3 - 4	annual broadleaf & grass	rice.	inhibition of photosynthesis
17	Triazines *						
	atrizine	2-chloro 4-ethylamino 6-isopropylamino 1,3, 5-triazine	pre&post emergence 1 - 4	1,869 - 3,080 24 - 48	annual & perennial & grass	corn,sorghum, sugarcane, pineapple and non-cropland	inhibition of photosynthesis
	simazine	2-chloro 4,6-bis (ethylamino) 1,3,5-triazine	pre-emergence 1 - 4	> 5,000 10 - 12	annual broadleaf & grass	corn,potato,beet, soybean, peanut.	inhibition of photosynthesis
	simetryne	2-methylthio 4,6-bis (ethylamino)- 1,3,5-triazine	pre-emergence 1.5 - 2	1,830	annual broadleaf and grass	rice, lawn, onion, vegetable.	
	hexazinone	3-cyclohexyl-6-dimethy amino-1-methyl-1,3,5-triazin-2,4-(1H,3H)-dione	post-emergence 6 - 12	1,690 4 - 48	annual, biennial and perennial weed, woody vines	sugarcane, pineapple, and tropical crops; rubber,oil,palm, tea, conifers, peacans.	Contect
18	Uracils *						
	bromacil	5-bromo-3-sec-butyl-6-methyl uracil	pre&post emergence 1.5 - 5	5,200 20 - 40	wide range of grass & broadleaf	pineapple & citrus, alfalfa peperment & non-cropland.	inhibition of photosynthesis

(continuous)

No.	Compounds * Common names.	Chemical name Structural formula	Herbicidal Use Rates (kg/ha)	Toxicity(LD50)ppm Residues (weeks)	Susceptible Weeds	Crops	Mechanism action
	isocil	5-bromo-3-isopropyl-6-methyl uracil	pre&post emergence 5 - 20	3,400 -	wide range of grass & broadleaf	non-cropland.	inhibition of photosynthesis
	terbacil	3-tert-butyl-5-chloro-6-methyl uracil	pre-emergence 1 - 4	> 5,000 20 - 40	wide range of grass & broadleaf	sugarcane, apple, peaches, citrus, mint.	inhibition of photosynthesis
19	Ureas * monuron	3-(4-chlorophenyl)-1, 1-dimethylurea	pre&post emergence 0.8 - 4.8	3,600 16 - 48	annual broadleaf & grass	cotton, sugarcane pineapple, citrus peanut, onion.	inhibition of photosynthesis
	diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea	pre-emergence & early post - emergence 0.6 - 4.8	3,400 32 - 64	annual broadleaf & grass	cotton, sugarcane pineapple, citrus grape, pepermint.	inhibition of photosynthesis
	fluometuron	1,1-dimethyl-3-(3-trifluoro-methylpheny) urea	pre&post emergence 1 - 2	7,880 - 8,900 16 - 20	annual broadleaf & grass	cotton, corn, potato, onion, asparagus.	inhibition of Hill reaction & photosynthesis
20	Miscellaneous * amitrol	3-amino-1,2,4-triazole	pre&post emergence 2 - 10	1,100 - 25,000 2 - 4	annual & perennial grass & broadleaf	aquatic, orchard, non-cropland.	translocate, Chlorosis
	fenac	2,3,6-trichlorophenyl acetic acid	pre-emergence 4 - 8	576 - 1,780 52 - 104	annual & perennial broadleaf	aquatic, sugarcane non-cropland.	hormone
	perfluidone	2-methyl-4-phenylsul-phonyl trifluoromethyl-sulphoanilide	pre-emergence 2 - 4	633 8	annual broadleaf & grass, Cyperus spp.	cotton, soybean, cabbage, cucumber, flax, rape.	
	endothal	7-oxabicyclo (2,2,1) heptane-2,3 dicarboxylic acid	pre&post emergence 1 - 6	182 - 206 -	pigweed, kochia foxtail, crabgrass ragweed, purslane, clover, aquatic	sugarcane, spinach desicant; alfalfa cotton, clover, potato. aquatic herbicide & algaecide.	

USE OF RADIOISOTOPES IN HERBICIDE PHYSIOLOGY

Katsuichiro Kobayashi
(National Weed Science Research Institute Project)

PREFACE

Herbicides are potent and specific inhibitors of plant metabolism to death or regulate plant growth, and herbicide for agricultural use should have the selectivity between cultivation plants and weeds. In order to utilize herbicides effectively and safely, selective herbicidal action should be clearly understood by the users.

A mechanism of the selective action of various herbicides has been studied and reported by a number of researchers, and, in the study field, radioisotopes (RI) have been used as valuable materials. ^{14}C, ^{3}H, ^{32}P and ^{35}S-labelled materials have been used as the tracer in herbicide physiology, among which ^{14}C-labelled materials have been most frequently used. RI-labelled materials have the advantages to be easily distinguished from one which had been already existed in plants or soils. RI is detectable to extremely small amounts, and makes it possible to clarify the behavior of herbicide in plant or soil and the effect of herbicide on plant metabolism, in which RI-labelled herbicides or precursors of plant metabolism are used.

The approaches for clarifying the mechanisms of selective action of herbicide and some examples of RI usage in herbicide physiology are introduced in this paper.

MECHANISMS OF SELECTIVE ACTION OF HERBICIDES

To be effective, a sufficient quantity of herbicide must penetrate into plant and reach to the sensitive site(s) in plant tissues where the herbicide can induce the phytotoxic action. Conceptually, the process can be roughly divided into two main steps : herbicide behaviors and activities in plants. And there is a series of barriers which may limit herbicidal action from the application to its ultimate effect on plant growth, which can be concluded by the procedure[4] in Fig. 1.

The selectivity of herbicides can be based upon the following main physiological factors : a) differences in absorption, b) in translocation, c) in chemical transformation including activation and inactivation reactions, and d) in affinity with primary action site(s) between plants, although the other factors such as herbicide placement and morphological difference are also the important factors in determining the actual selectivity in the fields.

APPROACHES TO MECHANISMS OF ACTION OF HERBICIDES

The approaches to the mechanism of action of herbicide can be actually undertaken both in the herbicide behavior in plant and the action on plant metabolisms and on plant growth.

In the search for the effect of herbicide on plant metabolisms, RI-labelled precursors of the biosynthetic metabolisms such as protein and nucleic acid synthesis and lipid metabolism can be frequently used, and $^{14}CO_2$ can be also used in the survey of the inhibitory effect on photosynthesis. RI-labelled precursors are usually applied to the

sectioned plant parts and to the isolated organelle from plant such as chloroplasts and mitochondria in the appropriate experimental medium. After the incubation for the designed time, the amount of incorporated RI into the target sections, tissues, organelle or metabolities is determined by a liquid scintillating spectrometer system. The measured inhibition might be, in some cases, in the consequence of another metabolic block on which the investigated pathway depends. In these cases, the primary site(s) of action of herbicide can be speculated by a comparison of the result obtained in a metabolism with those obtained in the others. In vitro investigation with the isolated enzyme system, of course, can confirm the primary site(s) of action of herbicide.

In search for herbicide behaviors in plant, RI-labelled herbicides are applied to leaf, stem or root by droping or soaking method. RI makes it possible to trace not only the parent compounds of herbicides but also their metabolic products in plants. The radioactivity in each organ or part of plants are measured by a liquid scintillating spectrometer system, and the amount of absorption and translocation of the parent and/or the metabolites of herbicide in plants can be calculated based on the radioactivity. Autoradiography is also a useful fool for the study of herbicide translocation in plants. Autoradiography reveals the location of the radioactive materials within the specimen in photograph. The method is very often employed in the translocation and the metabolism studies of RI-labelled herbicides in plants. The former case provide the information about the distribution or location of RI in the plant in a superposed image of the specimen. In the latter case, the locations of radioactive spots on the thin-layer chromatograms are surveyed by autoradiography, and identified by co-chromatograph with the authentic compounds.

The mechanism of action and selectivity of herbicides can be clarified based on the informations given in both studies on herbicide behaviors in plant and on herbicide activity on plant metabolisms.

EXAMPLES IN CASE STUDIES

Barban (4-chlorobut-2-ynyl 3-chlorphenylcarbamate) has a highly selective herbicide on wild oat in fields of wheat, barley and other crops. By use of some RI-labelled precursors of protein and RNA synthesis, the selective activity was investigated in the physiological aspects [2,6,7]. Barban inhibited ^{14}C-methionine and ^{14}C-leucine incorporation into protein of wild oat and oat seedling (susceptible) but slightly inhibited the incorporation into protein of wheat and barley (tolerant) seedlings. In RNA synthesis, ^{14}C-uracil and ^{32}P incorporation into RNA were more remarkably inhibited in the susceptible plants than in the tolerant plants. Respiration and photosynthesis of both susceptible and tolerant plants were not inhibited, which were determined by means of the manometric method or of the infrared gas analyzer. The results demonstrated that the inhibition of protein and RNA synthesis might induce the inhibition on growth of susceptible plants. By use of ^{14}C-(carbonyl) and ^{14}C-(phenyl) labelled barban, absroption, translocation and metabolism of barban in plants were also investigated. The rates of absorption of ^{14}C-barban by the intact shoots of the susceptible plants were much higher than by these of the tolerant plants. However, radioautography showed little difference in the rates of translocation from the ^{14}C-barban treated leaf to the

other leaves or to the roots between the susceptible and the tolerant plants. The distribution of ^{14}C-radioactivity in unchanged barban decreased with time in both susceptible and tolerant plants with a compensating increase of ^{14}C-radioactivities in water and none-extractable residues, and the tendency was observed similarly with both ^{14}C(carbonyl)-barban and ^{14}C(phenyl)-barban. Little difference was found in the rate of chemical transformation between the susceptible and the tolerant plants. In contrast to using the intact shoots, the sectioned shoots of the tolerant plants obsorbed ^{14}C-barban as much as the susceptible plants, in addition that protein synthesis was inhibited by barban to the same extent in both of the susceptible and the tolerant plants. It was concluded, actually with intact plants, that one of the main factors which determined the barban selectivity in foliar application resides in the differential absorption by intact shoots between the susceptible and the tolerant plants, while the primary site of action was suggested to be protein and RNA synthesis.

By use of ^{14}C-barban, absorption, translocation and metabolism of barban applied to the roots were also investigated [8], and it was indicated that the concentration of unchanged barban in the shoots, in which the action site of barban is located, was higher in oat than in wheat. The difference in concentration of unchanged barban was concluded to be mostly derived from the differential rates of translocation of barban from roots to shoots. These experimental results are summarized in Table 1.

The selective mode of action of simetryn [2,4-bis(ethylamino-6-methylthio-1,3;5-triazine] among rice cultivars was studied [5], and it was concluded that a major factor determining the simetryn selectivity among the cultivars was found in their differential rates of metabolism of simetryn, greater in Nihonbare (Japonica - type, tolerant) and less in IR (Indica - type, susceptible) and Yushin (a hybid-type, susceptible). The mechanisms of differential responses of rice cultivars, Nihonbare (japonica type), choseng Tongil (a hybrid type), to simetryn and dimethametryn [2-(1,2-dimethylpropylamino)-4-ethylamino-6-methylthio-2,3,5-triazine] was also investigated with emphasis on comparison of their behaviors in plants by use of ^{14}C-labelled simetryn and demethametryn [1]. Nihonbare cultivar (more tolerant to simetryn and dimethametryn) demonstrated more rapidly to metabolized both herbicides than choseng Tongil cultivar (less tolerant) and barnyardgrass (susceptible), and it converted simetryn to metabolites at the higher rate than dimethametryn. The different rates of their metabolisms were considered the most important factor determining the different action of both herbicides and the different sensitivities to both herbicides among the rice cultivars and barnyardgrass.

The injury induced by simetryn in rice seedlings in sandy paddy fields under high temperature condition in Japan was also investigated [3,10,14]. The greater concentration of ^{14}C in the shoots was detected under higher temperature than under lower temperature, and it was suggested that simetryn concentrations in shoots were largely dependent upon rates of absorption by roots. The enhancement of ^{14}C-concentration in shoots with higher temperature was found to be differed among the rice cultivars, but temperature variation had little effect on the rate of metabolic reaction of simetryn in the rice cultivars.

The approach using RI-labelled materials was applied to the study on the mechanism of tuberization inhibition by naproanilide [2-(2-naphthoxy) propionanilide] [13]. Naproanilide inhibited the tuber initiation from rhizome with a slight inhibition to the shoot and the root growth of Cyperus serotinus, one of the troublesome weeds in paddy fields in Japan, and showed the most remarkable abnormalizing effect on the rhizome among the organs [11]. It was found that not only the amount of radioactivity derived from both naproanilide and its metabolites but also the production rates of 2-(2-naphthoxy) propionic acid (M-1) and 2-(2-naphthoxy) propionate (M-2), both of which had been detected as the activated metabolites of naproanilide [9,11], were the greatest in the rhizome, and that the rhizome was the most sensitive to naproanilide in terms of RNA synthesis distrubance, expressed by ^{14}C-uracil incorporation into RNA. It was concluded that the inhibition of tuber initiation of C. serotinus by naproanilide application was autually induced by M-1 and M-2 probably through their action on the RNA synthetic process related to the development of rhizome into tuber.

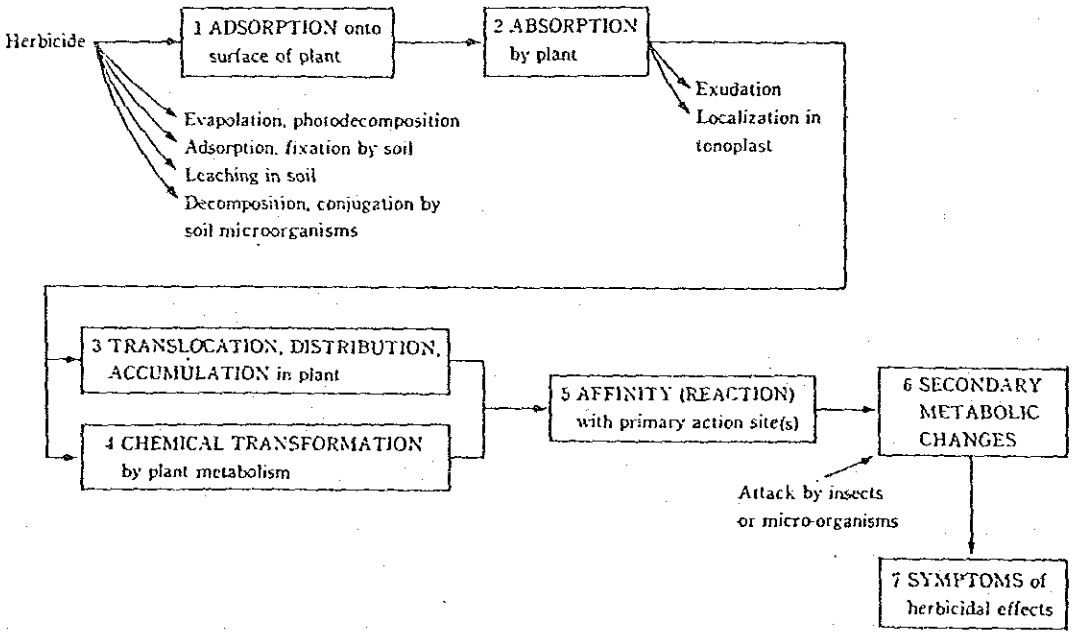


Fig. 1. Herbicide behaviors and activities in plants (Ishizuka, 1983)

Table 1. Comparison of Physiological Responses of Susceptible and Tolerant Plants to Barban.

Experimental Items	Comparison between Susceptible and Tolerant Plants	
	Foliar Application	Root Application
Absorption	S ≫ T S ≒ R (Sectioned Shoot)	S = T
Translocation	S = T	S ≫ T
Chemical Transformation	S < T	S < T
Affinity (Reaction)	(S = T)	
Effect on Respiration	S = T*	
Photosynthesis	S = T*	
Proteing Synthesis	S ≫ T S = R (Sectioned Shoots)	S ≫ T
RNA Synthesis	S ≫ T	

The asterisk indicates no or less effect.
S and T indicates the susceptible and tolerant plants.

REFERENCE

1) Chinawong, S. : Master thesis. (1986).
2) Ishizuka, K., K. Kobayashi and Y. Hashimo : Proc. 8th International Plant Protection Congress, 358-376 (1975).
3) Ishizuka, K.: Weed Res. (Japan), 28, 229-249 (1983).
4) Ishizuka, K., H. Matsumoto and Y. Kakumoto : Weed Res. (Japan) 29, 116-122 (1984).
5) Ishizuka, K., H. Matsumoto and T. Imahase : Weed Res. (Japan) 29, 289-294 (1984).
6) Kobayashi, K. and K. Ishizuka : Weed Sci. 22, 131-135 (1974).
7) Kobayashi, K. and K. Ishizuka : J. Pesticide Sci. 2, 59-65 (1977).
8) Kobayashi, K. and K. Ishizuka : Weed Res. (Japan) 24, 23-28 (1979).
9) Kobayashi, K., H. Hyakutake and K. Ishizuka : Weed Res. (Japan) 26, 30-36 (1981).
10) Kobayashi, K., K. Fukuchi, H. Hyakutake and K. Ishizuka : Weed Res. (Japan) 27, 210-216 (1982).
11) Kobayashi, K., K. Ichinose, H. Hyakutake and K. Ishizuka : Weed Res. (Japan) 28, 43-50 (1983).
12) Kobayashi, K. and K. Ichinose : Weed Res. (Japan) 29, 38-44 (1984).
13) Kobayashi, K. and K. Ichinose : Weed REs. (Japan), in press.

ECOLOGY AND CONTROL OF MIMOSA PIGRA L.

PAITOON KITTIPONG

ABSTRACT

Giant sensitive plant or Mimosa pigra L. was the native species of the central America. Spreading out from the native land to other tropical regions, such as Central Africa, South East Asia and North-western section of Australia can be traced at the moment.

In Thailand, Mimosa pigra L. and Mimosa invisa (Mart.) were introduced from Indonesia in 1952. Both species were planted as cover crop in tobacco plantation in Chiengmai province of the same year.

Because of its high adaptability to Thai conditions, this plant has become a noxious weed in agriculture land as well as non-agriculture lands within a few decades. Unused lands, irrigation systems, streams, swamps and roadsides of Chiengrai, Chiengmai, Lampoon and Lampang are fully occupied by Mimosa pigra L.

Growth and development of giant mimosa was fast during rainy season. Flowering period started from May to February with high peak on September and October. Fruit setting within a year were 6-7 times. Ripening period lasted 28-30 days after fertilization was completed. True domancy state of Mimosa pigra L. seeds could not detect. Longivity of seeds under water logged conditions was over 2 years period.

Manual control was not effective for giant mimosa because this plant was fast growing perennial weed and each year it produced a large number of seeds. Chemical application of effective compounds such as glyphosate and dicamba to fully growth plants by ground and aerial sprayed provided complete control of the weeds.

While early post application of dicamba, ethidiuron, glyphosate, triclopyr and sulfosate gave good control of young seedling 1-3 months old and pre-emergence herbicids such as atrazine, bifenox, diuron, isouron, oxadiazon and oxyfluorfen inhibited growth of seeds effectively.

นิเวศน์วิทยาและการควบคุมไมยราบยักษ์

บทนำ

ไมยราบยักษ์ ไมยราบหลวง หรือจี้ยอบหลวง เป็นไม้ยืนต้นขนาดกลางในตระกูลถั่ว (Leguminosae) ปัจจุบันมีชื่อทางพฤกษศาสตร์ว่า Mimosa pigra Linn. ชื่อสามัญในภาษาอังกฤษคือ Thorny sensitive plant. หรือ Giant sensitive plant. ไมยราบยักษ์มีถิ่นกำเนิดอยู่ในประเทศแถบอเมริกากลางและทางตอนเหนือของทวีปอเมริกาใต้ บริเวณประเทศเม็กซิโก โคลัมเบีย และเวเนซูเอล่า ไมยราบยักษ์ได้แพร่กระจายไปทางทิศเหนือสู่ภาคใต้ของทวีปอเมริกาเหนือ และทางทิศใต้สู่ประเทศบราซิลและบริเวณใกล้เคียงในทวีปอเมริกาใต้ และข้ามฝั่งมหาสมุทรแอตแลนติกสู่ทวีปอาฟริกาทางฝั่งตะวันตกบริเวณประเทศมอริเตเนีย กานา คองโก และทางตอนเหนือแถบประเทศซูดาน อียิปต์ รวมทั้งประเทศทางด้านทิศตะวันออกของทวีปอาฟริกา และมาลากาซี ตามลำดับ

ไมยราบยักษ์ถูกนำมาปลูกในประเทศไทยเมื่อประมาณ พ.ศ. 2495 โดยผู้นำเกษตรกรย้ายไร่ยาสูบทางภาคเหนือ ท่านผู้นี้ได้นำเมล็ดพันธุ์ไมยราบจากประเทศอินโดนีเซียมาปลูกที่อำเภอเชียงดาว และอำเภอแม่แตง จังหวัดเชียงใหม่ ด้วยกันสองชนิดคือ ชนิดต้นซึ่งเป็นไม้ยืนต้น ได้แก่ ไมยราบยักษ์ (Mimosa pigra Linn.) และชนิดเถาซึ่งเป็นพืชล้มลุก คือ ไมยราบเครือ (Mimosa invisa Mart.) โดยมีความมุ่งหมายเพื่อต้องการใช้เป็นพืชปรับปรุงดินในอุตสาหกรรมไร่ยาสูบเป็นหลัก

นิเวศวิทยา

การเจริญเติบโตของไมยราบยักษ์เป็นไปเช่นเดียวกับพืชชั้นสูงอื่น ๆ ทั่วไปกล่าวคือต้องอาศัยปัจจัยที่จำเป็นเพื่อสร้างสรรค์การเจริญเติบโต เช่น ความชุ่มชื้น แสงแดด ธาตุอาหาร และปริมาณออกซิเจนในบรรยากาศเป็นตัวการสำคัญสำหรับการดำรงชีวิตและขยายพันธุ์ ปัจจัยต่าง ๆ เหล่านี้จำเป็นต่อไมยราบยักษ์อย่างมาก เริ่มตั้งแต่การงอกของเมล็ด การเจริญเติบโตของต้นอ่อน จนถึงการเจริญเติบโตของต้นโตซึ่งอยู่ในระยะออกดอก

ความชุ่มชื้นพบได้ว่าเป็นปัจจัยที่มีความสัมพันธ์โดยตรงต่อการเจริญเติบโตและการแพร่กระจายพันธุ์ของไมยราบยักษ์ ในธรรมชาติจะพบไมยราบยักษ์ที่ขึ้นใกล้แหล่งน้ำและบริเวณที่ลุ่ม เช่น อ่างเก็บน้ำ หรือแม่น้ำลำธาร เจริญงอกงามมากกว่าที่ขึ้นบนที่ดอนหรือบริเวณที่สูงตามเนินเขา การออกดอกและติดฝักก็เช่นกันจะพบว่าไมยราบยักษ์ที่เจริญใกล้แหล่งน้ำออกดอกเร็วกว่า

และติดฝักมากกว่าที่ขึ้นตามบริเวณที่แห้งแล้ง

ต้นอ่อนของไมยราบยักษ์ที่งอกจากเมล็ดและเติบโตจนตั้งตัวได้แล้วจะเจริญเติบโตได้ดีในทุกสภาพแวดล้อม ไม่ว่าจะเป็นสภาพที่ลุ่มซึ่งมีน้ำขังตลอดปี หรือที่ลุ่มซึ่งถูกน้ำท่วมเป็นครั้งคราว ไมยราบยักษ์ที่ขึ้นอยู่ในบริเวณที่ลุ่มจะปรับตัวและสร้างระบบรากให้เหมาะกับการดำรงชีวิตอยู่ภายใต้สภาพน้ำท่วมรากซึ่งมีปริมาณออกซิเจนสำหรับการหายใจของรากน้อย โดยสร้างเซลล์ที่รากและบริเวณโคนต้นให้โป่งคล้ายฟองน้ำเพื่อเก็บกักออกซิเจนไว้ให้รากหายใจ ไมยราบยักษ์ที่ขึ้นในบริเวณนี้จะไม่สามารถดำรงชีวิตอยู่ได้ต่อเมื่อระดับน้ำบริเวณนั้นสูงมากขึ้นจนท่วมยอด

ต้นไมยราบยักษ์ที่ขึ้นอยู่ในบริเวณที่แห้งแล้งและมีความอุดมสมบูรณ์ของดินต่ำ เช่น ในดินทราย หรือดินลูกรัง ส่วนใหญ่จะสร้างระบบรากให้ยาวกว่าปกติประมาณ 3-4 เท่าของความสูงของต้น เพื่อเสาะแสวงหาความชุ่มชื้นและความอุดมสมบูรณ์จากดินชั้นล่างที่อยู่ลึกลงไป นอกจากนี้ที่ส่วนของรากไม่ว่าจะเป็นรากแก้ว หรือรากแขนงจะปรากฏปม (nodules) เช่นเดียวกับที่เกิดขึ้นบนรากของต้นถั่ว ปมเหล่านี้เป็นเองที่อาจทำหน้าที่ช่วยให้ต้นอ่อนของไมยราบยักษ์มีโอกาสได้รับธาตุอาหารที่จำเป็นในการเจริญเติบโตได้โดยไม่ขาดแคลน ความสามารถพิเศษนี้เป็นสิ่งสำคัญที่ช่วยให้ไมยราบยักษ์สามารถดำรงชีวิตอยู่ได้ในสภาวะแวดล้อมซึ่งพืชอื่นไม่สามารถเจริญได้ตามปกติ ปรากฏการณ์เช่นนี้จะไม่พบกับไมยราบยักษ์ที่เจริญเติบโตในดินที่มีความอุดมสมบูรณ์สูงแต่อย่างใดเลย และเมื่อต้นไมยราบยักษ์เจริญเติบโตมีอายุได้ประมาณ 6-8 เดือน และถึงฤดูออกดอกในหน้าฝน ไมยราบยักษ์จะเริ่มออกดอกเพื่อขยายพันธุ์ตามธรรมชาติ ปริมาณการออกดอกในปีแรกมีไม่มากนักแต่จะเพิ่มขึ้นเรื่อย ๆตามเกณฑ์อายุการเจริญเติบโตที่เพิ่มขึ้น และไมยราบยักษ์จะสามารถมีชีวิตอยู่ได้นานนับสิบ ๆ ปี ตราบเท่าที่ยังมิได้ถูกภัยธรรมชาติหรือภัยจากมนุษย์ทำลายลงเสียก่อน

ลักษณะทางพฤกษศาสตร์และการเจริญเติบโต

ต้นไมยราบยักษ์ที่งอกจากเมล็ดและมีอายุประมาณ 1 เดือน จะมีใบจริง 4-5 ใบ และมีความสูงประมาณ 8-10 ซม. ต่อเมื่อเจริญเติบโตขึ้นมีอายุประมาณ 3 เดือน ความสูงของต้นจะเพิ่มขึ้นเป็น 80-90 ซม. และเมื่อไมยราบยักษ์มีอายุได้ประมาณ 1 ปี จะมีความสูงโดยเฉลี่ยไม่ต่ำกว่า 1.5 เมตร ส่วนต้นโตที่เจริญอยู่ในช่วงปีที่ 2 และ 3 แล้วนี้จะมีความสูงตั้งแต่ 2.2 ถึง 4.3 เมตร ตามลำดับ โดยทั่วไปเมื่อไมยราบยักษ์เติบโตเต็มที่เป็นที่ปรากฏให้เห็นในที่ต่าง ๆ

พืชจะมีความสูงโดยเฉลี่ยประมาณ 3.5 เมตร

เมื่อไมยราบยักษ์เจริญเติบโตและมีอายุได้ประมาณ 3-4 เดือน ก็จะเริ่มออกดอก เมื่อถึงฤดูกาลเพื่อขยายพันธุ์ ปริมาณการออกดอกในรอบปีแรกนั้นจะยังไม่มากนักจะทวีจำนวนมากขึ้นเรื่อย ๆ ในปีที่ 2 และ 3 เมื่อไมยราบยักษ์มีขนาดโตขึ้น

การออกดอกของวัชพืชนี้เป็นไปในแบบค่อย ๆ ทะยอยออกติดต่อกันไปเรื่อย ๆ เกือบตลอดปี เริ่มตั้งแต่ประมาณต้นเดือนพฤษภาคมจนถึงเดือนกุมภาพันธ์ โดยมีช่วงระยะการออกดอกหนาแน่นในระหว่างเดือนสิงหาคมถึงตุลาคม และมีช่วงออกดอกน้อยที่สุดในระหว่างเดือนมีนาคม-เมษายน ไมยราบยักษ์ที่ขึ้นใกล้แหล่งน้ำจะออกดอกเร็วกว่าและมีช่วงการออกดอกยาวนานกว่าที่ขึ้นอยู่ในสภาพแห้งแล้งหรือที่ดอน

ดอกไมยราบยักษ์จะออกที่บริเวณส่วนปลายของกิ่งที่แตกใหม่และบนแยนงใหม่ของกิ่งเก่า ลักษณะของดอกที่ปรากฏให้เห็นมีลักษณะเป็นพุ่มทรงกลม ซึ่งมีเกษรตัวผู้ขนาดเล็กจำนวนมากเรียงติดอยู่โดยรอบเช่นเดียวกับดอกกระถิน ดอกของไมยราบยักษ์จัดเป็นดอกสมบูรณ์ เมื่อแรกบานจะมีสีชมพูและมีขนาดความยาวประมาณ 1.8 ซม. เส้นผ่าศูนย์กลางประมาณ 1.5 ซม. ดอกไมยราบยักษ์จะบานอยู่ประมาณ 2-3 วัน หลังดอกบานและการผสมเกษรเกิดขึ้นเรียบร้อยแล้วดอกจะเริ่มโรยและสีซีดลงเรื่อย ๆ ในไม่ช้าเกษรตัวผู้ก็จะหลุดร่วงไป จากนั้นประมาณ 6-7 วัน จะปรากฏฝักอ่อนสีเขียวลักษณะคล้ายนิ้วมือเล็ก ๆ ปกคลุมด้วยขนละเอียดสีน้ำตาลอ่อนเกิดขึ้นให้เห็นทั่วไป ฝักอ่อนของไมยราบยักษ์จะค่อย ๆ เจริญเติบโตขึ้นเรื่อย ๆ ภายในระยะเวลาประมาณ 28 วันก็จะเริ่มแก่ สีเขียวที่ปรากฏให้เห็นจะค่อย ๆ เปลี่ยนเป็นสีน้ำตาลและน้ำตาลปนดำเมื่อแก่จัด ซึ่งจะใช้เวลาประมาณ 35 วัน เมื่อฝักแก่เต็มที่เมล็ดแต่ละเมล็ดที่อยู่ภายในฝักของแต่ละฝักจะแยกตัวจากกันตรงบริเวณรอยต่อระหว่างเมล็ดภายในฝัก และพร้อมที่จะหลุดจากฝักแห้งลงสู่พื้นดินหรือล่องลอยไปตามกระแสน้ำเพื่อให้กำเนิดแก่ชีวิตใหม่ต่อไป

การควบคุมไมยราบยักษ์

วิธีการป้องกันกำจัดไมยราบยักษ์ที่เกษตรกรทั่ว ๆ ไป รวมทั้งหน่วยงานของรัฐปฏิบัติอยู่สามารถรวบรวมและสรุปได้ดังนี้คือ

1. การควบคุมด้วยวิธีกล (Mechanical Control)

การควบคุมไมยราบยักษ์วิธีนี้หมายถึงการใช้แรงคน เครื่องมือ ตลอดจนเครื่องจักร

กล ป่วยกำจัดไมยราบยักษ์ให้หมดสิ้นไป ซึ่งมีวิธีปฏิบัติ 2 แบบ คือ

1.1 การใช้แรงงาน (Manual operation)

วิธีนี้ได้แก่การใช้แรงงานคนหรือสัตว์เข้าทำลายไมยราบยักษ์ที่ระบาดตามที่ต่าง ๆ เช่น บริเวณข้างถนน แนวคลองชลประทาน ริมฝั่งแม่น้ำลำคลอง ที่สาธารณะ บริเวณอ่างเก็บน้ำ และพื้นที่อื่น ๆ อุปกรณ์ที่ใช้ได้แก่เครื่องมือง่าย ๆ สำหรับการตัดฟันและขุดทำลาย ได้แก่ มีด จอบ เสียม เป็นต้น

1.2 การใช้เครื่องจักรกล (Mechanical operation)

วิธีนี้ก็คือการใช้เครื่องมือและเครื่องทุ่นแรง เช่น ; แทรกเตอร์ หรือ รถเกรดดิน เข้าทำลายไมยราบยักษ์ในพื้นที่ซึ่งระบาดรุนแรง เช่น บริเวณข้างถนน หรือที่สาธารณะ วิธีนี้สามารถป่วยกำจัดไมยราบยักษ์ต้นโตให้หมดไปจากพื้นที่ได้ในเวลาอันรวดเร็วถ้าสภาพแวดล้อมเหมาะสม เช่น ฝนไม่ตกหรือดินไม่ลุ่มเกินไป แต่การควบคุมวิธีนี้ต้องใช้กำใช้จ่ายสูง และมักมีอุปสรรคในการปฏิบัติเสมอเนื่องจากสภาพพื้นที่ไม่เอื้ออำนวย นอกจากนี้หลังจากดำเนินการแล้ว และไมยราบยักษ์ต้นโตถูกทำลายหมดไป สภาพแวดล้อมจะเปลี่ยนไปในทางที่ป่วยกระตุ้นให้เมล็ดที่จมอยู่ในดินงอก และเจริญเติบโตเป็นต้นอ่อนได้รวดเร็วขึ้นเมื่อได้รับสภาพแวดล้อมที่เหมาะสม ดังนั้นภายหลังจากที่ได้มีการกำจัดไมยราบยักษ์ด้วยวิธีนี้แล้วจะต้องมีการใช้ประโยชน์จากพื้นที่อย่างใดอย่างหนึ่งโดยเร็วที่สุด มิฉะนั้นแล้วภายในระยะ 6-7 เดือน ไมยราบยักษ์รุ่นใหม่จะงอกงามขึ้นแทนที่เหมือนเช่นเดิม

2. การควบคุมไมยราบยักษ์ด้วยสารกำจัดวัชพืช

การกำจัดไมยราบยักษ์ด้วยสารกำจัดวัชพืชเป็นกรรมวิธีการปฏิบัติทางด้านวิชาการที่มีขั้นตอนซับซ้อนพอควร ทั้งนี้เพราะจะต้องเกี่ยวข้องโดยตรงกับไมยราบยักษ์ต้นโต และต้นขนาดเล็กซึ่งเจริญบนพื้นดิน และในสภาพน้ำยังรวมทั้งเมล็ดบนพื้นดินอีกด้วย ประกอบกับสารกำจัดวัชพืชที่มีจำหน่ายในท้องตลาดมีหลายชนิดและมีคุณสมบัติแตกต่างกัน ดังนั้นการวิจัยรวมทั้งรายละเอียดของการปฏิบัติจึงต้องวางแผนให้รัดกุมมีขั้นตอนเหมาะสมที่สุด จึงจะทำให้การควบคุมไมยราบยักษ์ได้ผลตามเป้าหมาย

ขั้นตอนการวิจัยเกี่ยวกับการควบคุมไมยราบยักษ์ด้วยสารกำจัดวัชพืชซึ่งผู้ปฏิบัติงานวิจัยได้วางไว้มีดังนี้คือ

2.1 การทดสอบประสิทธิภาพเบื้องต้น

2.2 การวิจัยภาคพื้นดิน

2.3 การวิจัยการพ่นสารกำจัดวัชพืชทางอากาศ

2.4 การวิจัยการควบคุมไมยราบต้นเล็กและการงอกของเมล็ด

2.1 การทดสอบประสิทธิภาพเบื้องต้นของสารกำจัดวัชพืช

ผลการทดสอบประสิทธิภาพเบื้องต้นเกี่ยวกับการออกฤทธิ์กำจัดไมยราบยักษ์ของสารกำจัดวัชพืชชนิดต่าง ๆ ครั้งแรก ที่ อ.เมือง จ.เชียงใหม่ ในระหว่างเดือนสิงหาคม 2518 - ธันวาคม 2518 แสดงไว้ในตารางที่ 1

ผลการทดสอบประสิทธิภาพเบื้องต้นแสดงให้เห็นว่าภายหลังการพ่นสารกำจัดวัชพืชแล้วประมาณ 40-50 วันนั้น สารกำจัดวัชพืชที่ใช้ส่วนใหญ่ออกฤทธิ์กำจัดไมยราบยักษ์ได้ดีคล้าย ๆ กัน แต่ในช่วงระยะต่อมาคือประมาณ 100-120 วันภายหลังการพ่นสารกำจัดวัชพืชแล้ว ปรากฏว่ามีสารกำจัดวัชพืชเพียงสามชนิดเท่านั้นที่ยังคงออกฤทธิ์กำจัดไมยราบยักษ์ได้ดีเป็นเด่น สารเคมีกำจัดวัชพืชเหล่านี้คือ glyphosate, silvex และ 2,4-D อัตรา 0.36 และ 0.72 กก. (ai)/ไร่ ตามลำดับ

2.2 การวิจัยภาคพื้นดิน

การทดสอบในช่วงนี้ปฏิบัติที่ อ.เมือง จ.เชียงใหม่ รายละเอียดของการวิจัยคงเป็นไปตามรูปแบบเดียวกับการทดสอบประสิทธิภาพเบื้องต้นทุกอย่าง มีเพิ่มเติมบ้างเล็กน้อยก็คือได้นำเทคนิคการผสมสารกำจัดวัชพืชเข้าด้วยกันมาใช้เพื่อเพิ่มประสิทธิภาพการกำจัดไมยราบยักษ์ให้กว้างขวางยิ่งขึ้น โดยคำนึงถึงค่าใช้จ่ายและผลกระทบต่อสภาพแวดล้อมเป็นหลัก ยกระเดียวกันช่วงระยะการตรวจผลวิจัยก็ได้ปล่อยให้นานกว่า 120 วัน ผลการวิจัยในช่วงนี้ได้แสดงไว้ในตารางที่ 2

ผลการทดสอบประสิทธิภาพของสารกำจัดวัชพืชเพื่อกำจัดไมยราบยักษ์ขั้นสุดท้ายแสดงให้ทราบว่ามีสารกำจัดวัชพืชเพียงสองชนิดเท่านั้นที่แสดงประสิทธิภาพกำจัดไมยราบยักษ์ดีที่สุดโดยให้ประสิทธิภาพสูงสุดคือ glyphosate อัตรา 0.36 และ 0.72 กก.(ai) /ไร่ กับอัตราผสมของ silvex + 2,4-D อัตรา .018 + .018 และ 0.36 + 0.36 กก. (ai)/ไร่ ตามลำดับ

2.3 การวิจัยการพ่นสารกำจัดวัชพืชทางอากาศ

วัตถุประสงค์ของการวิจัยลักษณะนี้ก็เพื่อต้องการที่จะทำการศึกษาและเปรียบเทียบประสิทธิภาพของสารกำจัดวัชพืชที่พบว่ามีประสิทธิภาพสูงจากการวิจัยทางภาคพื้นดินว่า ถ้าใช้มาพ่นทางอากาศยิ่งสามารถจิดพ่นลงบนส่วนยอดของไมยราบยักษ์ได้โดยตรงแต่ใช้ปริมาณน้ำเพียงเล็กน้อยแล้วประสิทธิภาพการควบคุมไมยราบยักษ์จะเปลี่ยนแปลงไปจากเดิมหรือไม่ ซึ่งประโยชน์ที่ได้รับจากการวิจัยนี้สามารถนำไปประยุกต์ใช้สำหรับควบคุมไมยราบยักษ์ในพื้นที่ใหญ่ ๆ ได้โดยตรง

การวิจัยการพ่นสารกำจัดวัชพืชทางอากาศครั้งนี้ปฏิบัติการวิจัยที่บริเวณอ่างเก็บน้ำห้วยลม อ.แจ้ห่ม จ.ลำปาง ระหว่างฤดูแล้งปี 2525 สารกำจัดวัชพืชที่ใช้คือ glyphosate, dicamba 40.6%(3,6-dichloro-o-amisic acid), pichloram 49.8% (4-amino-3,5,6-trichloro picolinic acid) และ triclopyr 48% [(3,5,6-trichloro-2-pyridinyl) oxy] acetic acid

การพ่นสารกำจัดวัชพืชใช้เครื่องบินปีกหมุน " Hiller " ติดหัวฉีด 59 หัว สามารถฉีดเป็นแนวกว้างได้ประมาณ 10 เมตร ขับด้วยอัตราความเร็ว 20 น็อต/ชม. ความสูงขณะฉีดพ่นประมาณ 1 เมตรจากยอดไมยราบยักษ์

ผลการวิจัยแสดงไว้ในตารางที่ 3 ซึ่งแสดงให้ทราบชัดเจนว่าสารกำจัดวัชพืช glyphosate อัตรา 2-4 ลิตร/ไร่ ผสมน้ำ 20 ลิตร ฉีดพ่นในพื้นที่ 1 ไร่ ออกฤทธิ์กำจัดไมยราบยักษ์ในระหว่างฤดูฝนดีที่สุด กล่าวคืออกฤทธิ์ควบคุมไมยราบยักษ์ในอ่างเก็บน้ำได้ตลอดระยะเวลาการวิจัย 12 เดือน ส่วนผลการวิจัยในช่วงฤดูแล้งพบว่า glyphosate อัตรา 10. และ 20. กก/ไร่ dicamba อัตรา 20. และ 4.0 กก/ไร่ picloram และ triclopyr อัตรา 1.0 และ 2.0 กก/ไร่ ออกฤทธิ์ควบคุมไมยราบยักษ์ในช่วงฤดูแล้งได้เป็นที่น่าพอใจ

2.4 การวิจัยควบคุมการงอกของเมล็ดและไมยราบต้นเล็ก

การวิจัยในช่วงนี้ได้แบ่งเป็นสองโครงการย่อยคือ การวิจัยเรื่องควบคุมการงอกของเมล็ดไมยราบยักษ์ในดิน และการควบคุมไมยราบยักษ์ต้นอ่อนหรือต้นยาก เล็กที่มีอายุการเจริญเติบโตประมาณ 1-4 เดือน ซึ่งเป็นช่วงก่อนไมยราบยักษ์ออกดอก

สารกำจัดวัชพืชที่ได้คัดเลือกไว้ใช้ในการวิจัยทั้งสองโครงการนี้ส่วนใหญ่เป็น

ชนิดที่เกษตรกรใช้สำหรับควบคุมวัชพืชในพืชปลูกทั่ว ๆ ไปในเอง ทั้งนี้เนื่องจากเหตุผลที่ว่าต้องการให้เกษตรกรใช้ประโยชน์จากสารกำจัดวัชพืชที่มีอยู่แล้วให้มากที่สุด ซึ่งเท่ากับเป็นการป้องกำจัดชนิดของสารกำจัดวัชพืชที่ใช้กันในด้านการเกษตรให้มีจำนวนน้อยลงด้วย

ระยะเวลาการวิจัยสำหรับปี 2527 เริ่มตั้งแต่เดือนกรกฎาคม ถึง ธันวาคม และในปี 2528 เริ่มตั้งแต่เดือนพฤษภาคม ถึงเดือนกุลาคม

ผลการวิจัยการควบคุมการงอกของเมล็ดและต้นอ่อนไมยราบยักษ์และไมยราบเครือ แสดงไว้ในตารางที่ 4 และ 5 ตามลำดับ

ผลการวิจัยในตารางที่ 4 แสดงให้ทราบว่าสารกำจัดวัชพืช atrazine, diuron และ isouron ทั้ง 3 อัตราออกฤทธิ์กำจัดไมยราบยักษ์และไมยราบเครือดีที่สุดคือให้ประสิทธิภาพการควบคุมสูง 80 ถึง 100 เปอร์เซนต์ ส่วนที่ให้ผลรองลงมาคือ bifenox, oxadiazon และ oxyfluorfen อัตราปานกลางและสูง ซึ่งให้ประสิทธิภาพการควบคุมวัชพืชทั้งสองสูงประมาณ 75 ถึง 98 เปอร์เซนต์ ส่วนอัตราต่ำของสารกำจัดวัชพืชทั้ง 3 ชนิดนี้ให้ผลไม่เป็นที่น่าพอใจเช่นเดียวกับ metolachlor

ตารางที่ 5 แสดงให้ทราบว่าสารกำจัดวัชพืชที่ใช้ทั้งหมด 7 ชนิด ออกฤทธิ์ควบคุมไมยราบยักษ์และไมยราบเครืออายุ 30 วัน ได้ดีมีประสิทธิภาพสูงสุด 100 เปอร์เซนต์ แต่เมื่อต้นไมยราบยักษ์และไมยราบเครือโตขึ้นประมาณ 2 เดือนขึ้นไป ปรากฏว่า สารกำจัดวัชพืช dicamba, ethidiuron, glyphosate, triclopyr, sulphosate และ paraguat อัตราสูงยังคงออกฤทธิ์กำจัดวัชพืชได้ดีเหมือนเดิม ส่วน paraquat อัตราปานกลางและต่ำประสิทธิภาพการควบคุมลดลงและสำหรับการควบคุมไมยราบเครือนั้นพบว่า dicamba อัตราต่ำ และ paraquat อัตราปานกลางและต่ำประสิทธิภาพลดลงจากเดิม ส่วนสารกำจัดวัชพืชที่เหลือยังคงออกฤทธิ์ดีเช่นเดิม

สรุป

ไมยราบยักษ์เป็นพืชตระกูลถั่วซึ่งมีถิ่นกำเนิดอยู่ในแถบประเทศลาตินอเมริกาเขตร้อน และได้แพร่กระจายไปสู่ภูมิภาคเขตร้อนส่วนอื่น ๆ ของโลก เช่น อาฟริกาตอนกลาง เอเชียตะวันออกเฉียงใต้ และภาคตะวันตกเฉียงเหนือของทวีปออสเตรเลีย ตามลำดับ สำหรับประเทศไทยนั้นได้มีผู้นำเมล็ดไมยราบทั้งชนิดต้นและชนิดเลื้อย มาปลูกเป็นพืชคลุมดินในไร่ยาสูบภาคเหนือ ที่จังหวัดเชียงใหม่เมื่อประมาณปี พ.ศ. 2495

การเจริญเติบโตและการแพร่ระบาดของไมยราบยักษ์ในประเทศไทยเกิดขึ้นอย่างรวดเร็วเพราะไมยราบยักษ์สามารถปรับตัวให้เข้ากับสภาพแวดล้อมของประเทศไทยได้เป็นอย่างดี และในปัจจุบันได้กลายเป็นวัชพืชสำคัญอีกชนิดหนึ่งที่ระบาดเป็นปัญหาแก่บ้านเมืองทั้งในพื้นที่ทำการเกษตรและนอกพื้นที่การเกษตร รวมทั้งบริเวณรกร้างว่างเปล่า แหล่งน้ำธรรมชาติ แหล่งน้ำเพื่อการเกษตรและพลังงาน ตลอดจนตามแนวเส้นทางคมนาคมที่สำคัญ ๆ ในภาคเหนือ

ไมยราบยักษ์เจริญเติบโตได้ดีในพื้นที่ทุกภาคของประเทศไทย และออกดอกขยายพันธุ์ต่อเนื่องกันไปแต่ละปีประมาณ 6-7 ครั้ง เมล็ดไมยราบยักษ์นอกจากจะไม่มีระยะพักตัวที่แท้จริงแล้ว เมล็ดยังมีความแข็งและทนทานต่อสภาพแวดล้อมโดยทั่วไปเป็นอย่างดี และเมล็ดสามารถมีชีวิตอยู่ได้ภายใต้สภาพที่ถูกน้ำท่วมหรือถูกฝังอยู่ใต้ดินได้เป็นระยะเวลามากกว่า 2 ปี

การควบคุมไมยราบยักษ์ด้วยวิธีการต่าง ๆ เช่น การใช้แรงคนตัดฟัน หรือใช้เครื่องจักรกลเข้าเหยียบย่ำและทำลายนั้นไม่มีผลในการลดปริมาณการระบาดมากนัก เนื่องจากในแต่ละปีไมยราบยักษ์ผลิตเมล็ดได้จำนวนมหาศาล ประกอบกับไมยราบยักษ์เป็นพืชอายุหลายปี ซึ่งเติบโตเร็วและค่อนข้างที่จะทนทานต่อการทำลายด้วยวิธีตัดฟันหรือเผา ดังนั้นจึงเป็นการยากที่จะทำลายให้หมดได้ด้วยการควบคุมโดยใช้แรงงานแต่เพียงอย่างเดียว

การควบคุมไมยราบยักษ์ด้วยสารกำจัดวัชพืชเป็นวิธีปฏิบัติที่ได้ผลดีด้วยตัวเองแล้วว่ามีประสิทธิภาพสูงสุดในการควบคุมไมยราบยักษ์ทั้งโตรวมทั้งต้นอ่อนและเมล็ดในดิน สารกำจัดวัชพืชที่ออกฤทธิ์ควบคุมไมยราบยักษ์ทั้งโตได้ผลเป็นที่น่าพอใจได้แก่ dicamba และ glyphosate และที่ออกฤทธิ์ควบคุมไมยราบยักษ์ต้นเล็กอายุระหว่าง 1-3 เดือนได้ดีคือ dicamba, ethidimuron, glyphosate, triclopyr และ sulphosate ส่วนที่ออกฤทธิ์ควบคุมการงอกของเมล็ดในดินได้ดีนั้นได้แก่ bifenox, diuron, isouron, oxadiazon และ oxyfluorfen ตามลำดับ

ตารางที่ 1 ประสิทธิภาพการกำจัดไมยราบยักษ์ของสารกำจัดวัชพืชชนิดต่าง ๆ ที่ จ.เชียงใหม่ และ จ.ลำพูน

สารกำจัดวัชพืช	อัตราการใช้ กก.(ai)/ha	กก.(ai) /ไร่	ประสิทธิภาพ: การกำจัด I	II
1. glyphosate	1.125	0.18	7.5	5.5
	2.25	0.36	9.0	8.5
	4.50	0.72	10.0	10.0
2. ioxynil	1.125	0.18	7.5	0.0
	2.25	0.36	9.0	2.0
	4.50	0.72	10.0	2.0
3. MCPA	2.25	0.36	5.0	2.0
	4.50	0.72	6.5	2.0
4. silvex	2.25	0.36	8.0	7.0
	4.50	0.72	9.0	5.0
5. tebuthiuron	2.25	0.36	5.0	1.0
	4.50	0.72	7.0	2.0
	9.00	1.44	9.0	3.0
6. 2,4-D	2.25	0.36	7.0	6.0
	4.50	0.72	8.0	5.5

หมายเหตุ: (I) การตรวจผลเมื่อ 40-50 วันหลังพ่นสารกำจัดวัชพืช

(II) การตรวจผลเมื่อ 100-120 วันหลังพ่นสารกำจัดวัชพืช

: การตรวจผลกระทำโดยวิธีตรวจด้วยสายตา (visual observation) ใช้ระบบการให้คะแนน 10 แต้มเป็นหลัก

ตารางที่ 2 ประสิทธิภาพการกำจัดไมยราบยักษ์ของสารกำจัดวัชพืชชนิดต่าง ๆ และอัตราผสม ที่ อ.เมือง จ.เชียงใหม่ ระหว่างปี 2520 - 2521

สารกำจัดวัชพืช	อัตราการใช้ กก. (ai)/ha	อัตราการใช้ กก.(ai) /ไร่	ประสิทธิภาพการกำจัด I	ประสิทธิภาพการกำจัด II
1. glyphosate	2.25	0.36	9.5	9.0
	4.50	0.72	10.0	10.0
2. silvex	2.25	0.36	8.0	6.5
3. 2,4-D	2.25	0.36	7.0	5.5
4. silvex + 2,4-D	2.25 + 2.25	0.36 + 0.36	9.5	10.0
5. silvex + 2,4-D	1.125 + 1.125	0.18 + 0.18	8.0	9.0

หมายเหตุ : (I) การตรวจผลเมื่อ 50-60 วันหลังพ่นสารกำจัดวัชพืช

(II) การตรวจผลเมื่อ 130-150 วันหลังพ่นสารกำจัดวัชพืช

: การตรวจผลกระทำโดยวิธีตรวจด้วยสายตา (visual observation) ใช้ระบบการให้คะแนน 10 แต้มเป็นหลัก

ตารางที่ 3 แสดงประสิทธิภาพสารเคมีกำจัดวัชพืชที่ใช้ควบคุมไมยราบยักษ์ทางอากาศที่อ่างเก็บน้ำกิ่วลม อำเภอเถิน จังหวัดลำปาง พ.ศ. 2526

สารกำจัดวัชพืช	อัตรา ลิตร(MAT)/ไร่	ปริมาณน้ำ	ประสิทธิภาพ 60 DAT	120 DAT	180 DAT	240 DAT
1. dicamba	2	10	10.0	9.5	8.0	
2. dicamba	2	20	10.0	10.0	10.0	
3. dicamba	4	10	10.0	10.0	10.0	
4. dicamba	4	20	10.0	10.0	10.0	
5. glyphosate	1	10	10.0	10.0	8.0	
6. glyphosate	1	20	10.0	10.0	10.0	
7. glyphosate	2	10	10.0	9.5	8.5	
8. glyphosate	2	20	10.0	10.0	10.0	
9. picloram	1	10	10.0	8.5	8.0	
10. picloram	1	20	10.0	10.0	9.0	
11. picloram	2	10	10.0	8.5	8.0	
12. picloram	2	20	10.0	10.0	9.0	
13. triclopyr	1	10	10.0	9.0	7.0	
14. triclopyr	1	20	10.0	10.0	8.0	
15. triclopyr	2	10	10.0	9.5	7.5	
16. triclopyr	2	20	10.0	9.5	8.5	

ตารางที่ 4 แสดงประสิทธิภาพการกำจัดไมยราบยักษ์และไมยราบเครือของสารกำจัดวัชพืชประเภทใช้ก่อนวัชพืชงอก 7 ชนิด ที่โครงการไร่มาลำธิตแม่เหียะ อำเภอหางดง จังหวัดเชียงใหม่ ปี 2527 และ 2528

กรรมวิธี	อัตรา	ประสิทธิภาพการควบคุม	
	กรัม(ai)/ไร่	ไมยราบยักษ์	ไมยราบเครือ
1. atrazine	160	9.3	9.0
	320	9.9	9.0
	640	100	9.0
2. bifenox	160	6.2	4.0
	320	8.4	7.0
	640	9.8	8.5
3. diuron	180	7.8	6.0
	360	9.3	8.2
	720	10.0	9.7
4. isouron	80	9.3	9.0
	160	10.0	10.0
	320	10.0	10.0
5. metolachlor	160	2.5	1.0
	320	4.0	2.8
	640	6.8	3.3
6. oxadiazon	80	6.7	3.7
	160	8.9	6.7
	320	9.8	8.0
7. oxyfluorfen	40	5.2	2.2
	80	7.5	5.0
	160	9.2	5.8
8. เปรียบเทียบ	-	0.0	0.0

หมายเหตุ ประสิทธิภาพการควบคุมเป็นค่าเฉลี่ยของการตรวจนับทุกผลสองครั้ง เมื่อ 30 และ 60 วันหลังพ่นสารกำจัดวัชพืชโดยใช้ระบบการให้คะแนน 10 แต้ม

ตารางที่ 5 แสดงประสิทธิภาพการกำจัดไมยราบยักษ์และไมยราบเครือของสารกำจัดวัชพืช ประเภทใช้หลังวัชพืชงอก 6 ชนิด ที่โครงการไร่นาสาธิตแม่เหียะ อำเภอหางดง จังหวัดเชียงใหม่ ปี 2527 และ 2528

กรรมวิธี	อัตรา กรัม(ai)/ไร่	ประสิทธิภาพของการควบคุม ไมยราบยักษ์ (1)	ไมยราบยักษ์ (2)	ไมยราบเครือ (1)	ไมยราบเครือ (2)
1. dicamba	120	10	10	6	5
	240	10	10	8	8
	480	10	10	10	10
2. ethidiuron	175	10	10	10	10
	350	10	10	10	10
	700	10	10	10	10
3. glyphosate	102.5	10	10	10	10
	205	10	10	10	10
	410	10	10	10	10
4. paraquat	69	10	6	10	5
	138	10	7	10	7
	276	10	10	10	10
5. triclopyr	154	10	10	10	10
	308	10	10	10	10
	616	10	10	10	10
6. sulphosate	210	10	10	10	10
	240	10	10	10	10
	480	10	10	10	10
7. เปรียบเทียบ	-	0	0	0	0

หมายเหตุ : ประสิทธิภาพการควบคุมเป็นค่าเฉลี่ยของการตรวจนับทุกซ้ำ เมื่อ 30 วันหลังพ่นสารกำจัดวัชพืชโดยใช้ระบบการให้คะแนน 10 แต้ม

: (1) = วัชพืชอายุ 30 วัน

(2) = วัชพืชอายุ 60 วัน

เอกสารอ้างอิง

1. ฉรัล ทองสกิตย์ และ วิรสันห์ มิลดาบุวงศ์ 2521 เอกสารวิชาการเรื่อง " การผลิตแผ่นใยไม้อัดจากไมยราบยักษ์"
2. แม่โจ้เชียงใหม่ 2521 : เอกสารทางวิชาการเรื่อง "ไมยราบยักษ์"
3. กองวิจัยและทดลอง กรมส่งเสริมการเกษตร 2521 : เอกสารทางวิชาการ สวท.0021-1 เรื่อง "ไมยราบยักษ์"
4. ไพฑูรย์ กิตติพงษ์ 2523 ไมยราบยักษ์ เอกสารวิชาการที่ 3/2523 กองวิทยาการ กรมวิชาการเกษตร
5. สุมนทิพย์ บุญมาก 2525 การศึกษาปริมาณมิโมซีนและโปรตีนในไมยราบยักษ์และกระถินยักษ์ วิทยานิพนธ์ปริญญาโท พ.ศ. 2525 ภาควิชาพฤกษศาสตร์ คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
6. B. Napompeth. 1982. Background, treat and distribution of Mimosa pigra L. in Thailand. Paper presented at the IPPC/NBCRC International Symposium on Mimosa pigra Management, Chiant Mai, Thailand Feb. 22-26, 1982.
7. Robert , G.L. 1982. Economic returns to investment in control of Mimosa pigra L. in Thailand. IPPC document No. 42-14-82 MCA Agricultural Economics. Report No. 15:163-166.
8. Harley, K.L.S., T.L. Miller, B. Napompeth and S. Thamasara. 1985. An intergrated approach to the management of Mimosa pigra L. in Australia and Thailand. Proc. No. 1. of 10 th APWSS Conf.:209-215
9. P. Kittipong, M. Rumakom and S. Thamasara. 1985. Chemical control of Mimosa pigra L. in (northern) Thailand by aerial spraying. Proc. No. 1. of 10 th APWSS Conf. : 325-330.
10. Premasthira, C., S. Zungsonthiporn and P. Kittipong. 1985. Viability of Mimosa pigra L. seeds in different environmental conditions. Abstracts of 10th APWSS Conf.:48.

11. Shibayama, H. and P. Kittipong 1985. Biology and control of Mimosa pigra L. Abstracts of 10th APWSS Conf.:143.

12. Wara-Aswapati and W. Watanadajsaree. 1985. Germination and respiration rate of Mimosa invisa Mart. and Mimosa pigra L. seeds. Abstracts of 10th APWSS Conf.:137.

To summarize the above mentioned, the taller population is characterized by the composition of heavier individuals in smaller numbers, and on the other hand, the smaller population (at more than 60 cm height) by the composition of slighter individuals in larger numbers. These differentiation may indicate the aspects of the population on growing process.

The vertical profile of the natural Waterhyacinth population determined by the stratified clip method has the following characteristics, gained from the natural population with 1.17 kg d.w./m^2 in standing crop, 100 cm in maximum height and 5.5 m^2/m^2 in leaf area index.

1. Blades was mostly distributed in the upper part of the population and petioles in the lower part of the population. Relative light intensity within the population was decreased largely among the upper part. The RLI values reached less than 10% and 1% at 35 cm and 55 cm from the top, respectively. The most productive portion within the population was situated at the upper 60% to whole height. This vertical profile corresponds with the "herb type" of a terrestrial plant population reported by Monsi and Saeki (1953).
2. There was about 60% of standing crop below water surface because, in addition to the roots and stolons, a half of petioles sank under water.

The values of Leaf Area Index (LAI) were varied from 4.3 to 7.1 m^2/m^2 in the Waterhyacinth population at more than 60 cm height, gained in Thailand. These values were larger among Aquatic macrophytes which show a wide ranges from 0.4 to 13 m^2/m^2, and close to those of Phragmites communis population. Furthermore, the values of the Waterhyacinth populations were larger than those of the terrestrial herbaceous population which generally ranges from 4 to 5 m^2/m^2 summarized by Iwaki (1971). Their larger LAI value may be due to their characteristics of upright blade shape, which may enable their population to avoid mutual shading in spite of the dense blades and to utilize the incident solor radiation efficiently.

THE NET PRODUCTION OF VARIOUS POPULATIONS

As the above mentioned, there were different types of populations characterized by density, height and stnading crop. So, about the different types in height as a indicator, the values of net production and distribution ratio of newly produced matter in organs were determined. For this purpose, the small, middle, tall and tallest population were set up in the creek with the following height, 20, 58, 82 and 107 cm, and with the following weight, 0.77, 15, 18 and 20 kg/m^2, respectively. The middle, tall and tallest population were based on the height, fresh weight and density of the natural populations gained before the experiment, and the small population corresponded to the population which are not dense and completely covered with water surface.

The almost experimental populations grew beyond the natural population as the model. But a plot of the tall population did not grow even beyond initial stage in standing crop because of death and shedding of leaves. The increasing rate (IR) of standing crop were 6.8, 12, 13 and 17 d.w.g/m^2/day in the small, middle, tall and tallest populations, respectively. The IR of decayed part were 0.22, 3.2, 4.8

and 5.3 d.w.g/m^2/day in the small, middle, tall and tallest populations, respectively. Net production were 7.0, 17, 18 and 22 d.w.g/m^2/day in the small, middle, tall and tallest population, respectively. The percentage of the IR of decayed part to Pn tended to be larger in taller populations.

The distribution ratios of the dry matter newly produced in the experimental populations except for the tallest population varied from 50% to 72%, from 28% to 47% and from -3% to 13% in underwater part, petioles and blades, respectively. In the tallest population, the distribution ratio in petioles was the largest among organs, and these ratios were 25%, 49% and 26% in underwater part, petioles and blades, respectively. As general, the great amount of the newly produced dry matters were transformed into non-photosynthetic organs, such as organs sustaining the structure of foliage and organs absorbing nutrients and water.

The number of new daughter stocks of the small population was 140 No/m^2 and that of the other population ranged from 44 to 76 No./m^2. The weight of a new daughter stocks was dependent on that of its mother stock in the various populations and the ratio of daughter's to mother's weight averaged 0.13.

STANDING CROP AND PRODUCTIVITY

The Waterhyacinth populations at more than 60 cm height studied in Thailand had a great deal of the standing crop which varied from 0.98 to 2.3 d.w.kg/m^2. These values are comparable to those previously reported in vaious location which ranged from 1.28 to 29 d.w.kg/m^2, and to these of the terrestrial grass population on temperate zone summarized by Whittaker (1975) which was 1.6 d.w.kg/m^2 on average and ranged from 0.2 to 5 d.w. kg/m^2.

The values of the net production gained from the Waterhyacinth population at more than 60 cm height which varied from 15.4 to 22.6 d.w.g/m^2/day are also comparable to those previously reported in various location which varied from 13.7 to 29 d.w.g/m^2/day. These values are beyond not only those of the terrestrial glass population on temperate zone but also those of the tropical rain forest which is the most productive among the plant communities on the earth, which varied from 0.5 to 4.1 and from 2.7 to 9.7 d.w.g/m^2/day (Whittaker, 1975), respectively.

In the lowland of Thailand, it is easy to find the Waterhyacinth population at more than 60 cm height. Therefore, the vast yield may be expected to be taken out from these population.

REFERENCES

1. Boyd, C.E. (1970). Vascular aquatic plants for mineral nutrient removal from polluted waters. Econo. Bot., 24, 95-103.
2. Center, T.D. and N.R. Spencer (1981). The phenology and growth of Waterhyacinth (Eichhornia crassipes (Mart.) Solms) in an eutrophic north central Florida lake. Aqua. Bot., 10, 1-32.
3. Iwaki, H. (1971). Ecology of plain. Kyoritsu Shuppar, Tokyo. 172 pp (in Japanese)
4. Penfound, W.T. (1956). Primary production of vascular aquatic plants. Simnol. Oceanogr., 1, 92-101.

5. Sato, H. and Kondo, T. (1981). Biomass production of Waterhyacinth and its ability to remove inorganic minerals from water I. Effect of concentration of culture solution on the rates of plant growth and nutrient uptake. Jap. J. Ecol. 31, 257-267.
6. Sato, H. and Kondo, T. (1983). Biomass production of Waterhyacinth and its ability to remove inorganic minerals from water II. Further experiments on the relation between growth and concentration of culture solution. Jap. J. Ecol. 33, 37-46.
7. Sculthorpe, C.D. (1967). The biology of aquatic vascular plants. Edward Arnold Ltd., London, 610 pp.
8. Ueki, K., M. Ito and Y. Oki (1977). Studies on Waterhyacinth II. Field surveys of community structure and its plant production. Weed Res., Japan, 22 (special issue), 184-186 (in Japanese).
9. Whittaker, R.H. (1970). Communities and ecosystems (2nd ed.) Macmillan, New York.
10. Wooten, J.W. and J.D. Dodd (1976). Growth of Waterhyacinth in treated sewage effluent. Econo. Bot., 30, 29-37.

AGRO-ECONOMICAL EVALUATION OF WEED CONTROL IN CORN

Teruhiko Nibe
NWSRI Project

BACKGROUND

National Weed Science Research Institute Project (NWSRI Project) raised a subject of "Agro-economical evaluation of Weed Control" as a part of its activities in 1983 in order to evaluate new technologies resulted from a series of research works on weed control. "Agro-economical evaluation", this subject is always discussed on an association with "Technology Transfer", "Appropriate technology" and "Technical recomendation to farmers" etc. All these topics are the methodologies of which to make farmers accept and practice a new technology or an improved technique smoothly and effectively. The reason why these topics are often discussed is that many cases are found on new technology it had obtained a good result by technical staff at its generating stages-has a difficulties on the realization of a practice by farmers at transfering stage. It may be considered the farmer's condition is not 1) familiar or ready to handle a given new material or equipment, 2) able to afford to invest newly, 3) able to realize an expecting result or necessity of change.

A farmer, he is a head of an independent body of a management as well as a life. Therefore, each farmer will take all the responsibility on profiability by his decision to his management then the result of his decision will give an affect directly to his life. Farmer takes a prudent attitude, when technical side try to introduce a new technology, wheather should accept or not. Criteria on decision vary depend upon a farmer on his 1. experience, 2. charactor, 3. understanding ability, 4. response of neighbours etc. to new informations.

Agriculture system depends upon natural condition such as temperature, rainfall, soil or solar radiation. Farming system is varied on a size of farm, available labour, capital investment ability or marketing possibility under the agriculture system. Cropping system is also varied on an employment and a practice of individual techniques under the farming system. An evaluation for individual production technology must be carried out on the view of cropping system as well as farming system.

Weed control on corn production based on our three crop cycles experience through a farmer's survey and a on-farm trial at Amphur Wichienburi, Changwat Petchabun discuss on the view of Agro-economy.

FARMER'S SURVEY ON WEEDING PRACTICE

The survey was conducted at two crop cycles on 21 farmers in 1985 and 34 farmers in 1986 at four Tambons and Amphoe Wichienburi, Changwat Petchabun where a on-farm a on-farm trials are applied. The interview consisted of two parts, general production background and corn cropping practice and inputs.

Sizes of interviewed farm on land hold and corn planting are shown

in Table 1.

Table 1. Distribution of land hold and corn planting in interviewed farmer, Wichienburi.

	Land Hold	Corn Planting
- 20	20.8 % (11)	28.3 % (15)
21 - 40	30.2 (16)	28.3 (15)
41 - 60	9.4 (5)	24.5 (13)
61 - 80	9.4 (5)	5.7 (3)
81 - 100	5.7 (3)	1.9 (1)
101 -	24.5 (13)	13.2 (7)

Frequency of weeding practice varies 1 to 3 times in the areas, 42% at once, 54% at twice and 2% at three times respectively.

Single practice is done by cultivator pulled by machine or animal at 33%, by hoe at 7% and by herbicide at 2%.

All the twice practiced farmer was employed a cultivator as the first means and followed by hoe at 47% and by herbicide at 7%. Second weeding normally practiced soon after passing cultivator to weed in between hills and remained weeds. By hoe weeding, thinning and fertilizing is done at the same in some case. On following by herbicide, Paraquat is applied with in a week after the first practice. Farmer's Survey on Weeding Practice. (Table 2).

Table 2. Weeding tools and combinations on plot size, Wichienburi

Tools / Plot Size	Cultivator	Cultivator + Hoe	Cultivator + Herbicide	Hoe	Herbicide	Herbicide + Hoe	Cultivator + Hoe + Herbicide
		(9)	--	5%(3)	--	--	--
21- 40	13 (7)	13 (7)	5% (3)	--	--	--	2% (1)
41- 60	5 (3)	9 (5)	2 (1)	--	2% (1)	--	--
61- 80	4 (2)	--	--	--	--	2% (1)	--
81-100	--	2 (1)	--	--	--	--	--
101-	4	7	--	2 (1)	--	--	--
Total	33 (18)	47 (26)	7 (4)	7 (4)	2 (1)	2 (1)	2 (1)

Machanical weeding by machine and hand is major means of Weeding at 90% chemical means by herbicide is only 10%. Various source of power for weeding are employed. In mechanical weeding, hand weeding by hoe is used 42% of farmer, at 29% by animal (cow or buffalo), at 11% by tiller, at 9% by small 4 wheel tractor (refer as small tractor) and at 8% by tractor. In chemical means, Paraquat is used by 6 farmers and Atrazine by 2 farmers among the 55 farmers (Figure 1). Required

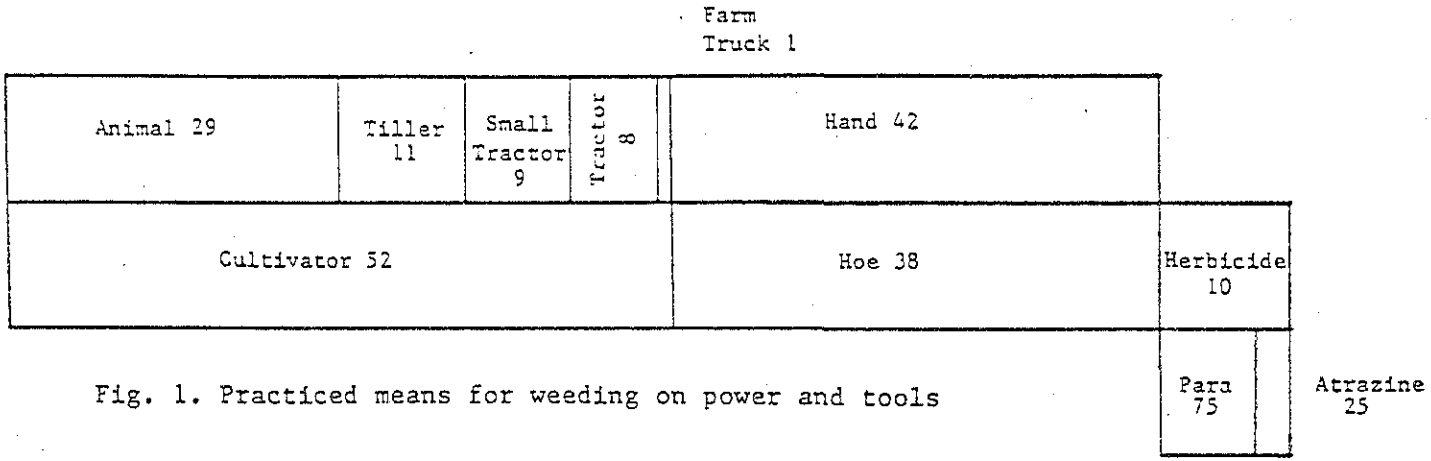


Fig. 1. Practiced means for weeding on power and tools

period to complete weeding by plot size varies 3.6 days to 12.9 days in average. Weeding period is gradually increased according to farm size increase as shown at Table 3.

Table 3. Required days to complete weeding by plot size

Plot size	Required day
- 20	3.6
21 - 40	6.7
41 - 60	7.1
61 - 80	-
81 -100	-
101 -	12.9

Smaller size of farmers use more man power or animal and large can use powerfull equipment. However, still to increase number of input is limited caused by difficulty of collecting large number of working force in one time and also supervising their work. It is rare to input more than 2 unit of machine or more than 20 mans power in a day.

Average ability of work by individual weeding method is shown in Table 4.

Table 4. Average ability of work by source of power

Source of Power	unit/rai	rai/day/unit
Tractor	0.09	11.1
Small tractor	0.10	10.0
Farm track	0.10	10.0
Tiller	0.13	7.7
Buffalo, Cow	0.22	4.5
Hand	0.99	1.0
Herbicides	0.34	2.9

It seems that ability of tractor is smaller. Farmers owned tractors are purchased at second hand conditioned, therefore, efficiency of work become may be lowered already.

Source of weeding work is divided into family and employ thoughout methods. Machine used weeding is done 70% by family source and 30% by employed source. Weeding by Animal is done 67% by family, 28% by employ and 5% by faminly + employ (worked with 2 sets). Hand weeding is done by family at 33%, by family and employ at 54% and by only employ at 13%. Chemical application is done all by family.

Source of weeding work by cropping size is examed as shown in Table 5.

Table 5. Source of work force in cropping size.

	Family	Family + employee	Employee
- 20	60% (12) 35%	30% (6) 35%	10% (2) 12%
21 - 40	53% (9) 26%	18% (3) 18%	29% (5) 29%
41 - 60	44% (7) 21%	19% (3) 18%	37% (6) 35%
61 - 80	67% (2) 6%	33% (1) 6%	-
81 -100	-	-	100% (1) 6%
100 -	36% (4) 12%	36% (4) 23%	28% (3) 18%
	(34) 100% 50%	(17) 100% 25%	(17) 100% 25%

Smaller size of farmers tend to uses more family source by animal and manpower use. Larger farms must employ worker for hand weeding, although use their own equipment for mechanical weeding.

Costs of weeding vary depend upon methods of weeding and area. In cases of complete contract work for weeding are done by cow or buffalo, small tractor and tiller. All through the area charges per one rai is ฿ 40-45. Hand weeding when farmers employ works, they pay by daily wage which ranges from ฿ 30 to ฿ 35 per day, none of them pay by a piece work. When farmers use their own equipment, they are hard to figure up consumed fuel for individual work. Average direct cash input as fuel for tractor is ฿ 10.4 per rai, for Small tractor is ฿ 9.3 per rai and for tiller is ฿ 5.7 per rai. For herbicide cost in average is ฿ 45 per rai for Atrazine and ฿ 22 per rai for Paraquat.

Although large variation is existing at direct input for weeding, ฿ 56 per rai of cash input plus 0.43 MD/rai of family worker in average are invested.

ON-FARM TRIAL

For agronomical study, on-farm trial was applied at 4 locations every year at 3-4 Tambons from 1984 to 1986. Although trial in 1984 was completely carried out by our hand, in 1985 and 1986 was superinposed over farmer's practice. Treatment of weed control by means of herbicide application was simply compared with farmer's practice. Tested herbicides use was followed to "Suggested Guide for Weed Control in Thailand" published as project technical bulletin No. 1 in 1984 by NWSRI Project. Herbicides applied at the rate of 240 gr. a.i./rai of Atrazine in 1984 and 240 cc a.i./rai of Alachlor in 1985 and 1986. Farmer's practice was used by mechanical method and done by themselves.

Average yield of 3 years at 4 Tambons and average yield of weeding practice across locations are shown at Table 6 and Table 7.

Table 6. Average yield of 4 locations in 3 years, Amphur Wichienburi, Changwat Petchabun. (kg/rai)/

Locations	1984	1985	1986	Average at Tambon
Nam Ron	877	526	364	589
Pwo Nam Yod	740	772	269	593
Sam Yek	595	739	508	614
Sap Sombun	766	765	-	765
Annual Average	744	700	412	

* Average of Sam Yek I and Sam Yek II
** Harvested one replication only

Table 7. Average yield of weeding practices across locations.(kg/rai)

Weeding Year Practice	1984	1985	1986	Average on Practice
Farmer's Practice	755	633	419	602
Herbicide Application	734	723	408	621

Yield between locations in each year is significant different, however, yield response for weeding practice across locations is no significant different in each year.

DISCUSSION

Under the resent difficult agricultural circumstance, an efficiency of production system should be raised moreover. At the same time, an ineffective inputs must be eliminated as much as possible.

Our agronomical study is not enough period to examine yield levels and yield fractuations of the area to determine the target yield leveles to meet appropriate level of inputs for profitable cropping or farming. Generally yield level of the area depends upon a rainfall especially distribution. Many farmers pointed up a drought at flowering time caused low yield. However drought at early stage of corn growth is also critical. More than a week without rain on late April to May is found in some years in the last 10 years records.

Yield response on weeding practices was no significant different between chemical and mechanical control every year. On cropping corn as the first crop, all the farmer practice at weeding with various methods. Therefore, lower cost of weeding is proffitable for farmers.

Full utilization of owened source for weeding such as family worker, equipments and exchange work to lower the cash expenses is preferable under the inactive market situation.

One of the way to lowered the cost is to finish weeding by one time with satisfactory enough effects by the efforts of improving tools, materials or method.

From farmer's survey, various weeding practices are observed. Weeding by cultivator is popular throughout the area at present and

its powers are by animal and machine in half. An increase of machine use is assumed by the phenomenon of declining the charges of contract on plowing and harrowing at some area due to increase of machine holding.

Chemical control still has advantage. Herbicide can apply even excess moisture in the soil to weed by hoe or machine after rainfall. It makes possible on time practice. Where a shortage of workers occures on hand weeding, herbicide can be replaced. More effective work is expected by using a boom sprayer attached to PTO of tractor for large scale. However, herbicide use is also associated with disadvantages such as proper herbicide is not available in local markert, transportattion of water to the field is hard work or desired herbicide is still high price.

Although, this type of work is required continuous efforts and observations, accumulated detail information of farmer's circumstance and utilize for establish new technologies and for transfer technologies will be effective to meet farmer's needs. The role of regional centers and stations of the Department of Agriculture is essencial as well as collaborative work with a network of the Department of Agricultural Extention is effective to carry out this type of studies.

A REPORT OF THE STUDY TOUR IN MALAYSIA AND SINGAPORE

Chanpen Prakongvongs and Tawee Sangtong
(Botany and Weed Science Division, DOA)

OBJECTIVES

The programme of this study tour in Malaysia and Singapore was practiced to learn the activity of researches and problems existing in weed control as well as crop production via talks and discussion in agricultural institutions there and to investigate the current distribution of weed species that pose problems in Thailand.

MEMBERS

Kenji Noda (Expert, NWSRI Project),
Chanpen Prakongvongs (Thai Researcher, DOA),
Tawee Sangtong (Thai Researcher, DOA)

SCHEDULE AND ACTIVITY

The term of study tour was 9 days from December 14, 1986, to December 22, 1986. Table 1 indicates the Organization and Personnel who contacted with the members in West Malaysia, Saba of East Malaysia and Singapore.

ABSTRACT OF RESULTS

Visiting the agricultural Institution and University allied in Malaysia and Singapore indicated us that installation and maintenance of equipment in their laboratories seemed to work and preserve well.

Full time weed scientists are rather less despite of its importance. Weed researches are generally being done as added work of crop scientists, plant physiologists or plant protection persons.

Weed species under deep awareness in Thailand are situated as follows :

1. Mimosa pigra was found at some places of west Malaysia; that is, Penang Island and the suburb of Kuala Lumpur City. On the other hand, M. invisa was found everywhere in Malaysia.
2. Pennisetum purpureum distributes in west Malaysia and Saba, but P. pedicellatum and P. polustachyon were hardly found. Botanical Garden indicated existence of P. clandestinum in penninsula Malaysia.
3. Salvinia molesta, the most serious species of Salviniaceae, was already distributed near the border of Thailand, Muda province.
4. Water hyacinth was found everywhere in Malaysia, but less growing probably due to less contamination of aquatic areas.
5. Eupatrium odoratum broadly distributed in highland Saba similar to Thailand.
6. Limnocharis flava was often found in paddy in west Malaysia.
7. Echinochloa spp. was often found to infest seriously in established paddi of Mada Rice Project Fields.

Table 1. Study Tour Activity in Malaysia and Singapore

Date	Organization	Personel
15/Dec.	MARDI Alor Star	Mr. Loo , Senior Researcher Dr. J. Hirao (TARC)
	MADA Alor Star	Dr. Nai Kin Ho, Senior Res. Mr. A. Kitsutaka (TARC) Mr. N. Sawamura (TARC)
16/Dec.	MARDI Seberang	Mr. A.W. Cheong, Coordinator Mr. Bin Man Azmi, Chief Weed Section
17/Dec.	MARDI (H.G. Place) Serdang	Dr. Haji Mohd Yusof b. Hashim, Director-General Dr. S. Miyashige (TARC) others
	MARDI Kelang	Dr. Abd. Wahabbin Ngah, Director Dr. S.A. Lee, Senior Researcher
	Univ. Pertanian Malaysia	Dr. Lim Eng Siong, Professor, Agronomy Dr. A. Rajam, Weed Scientist
18/Dec.	RRIM Exp. Station	Dr. A. Aziz Kadir, Director RRIM Mr. Rieng Chee Ping Mr. Ahmad Faiz Bin MD, Alif, Weed Scientist Mrs. Chong Dai Thai
19/Dec.	Dep. Agriculture, Saba	Dutuk Aripen Haji Ampong, PGDK, ASDK, Director Dr. Tay Eong Beok, AMN, Deputy Director
20/Dec.	Tuaran Agri. Res. Center, DA	Mr. Pang Tshung Chee, Chief of Centre Miss Liaw Hiew Lian, Horticulture Miss Jamilah Idris, Agronomy Mrs. Jenng Lee, Plant Physiology Mrs. Tan Guay Ling, Chemistry
	Kundasang Highland Research Station	(Miss Liaw Hiew Lian)
22/Dec.	Nat. Univ. Singapore, (Dep. Botany) Botanical Garden	Dr. Wee Yeon Chin Dr. P.N. Avadhani, Professor -

Abbreviation : MARDI = Malaysia Agricultural Research Development Institute
TARC = Tropical Agricultural Research Center (Japan)
RRIM = Rubber Research Institute of Malaysia
MADA = Muda Agricultural Development Authority of Malaysia

A REPORT OF THE STUDY TOUR IN BURMA

WEED SURVEY IN THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

Y. Paisooksantivatana[1/], C. Premasthira[2/] and Jiro Harada[2/]

1/ Botany Section, Botany and Weed Science Division, Department of Agriculture, Bangkhen, Bangkok 10900, Thailand

2/ National Weed Science Research Institute Project

INTRODUCTION

During December 20-27, 1986, the authors visited many cultivated areas in Rangoon Division, Mandalay Division and Shan State for the purpose of assessing the current status of weed flora and weed control in Burma, We hoped, by visiting research institutes, universities, cultivated lands, and experiment stations, to learn something about weed problems in this country. Our concentration was aimed at the weed flora on highlands as to compare with the highland weed flora of northern Thailand.

PROBLEMS

It soon become obvious that certain factors were to make our trip more difficult than we had expected. The most important factor was inseparability of politics and academic environment in Burma. All foreigners had been treated as tourists. Land-route transportation between towns, states or divisions was not allowed for all foreigners. Only four tourist centres were allowed for the tourists to travel within their limited vicinities : Rangoon, Mandalay, Pagan and Taunggyi. Tourists who travel out of the limited areas without permission will be punished. To overcome the problem, we decided to contact the Tourist Burma, the sole tour operator and travel agent in Burma, to arrange our trip to Shan State and Mandalay Division.

Our trip could be scheduled as follows and the routes of travel are shown in the map :

Dec. 20, 86 : Bangkok —— TG ——→ Rangoon

Dec. 21, 86 : Rangoon — Weed Survey

Dec. 22, 86 : Rangoon —— Burma Airways ——→ Heho Airport

Heho Airport, —— Bus ——→ Taunggyi

Weed Survey

Dec. 23, 86 : Taunggyi —— Bus ——→ Inle Lake —— Bus ——→ Pindaya

←—— Weed Survey ——→

Dec. 24, 86 : Pindaya —— Bus ——→ Heho Airport

Weed Survey

Heho Airport —— Burma Airways —— Mandalay

Dec. 25, 86 : Weed Survey in Mandalay

Mandalay —— Burma Airways ——→ Rangoon

Dec. 26, 86 : Rangoon ——car——→ Hlegu (CADTC)

Weed Survey in CADTC

Dec. 27, 86 : Rangoon ——TG——→ Bangkok

As can be seen from our schedule, we had only few opportunities to survey weeds. Only when we stayed overnight in Rangoon, Taunggyi, Mandalay and Pindaya and during our trip by bus that we could ask our guide to stop by some cultivated fields and make a survey of weeds. We did have an opportunity to visit coffee seedling nursery and have some discussion with the official in-charge.

TOPOGRAPHY AND CLIMATE

Burma is situated on the west of Thailand, with its boundary extended between 10°N - 28°N, from the humid, tropical climate in the south to dry and cool climate in the north.

Rangoon, the capital city of Burma, is situated almost at the same latitude as Tak province of Thailand at the near sea level altitude. The climate during our visit was similar to Tak expect of its high humidity because it is much closer to the sea.

Mandalay township, is located at 22°N, around 150 meters above mean sea level. The weather was quite comfortable during night time but very hot and less humid than in Rangoon in the day time.

Taunggyi - Pindaya regions are highlands in Shan State, about 1,000-1,600 metre elevation. The weather was fine there; the temperature was around 10°C at night which is very much similar to the weather on the highlands of northern Thailand. The topography of this region is hilly, mild slopes, and most areas were deforested for cultivation of crops.

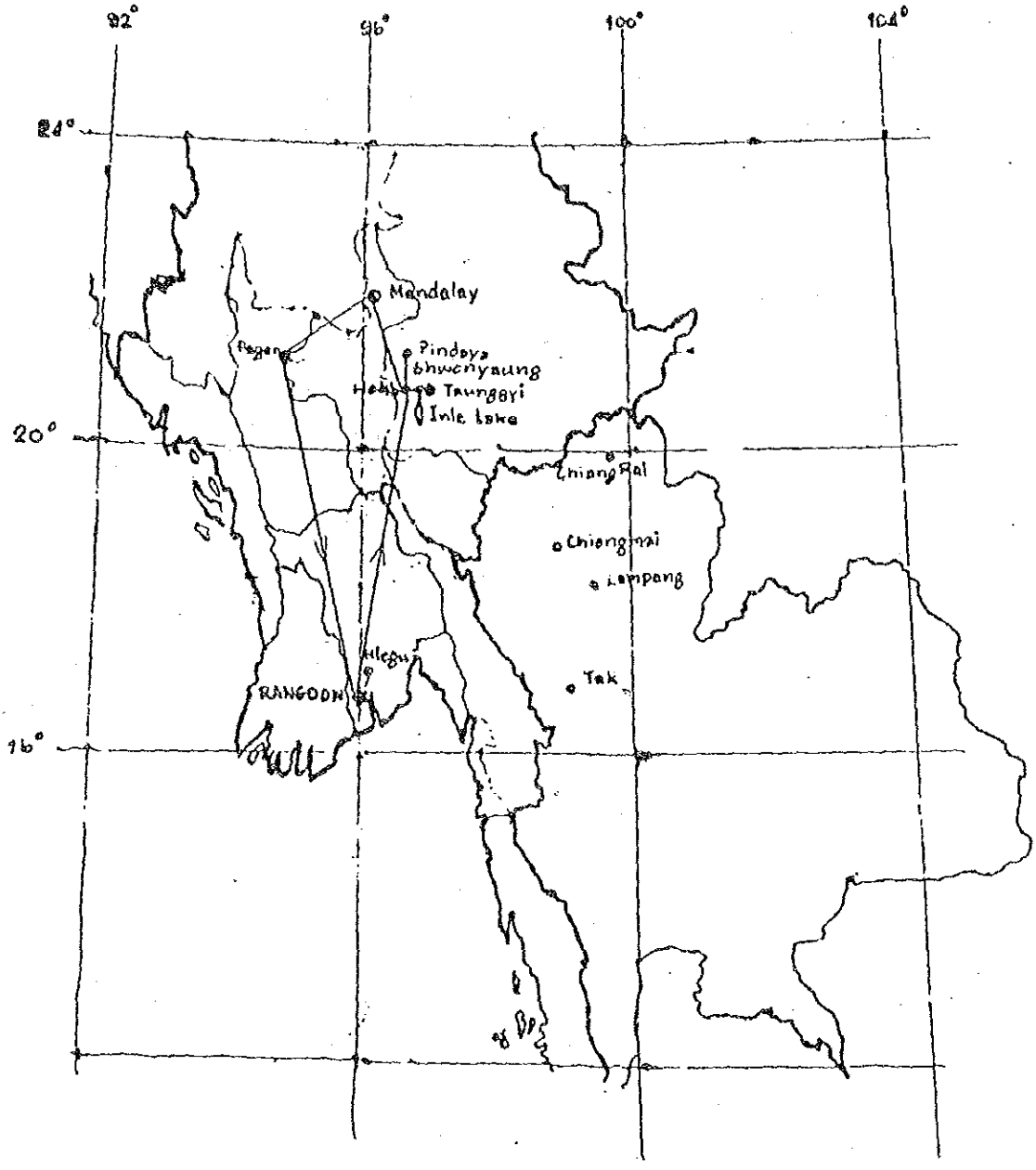
CROPS

During our trips in Rangoon and Mandalay, we did not have a chance to visit any farms or plantations but we did observe various kinds of crops sold on sidewalks and in the markets. Apart from rice, which is the main crop, there are also oranges, various kinds of bananas, papayas, lemons, betel leaves, betel nut, niger, turmeric, and numerous kinds of peas and beans.

In Taunggyi and Pindaya region, we saw many crops grown during our visit by bus. There are tomatoes, potatoes, cabbages, niger, wheat, cowpea, cucumbers, aster, pears, avocadoes, oranges, bananas, papayas, pomeloes, and chayotes.

WEED FLORA OF BURMA

In general, major weeds in lowland areas in Rangoon, Hlegu and Mandalay are much similar to those found in northern Thailand. Mikania cordata Rob., distributed mainly in southern peninsula of Thailand, is found in abundance on the shore of Inya lake in Rangoon. The only dominant species of weed found in this area is still unidentified species of Alternanthera. It is similar to A. pungens H.B.K. in habit but with somewhat less spiny inflorescence.



MAP Routes of Journey in Burma during

20 - 27 December 1986

In the Taunggyi - Inle Lake - Pindaya region the weed flora is quite different from the lowland areas. This region is a hilly plateau, located between 1,000 - 1,650 metres above mean sea level and between 21°N - 22°N. Inle lake, 1,050 m.s.l., is the most interesting place for ecological and limnological studies. It occupies over 60 sq. miles of the area with nearly 100,000 people in and around the lake. The dominant submerged weeds in the lake area are Ceratophyllum, Hydrilla, Najas, and Elodea. Emergent weeds are Phragmites, Sagittaria, Leersia, Coix, and Zizania Latifolia Turcz. The last species is not found naturalized in Thailand. The only dominant floating species found is Eichhornia crassipes Solms. Water lettuce (Pistia stratiotes Linn.) is rarely seen in the lake. The most interesting species is Eupatorium adenophorum Spreng., the dominant upland species of northern Thailand and also Shan State, which is found in association with the emergent and floating vegetation in the lake. In Thailand, we have never seen such a similar habit. Apart from the aquatic habitat, the dominant weed species of upland area in this region are Galimsoga parviflora, Bidens sp., Ageratum conyzoides, Spilanthes sp., Eupatorium adenophorum and Tithonia diversifolia. Major weed species in this area are members of the sunflower family (Compositae) which is similar to highlands of northern Thailand. Only in some extremely dry and rocky habitats, we found the xerophytic species not recorded for Thailand, Echinops sp. for example.

Tentative Check-list of Weed species found during the trip is provided in the table. Specimens of unknown species were also collected for later identification.

WEED CONTROL

According to our discussion with an agricultural technician in Pindaya, weed is the most serious problem in Burmese agriculture. Insect pests and plant diseases are ranked second to the weed. However, with the low income, farmers can not afford to use any herbicides in their farms. Thus, hand weeding is the only method practised in farms and plantations.

CONCLUSION

The study tour to Burma was concentrated on weed problem on highlands in order to find the relationship of weed vegetation on highlands of the two neighboring countries. The result shows that there are some similarities in weed species and distributions in these areas. Asteraceae and Poaceae are the two major families of weeds on highlands of both countries. Eupatorium adenophorum in Thailand is beleived to have been introduced from Burma. In fact, the distribution range of the species in Thailand is confined only in western - north of Thailand which is adjacent to highlands of Shan State. It was also found on roadsides, field-borders, everywhere in Taunggyi - Inle - Pindaya region, Shan State. At least 30 families, 81 genera, and 109 species of weeds were recorded during the trip. About one hundred specimens of unknown species were collected for later identification and will be deposited in Bangkok Herbarium, Botany Section, Division of Botany and Weed Science, DOA.

ACKNOWLEDGEMENT

Financial support of the study tour to Burma was provided by the Japan International Cooperation Agency (JICA). The authors are indebted to Mr. Visut Chandrangsu, Director of the Botany and Weed Science Division, for his understanding and encouragement throughout the Highland Weed Survey Project.

Tentative

Check - list of Burmese

Weed Flora

SPECIES	1. RANGOON (near sea level)	2. TAUNG GYI (~ 1,650 m)	3. INLE LAKE-SEWENYAUNG (~ 1,050 m)	4. AUNG BAN-PINDAYA (1,300-1,400 m)	5. MANDALAY (~ 150 m)	6. HLEGU (~ near sea level)
1. ACANTHACEAE						
1. Lepidagathis sp.	x					
2. Ruellia tuberosa Linn.					x	
2. ALISMATACEAE						
1. Sagittaria trifolia Linn.			x			
3. AMARANTHACEAE						
1. Achyranthes aspera Linn.	x	x		x	x	
2. Alternanthera sessilis DC.						x
3. Alternanthera sp.	x					
4. Amaranthus gracilis Desf.	x					
5. A. lividis Linn.						x
6. A. spinosus Linn.				x		x
7. Amaranthus sp.	x					
8. Cyathula prostrata Bl.	x					
4. ASTERACEAE						
1. Ageratum conyzoides Linn.	x	x	x	x	x	x
2. Artemisia dubia DC.		x		x		

SPECIES	1. RANGOON (near sea level)	2. TAUNG GYI (~ 1,650 m)	3. INLE LAKE-SHWENYAUNG (~ 1,050 m)	4. AUNG BAN-PINDAYA (1,300-1,400 m)	5. MANDALAY (~ 150 m)	6. HLEGU (~ near sea level)
3. Artemisia sp.				x		
4. Bidens pilosa Linn.		x		x		
5. Blumea sp.	x					
6. Crassocephalum crepidioides (Benth.) S. Moore		x		x		
7. Echinops sp.				x		
8. Ecliptra prostrata Linn.					x	x
9. Eupatorium adenophorum Spreng.		x	x	x		
10. E. odoratum Linn.	x	x		x	x	x
11. Galinsoga parviflora Cav.		x	x	x		
12. Gynura sp.			x			
13. Laggera pterodonta Sch. Bip. ex Oliver				x		
14. Mikania cordata B.L. Robinson	x					
15. Sigesbeckia orientalis Linn.		x	x	x		
16. Sonchus arvensis Linn.		x				
17. S. oleraceus Linn.			x	x		
18. Sphaeranthus africanus Linn.						x
19. S. indicus Linn.			x			
20. Spilanthes sp.		x	x	x		x
21. Synedrella nodiflora (L.) Gaertn.		x				
22. Tithonia diversifolia A. Gray		x		x		
23. Tridax procumbens Linn.					x	
24. Vernonia cinerea Less.	x					x
25. Youngia japonica (L.) DC.		x				
5. AZOLLACEAE						
1. Azolla pinnata R. Br.			x			
6. BORAGINACEAE						
1. Heliotropium indicum Linn.						x
7. CAPPARIDACEAE						
1. Cleome rutidosperma DC.						x
2. Cleome sp.						x

SPECIES	1. RANGOON (near sea level)	2. TAUNG GYI (~ 1,650)m)	3. INLE LAKE-SHWENYAUNG(~1,050m)	4. AUNG BAN-PINDAYA(1,300-1,400m)	5. MANDALAY (~ 150 m)	6. HLEGU (~ near sea level)
8. CARYOPHYLLACEAE						
1. Stellaria sp.				x		
9. COMMELINACEAE						
1. Commelina benghalensis Linn.					x	x
2. C . diffusa Burm. f.						x
10. CYPERACEAE						
1. Cyperus diffusus Vahl						x
2. C. iria Linn.						x
3. C. kyllingia Endl.	x					
4. C. rotundus Linn.	x					
5. Cyperus sp.	x					
6. Eleocharis dulcis Henschel			x			
7. Eleocharis sp.			x			
8. Fimbristylis miliacea Vahl			x			x
9. Scirpus juncoides Roxb.			x			x
11. DENSTAEDTIACEAE						
1. Pteridium aquilinum Kuhn.		x		x		
12. EUPHORBIACEAE						
1. Euphorbia heterophylla Linn.		x		x		
2. E. hirta Linn.				x	x	x
13. FABACEAE						
1. Mimosa pudica Linn.	x		x			x
14. LYTHRACEAE						
1. Ammannia baccifera Linn.			x			
15. MALVACEAE						
1. Urena lobata Linn.	x					x
16. MARSILEACEAE						
1. Marsilea crenata Presl					x	

SPECIES	1. RANGOON (near sea level)	2. TAUNG GYI (~ 1,650 m)	3. INLE LAKE-SHWENYAUNG (~1,05 m)	4. AUNG BAN-PINDAYA(1,300-1,400 m)	5. MANDALAY (~ 150 m)	6. HLEGU (~ near sea level)
17. OXALIDACEAE						
1. Oxalis corniculata Linn.		x		x		
2. Oxalis sp.		x		x		
18. PLANTAGINACEAE						
1. Plantago major Linn.		x	x	x		
19. POACEAE						
1. Alloteropsis semialata (R.Br.) Hitchc.	x					
2. Arundinella sp.		x				
3. Apluda mutica Linn.		x				
4. Chloris pycnothrix Trin.		x		x		
5. Coix sp.			x			
6. Cynodon dactylon (L.) Pers.	x	x			x	x
7. Dichanthium annulatum Stapf	x	x			x	
8. D. caricosum Camus			x			
9. Digitaria sp.	x					x
10. Eleusine indica Gaertn.	x			x		x
11. Elytrophorus spicatus A. Camus			x			
12. Eragrostis elongata Jacq.						x
13. E. tenella P. Beauv. ex R. & S	x					
14. Eragrostis sp.	x	x				
15. Heteropogon contortus P. Beauv.	x					
16. Imperata cylindrica P. Beauv.						x
17. Ischaemum sp.	x					
18. Ischaemum sp.						x
19. Leersia hexandra Swartz			x			
20. Panicum rapens Linn.						x
21. Paspalum conjugatum Berg.						x
22. Pennisetum pedicellatum Trin.	x					
23. P. polystachion Schult.						x
24. P. purpureum Schumach.						x
25. Pennisetum sp.	x					
26. Phragmites karka Trin.			x			

SPECIES	1. RANGOON (near sea level)	2. TAUNG GYI (∼ 1,650 m)	3. INLE LAKE-SHWENYAUNG (∼1,050 m)	4. AUNG BAN-PINDAYA(1,300-1,400 m)	5. MANDALAY (∼ 150 m)	6. HLEGU (∼ near sea level)
27. Saccharum arundinaceum Retz.		x				
28. Setaria verticillata P. Beauv.		x				
29. Setaria sp.	x					
30. Zizania latifolia Stapf			x			
20. POLYGONACEAE						
1. Polygonum orientale Linn.				x		
2. P. tomentosum Willd.	x					
3. Polygonum sp.					x	
4. Rumex sp.		x		x		
21. PONTEDERIACEAE						
1. Eichhornia crassipes Solms	x		x			
2. Monochoria vaginalis Presl.			x			
22. PORTULACACEAE						
1. Portulaca oleracea Linn.						x
23. RUBIACEAE						
1. Borreria alata (Aubl.) DC.						x
2. Borreria sp.				x		
3. Mitracarpus villosus Sw.						x
24. SCROPHULARIACEAE						
1. Scoparia dulcis Linn.						x
25. SOLNACEAE						
1. Physalis sp.		x				
26. STERCULIACEAE						
1. Melochia corchorifolia Linn.						x
27. TILIACEAE						
1. Triumfetta sp.	x					
28. TYPHACEAE						
1. Typha sp.			x			
29. VERBENACEAE						
1. Lantana camara Linn.	x					
30. ZIGOPHYLLACEAE						
1. Tribulus sp.						x

ECOPHYSIOLOGICAL STUDIES OF *EUPHORBIA GENICULATA* ORT. AND ITS CONTROL IN CORN*

Maneesa TEERAWATSAKUL**

CONTENTS

---

* Presented in Tokyo University of Agriculture as the Thesis of Dr. Agriculture.

** Weed Science Branch, Botany and Weed Science Division, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkhen, Bangkok 10900, Thailand.

SUMMARY

Belonging to the family of *Euphorbiaceae*, *E. geniculata*, commonly called as milkweed, painted spurge or red spurge, is a broad-leaved weed as tall as 2 meters, distributed to tropical upland areas in some 20 countries in the world. In Thailand, it is known as the most noxious weed in corn and cotton fields, but its controlling measure is yet to be established.

The present paper which is essentially composed of eight chapters from distribution (II) to control of *E. geniculata* (IX) contains the results of studies achieved mainly under the National Weed Science Research Institute Project which was started in 1980 under the cooperation between JICA and the Department of Agriculture, Thailand, including some of the results obtained before that. The aim of these studies was to elucidate the little-known ecophysiological characteristics of *E. geniculata* to find out the reason for its strong competitiveness and, finally, to contribute to establishing controlling measures. The main results obtained are as follows:

Distribution

Surveys on the distribution of this species in Thailand showed that it is most abundant in North plateau, and Central and Northeast highlands. The optimum annual precipitation ranged from 1,100 to 1,500*mm*, with the most rapid growth taking place in July and August.

Seed Germination

As a result of examination on the effect of temperature, light and oxygen concentration on many weed species in Thailand, including *E. geniculata*, the followings were found:

1. The seeds (1 ~ 2 months after harvest) belonging to 113 species showed various percentage germination from 0 to 100. *E. geniculata* together with *Ruellia tuberosa* showed that highest ones, 97% and 100%, respectively, with weak dormancy.
2. Among the seven main weeds, too, *E. geniculata* together with *Amaranthus viridis* gave the highest percentage, others being medium to very low.
3. The optimum temperature for the germination of *E. geniculata* ranged widely from 25°*C* to 35°*C*, with promotion by light, as far as a weak dormancy remained. However, no accelerating effect of light was observed at temperatures lower than 20°*C* or higher than 40°*C*.
4. The growth of top and root just after germination seemed to be controlled more strongly by night temperature than day temperature, the optimum being 30°*C*. Light always gave an inhibitory effect.
5. *E. geniculata* showed highest percentage germination at the initial oxygen concentration of 15%, with 10% germination at 3% or 0.5% oxygen and 7% germination without oxygen.

Ecological Characteristics

1. Regarding changes in growth pattern according to season of the year, Comparison of growth patterns of *E. geniculata* among four different seasons in a year revealed out the following facts:

i) The total length of a life-cycle changed from the longest 134 days of the 2nd

season (sown at the end of Dec.) to the shortest 67 days in the 1st season (sown in Sept.).

ii) Both plant height 210 *cm* and its average rate of increase 1.86 (cm/day) highest in the 3rd season (sown at the end of April when it competes with corn in the field.

iii) Seed production was highest (more than 600 seeds per plant) in the 1st season.

2. In another experiment dealing with changes according to growth stage, a close relative growth, or parallelism, was observed to exist between growth in plant height and that in dry weight.

3. When *E. geniculata* was grown under the day-length of 8, 12 or 16*hr*, plant height and leaf number were highest under 12*hr* with early flowering and matured seeds. Under 8*hr*, flowering did occur but without fertile seeds, and under 16*hr* no flowering at all. From these, it was concluded that *E. geniculata* is most probably an intermediate plant, with the optimum day-length of around 12*hr* but not shorter than 8*hr*.

4. Corn and *E. geniculata* were grown under various light conditions of 0 to 70% shading and changes in various growth parameters were followed in dry as well as wet season. The results of two experiments were generally agreed well except a few points.

i) Growth in plant height and leaf area was accelerated by shading in both species, to a higher degree in *E. geniculata* than in corn.

ii) Growth in dry weight was inhibited by shading in both species, to a smaller extent in *E. geniculata* than in corn.

iii) The severer the degree of shading, the lower became the net assimilation rate, with the degree of reduction lighter in *E. geniculata* than in corn at least in the wet season.

From these results, it was concluded that *E. geniculata* has the properties to be less affected by shading than corn does.

5. From a test on emergence depth, it was ascertained that *E. geniculata*, as compared with other species, has exceptionally high a capacity to emerge out from a depth more than 8 *cm* in the soil.

6. By comparing the root system in the soil, it was found that, although the root system of *E. geniculata* is narrower in horizontal distribution, its vertical distribution is far deeper than that of corn.

7. With the root of plants grown under 50% shading, it was found that the α-naphthylamine-oxidizing activity of corn root was reduced to 46% of non-shaded plants, while no decrease of activity was observed in *E. geniculata* root. Decrease due to shading of chlorophyll content of leaves was smaller in *E. geniculata*, with even an increase in the total amount occurring.

8. Among the three species grown in the same pot, it was found, *E. geniculata* was most tolerant to water stress, *P. polystachyon* was next and corn was the least tolerant.

Physiological Characteristics

1. With attached leaves, apparent photosynthesis and transpiration were compared, by simultaneous measurement through an open system apparatus equipped with IRGA, between *E. geniculata*, C_3 species, and *E. hirta* and corn, both C_4 species. The following results were obtained:

i) *E. geniculata* had a lower light saturation point of photosynthesis than corn and *E. hirta* did, but no difference was found in the "initial slope", i.e., the efficiency of photosynthesis under weak light.

ii) In *E. geniculata*, apparent photosynthetic rate under strong light (Ap) was

considered to be limited by r_m, mesophyll resistance, but in corn and *E. hirta* it was limited by r_s, stomatal resistance.

iii) Transpiration rate under strong light (Tr) of *E. geniculata* was twice that of corn, and also its Tr/Ap ratio which is equivalent to short-term water requirement was highest among the three species.

iv) The closing response of stomata to light-off was slower in *E. geniculata* than in the other two species.

2. A young leaf (11th leaf) of *E. geniculata* had a higher light saturation point and Ap, but a lower initial slope as compared with an old leaf (6th leaf) of the same species.

3. With plants grown under 50% shading, the following facts were observed:

i) The light saturation point decreased conspicuously in *E. geniculata*, but scarcely decreased in corn.

ii) Decrease in Ap was far greater in *E. geniculata* than in corn with no conspicuous difference in the initial slope.

iii) The cause for decreased Ap due to shading was in most part attributable to increased r_m in *E. geniculata*, but in corn increased r_s was also responsible.

iv) Shading did not affect Tr of *E. geniculata*, while it considerably decreased that of corn. In consequence, the water requirement of *E. geniculata* which was twice that of corn in normally grown plants increased to thrice that of shade-grown corn.

4. When *E. geniculata* plants were grown under 8, 12 and 16 *hr* day-length:

i) Ap tended to decrease as day-length increased, the reason being attributable to increased r_m.

ii) Under 12 *hr* day-length, both the light saturation point and Tr were highest and water requirement was smallest.

iii) Stomatal response to light-off was far quicker in those grown under 8 *hr* than in those grown under 12 *hr* or 16 *hr*.

Morphological and Anatomical Characteristics

1. It was observed that seed surface of *E. geniculata* was covered with many porous colonies, cave-ins and others.

2. Both upper and lower surfaces of *E. geniculata* leaves were covered with thick cuticular, dense epicuticular wax and evenly distributed silica-like knobs, in contrast to little wax deposit of *E. hirta* on the upper surface of leaves.

3. It was confirmed anatomically that *E. geniculata* is a C_3 species with undeveloped bundle sheath cells, and consequently lacking in Kranz anatomy, while *E. hirta* and *E. thymifolia* had distinctive Kranz anatomy, the most clear C_4 characteristic.

Productive Structure of Corn and *E. geniculata* and Yield Loss

1. As a result of investigation on corn stands differing in the degree of infestation by *E. geniculata*, it was found:

i) Corn yield (grain or ear weight) decreased with increasing population density of *E. geniculata*.

ii) The ear weight of corn showed a close negative correlation with population density of *E. geniculata* ($r = -0.7858^{**}$), fresh weight (-0.8135^{**}) and dry weight (-0.7879^{**}), the correlation with fresh weight being the highest.

iii) Grain yield, on the other hand, was most closely correlated with grain number per ear ($r = 0.9784^{***}$), and not with 100-grain weight, among various yield components. This implies that the yield-decreasing effect of *E. geniculata* has worked

on corn most probably through its grain-number-determining processes.

iv) It was inferred that one of the grain-number-determining processes, the potential grain number, decreased linearly with increasing fresh weight of *E. geniculata*, while fertility began to decrease only after fresh weight increased beyond a certain level.

2. Comparison of productive structure between the pure stand of corn and mixed stands with differing degrees of *E. geniculata* infestation revealed out the following facts:

i) Compared with corn plants in a pure stand, those in a mixed stand had vastly decreased amount of leaves at higher than the ear-bearing position, while on the other hand at the height about 100 to 140 *cm* from the soil surface, horizontal leaves of *E. geniculata* were densely developed.

ii) Such a special distribution of dry matter gives profound influence upon the light distribution pattern within the stand: In mixed stands as compared with pur stand, the higher the population density of *E. geniculata*, the more conspicuous the decrease of light intensity. Such a high light-intercepting effect of *E. geniculata* was due, without doubt, to its horizontal leaf habit.

iii) The strong light-interception affected most seriously the growth of upper leaves and ears. However, it was suggested that the adverse-effect of competition with *E. geniculata* is not confined to this: such factors as decrease of photosynthetic ability due to decreased chlorophyll content and lowered root activity may also be added.

Allelopathy of *E. geniculata* to Corn

1. Three fractions of extract from fresh materials of three *Euphorbia* species were bioassayed with rice seedlings:

i) All the three fractions from *E. geniculata* showed more or less growth-inhibiting activity, although it was inferior to that of *E. hirta* and *E. thymifolia*.

2. The total dry matter yield (corn plus *E. geniculata*) in the VII-1 experiment, was not found to follow the "law of constant final yield", but showed the tendency to decrease with increasing density of *E. geniculata*.

These two facts were interpreted as supporting the possibility of allelopathy of *E. geniculata* on corn.

Control of *E. geniculata*

1. A series of field experiments using various herbicides, revealed that such herbicides as atrazine, alachlor, metolachlor and 2,4-D can effectively control most of the broad-leaved and grassy weeds by soil application, through suppression of their germination. However, they cannot inhibit the germination of *E. geniculata* and, consequently, ineffective to control it. On the other hand, it was found that foliar application of atrazine or linuron was effective for killing *E. geniculata* depending on growth stage.

2. It was found by glasshouse experiments that foliar application of 1.5 ~ 3.0 *kg/ha* of atrazine can reduce the dry weight and consequently kill *E. geniculata* seedlings up to the 3-leaf stage, giving, on the other hand, an accelerating influence on the height of corn.

3. As described above, it is before the 3-leaf stage that atrazine is effective to *E. geniculata*. On the other hand, it has been pointed out that delayed emergence of *E. geniculata* is continued for long, making the complete control of this species very difficult.

General Discussion and Conclusion

Incorporating all the results described above, the factors related to the strong competitiveness of *E. geniculata* were identified, their ways of working on corn plants through the "weediness" of *E. geniculata* were analyzed and the processes leading to loss of corn yield were discussed.

The aspect in which *E. geniculata* adversely affects corn plants through multiple factors, was called "Weediness Syndrome". Based on the phenomenon of this syndrome, future direction of *E. geniculata* control was discussed.

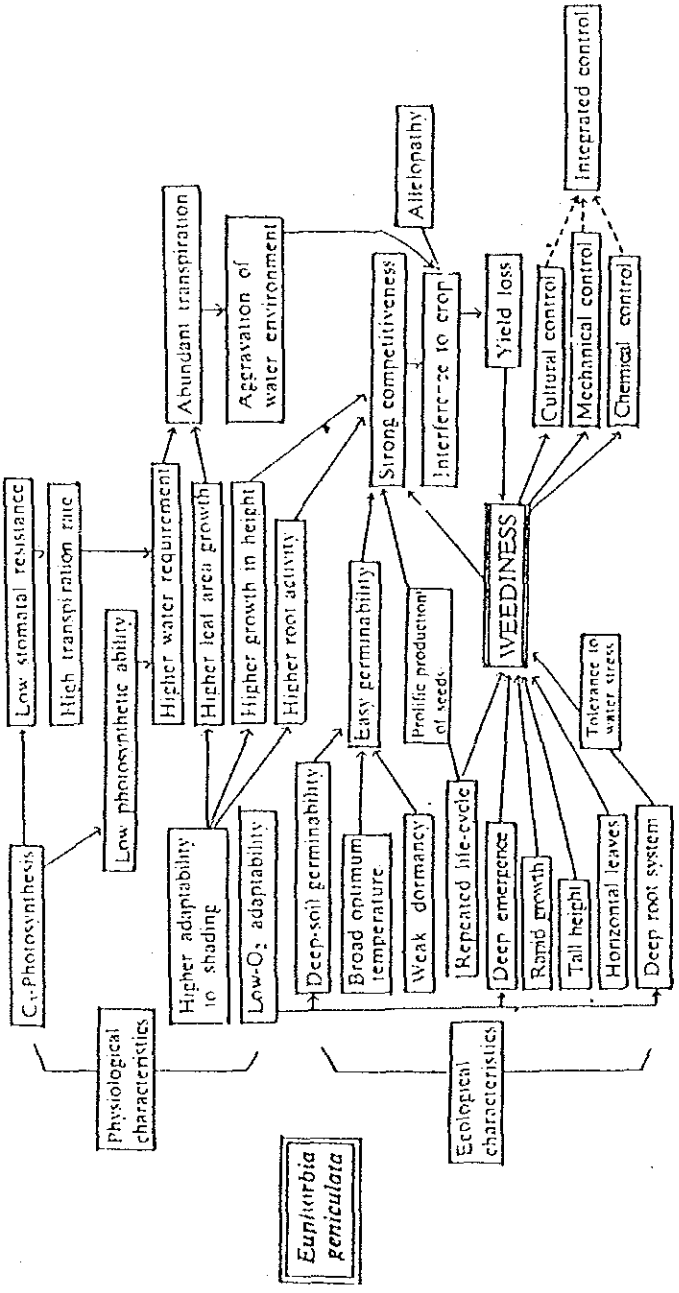


Fig. Schematic Illustration of the Results of the Ecophysiological Studies of *Euphorbia geniculata* and its Control in Corn (Broken lines indicate expected direction

（付）

〈短　期　専　門　家　報　告〉

（昭和６０年度・６１年度）

１．松本　宏 （筑波大学）	口頭報告 （Ｓ．６０．１１．１～６０．１２．２０）	生物生理学
２．長田　正夫	「the Ecological Studies on the Waterhyacinth」 （Ｓ．６０．１．２２～６１．８．２１）	（参考１）雑草生態
３．山田　忠男 （農林水産省農業 環境技術研究所）	「Survey of Herricide Residues」 （Ｓ．６１．４．８～６１．６．１３）	（参考２）除草剤残留
４．板　　斉 （農林水産省農業 生物資源研究所）	「Hericide － Plant Hormone in Teractions in rice Plant」 （Ｓ．６１．１０．４～６１．１１．８）	（参考３）植物生理
５．小林　勝一郎 （理化学研究所）	「Report on Study Work in National Weed Science Research Institute Project」 （Ｓ．６１．１１．１３～６２．１．３０）	（参考４）除草剤特性
６．沖　　陽子 （岡山大学農業 生物研究所）	「Report on Aquatic Weeds Management in Thailand」 （Ｓ．６１．１２．２～６２．１．３１）	（参考５）雑草生態生理

参考 1

THE ECOLOGICAL STUDIES ON THE WATERHYACINTH (EICHHORNIA CRASSIPES (MART.) SOLMS) POPULATION

MASAO OSADA
CHANPEN PRAKONGVONGS
NATIONAL WEED SCIENCE RESEARCH INSTITUTE PROJECT
IN THAILAND

JAPAN INTERNATIONAL COOPERATION AGENCY, JAPAN

AUGUST 20TH, 1986

PREFACE

The waterhyacinth, Eichhornia crassipes (Mart.) Solms, is native to South America and is found throughout the warm regions of the earth. Owing to its high growth, it has become notorious as a troublesome species (Sculthorpe, 1967). Many authors have endeavored to elucidate its ecological characteristics and reported its high productivity (Penfound, 1956; Boyd, 1970; Wooten and Dodd, 1976; Center and Spencer, 1981; Sato and Kondo, 1981, 1983). On the other hand, other researchers who were interested in an applied aspect of this weed have tried to use it for the improvement of polluted waters (Boyd, 1970; Wooten and Dodd, 1976; Sato and Kondo, 1981, 1983), and bio-resources, such as bio-gass, charcoal, feeds and composts.

In Thailand, Waterhyacinth has been brought into the King garden as an ornamental flower from Indonesia and has been spreading everywhere today. Recently, a great deal of Waterhyacinth is growing in canals, ponds, reservoirs near villages, lakes in lowlands, dams and tributary waters. They grow in the pools created along the roads in the wake of road construction, and in the water-polluted areas around the high density housing areas in the vicinity of large cities. In these areas, particularly, this plant has become a nuisance.

This study concerning "The ecological studies on the Waterhyacinth (Eichhornia crassipes (Mart.) Solms) population" was carried out to gain the basic knowledge for searching the way of its use and control in Thailand, in the future.

This study was conducted as a part of Japan-Thai technical cooperation

by Japan International Cooperation Agency. On the occasion, I would like to express my thanks to Dr. Yookti Sarikaphuti: Director-General of Department of Agriculture, Dr. Tanongchit Wongsiri: The Deputy Director-General and Mr. Visut Chandrangsu: The Director of Botany and Weed Science Division, for the admistrative support. And I wish to extend special thanks to Dr. Paitoon Kittipong: The Chief of Weed Science Branch and all researchers of this Branch for their cooperation and friendship. I also express my sincere thanks to Dr. Kenji Noda: The Leader of NWSRI Project, Dr. Jiro Harada and Mr. Teruhiko Nibe: The Experts of this project for their useful advices and encouragement. I would like to express my thanks to Mrs. Yupin Kittipong and Miss Nongnit Khuntong as the secretaries of NWSRI Project for their useful advices and assistances.

August 20th, 1986

Masao OSADA

JICA Expert, NWSRI Project

I. THE NET PRODUCTION OF THE WATERHYACINTH (EICHHORNIA CRASSIPES (MART) SOLMS) POPULATION.

INTRODUCTION

It is important for the establishment of the way about the use and control of Waterhyacinth in the future to know the standing crop and the productivity of the Waterhyacinth population in Thailand. The purpose of this report was that the net production of the Waterhyacinth population was investigated in the population of different size of plants. The standing crop of the Waterhyacinth populations will be related in Chapter III.

METHOD

(1) The principle of the measurement on the net production of a plant population.

Net production (Pn) as shown in the following equation; $Pn = \Delta B+L+G$ -(1), the unit of all terms is d.w.g/m^2/day, C g/m^2/day or cal/m^2/day,etc..., is composed of the increasing rate of biomass (B), loss (L) by death and shedding and grazing loss by consummers. The increasing rates of biomass was determined by the following equation in this report ; increasing rate $= (B_2-B_1)/t$ -(2), B_1 means the amount of plants in the beginning of the measurement, B_2 means the amount of plant in the end of the measurement, and t means the duration of the measurement. The determination of L is the same as that of B. The value of G was assumed to be negligible in comparison with that of net production.

Net Production (Pn) $= \Delta B + L + G$ ----------(1)

B : Biomass change

L : Loss by death and shedding

G : Grazing loss by consummers

Increasing rate of Biomass (ΔB) $= \frac{B_2 - B_1}{t}$ ----(2)

B_2: Biomass in the end of a certain growing period

B_1: Biomass in the beginning of a certain growing period

t : growing period

(2) Materials and Method

Four sizes of Waterhyacinth as called the population of small, middle, large and largest plants were used for studying growth and productivity. All the populations of Waterhyacinth were collected from the small canal at Kasetsart Campus excepted for the largest population which were collected from a small pond beside Sansab Canal in Bangkok. The height of each plant was measured from base of petiole to the top. The height and fresh weight of each plant was observed before the experiment. The characteristics of the individual populations of Waterhyacinth prepared for this experiment were shown in Table I-1. Ten mother stocks of each size of populations were measured to obtain the dry and fresh weight ratio as shown in Table I-2, which were used to estimate the initial dry weight of each population in this experiment. In the starting stage, the height, the numbers of plants and the total fresh weight of Waterhyacinth used for this experi-

ment were shown in Table I-3.

The experiment was conducted since January to April 1986, in a small canal near Weed Science Building in Bangkhen. The quadrats of 50 x 50 cm with 9x replications for each population of Waterhyacinth were set up in this canal (Fig. I-1). Nine sets of populations of Waterhyacinth were planted in these quadrats. The first harvest was made during 20 days after planting, the second and third harvests were 60 and 90 days, respectively.

After harvesting; the amount of shoots and daughter plants were counted as well as height of the plants were measured. Each part of these harvested plants was separated into blades, petioles, roots, stolons and decayed parts. Fresh weight of these individual organs were noted before put into the oven. When all of these samples were completely dry at 2-3 days in the oven, the dry weight of these samples were examined. The difference between initial and final dry weight of the Waterhyacinth populations were used to calculate the increasing rate of the populations.

Table I - 1. The characteristics of the individuals used for determining the increasing rate of the Waterhyacinth (Eichhornia crassipes (Mart.) Solms) population. AVE., S.D. and C.V. are the average value and the standard deviation of individuals within a given quadrat, and the coefficient of variation between AVE. and S.D., respectively.

Plant sizes	Characteristics of individuals								
	Height (cm)			Number of petioles (No.)			Fresh weight (g)		
	AVE.	S.D.	C.V.	AVE.	S.D.	C.V.	AVE.	S.D.	C.V.
Small	21	3	10 %	5	1	20 %	31	9	30 %
Middle	56	5	9 %	10	2	20 %	436	14	3.2 %
Large	78	7	9 %	6	1	20 %	362	36	9.9 %
Largest	106	1	0.9 %	14	1	7 %	1630	150	9.2 %

Table I-2. The ratio of the dry weight to the fresh weight and the distribution ratio in each organ of the mother stock of Waterhyacinth (Eichhornia crassipes (Mart.) Solms). This value is the average of 10 mother stocks.

The size of mothe stocks	Height (cm)	D.W./F.W. ratio (%)	Distribution ratio (%) blades	petioles	roots
small	23	6.0	39	39	22
middle	58	6.6	31	48	21
large	89	7.1	26	59	15
largest	111	5.3	21	49	30

Table I-3. The characteristics of the experimental population of Waterhyacinth (Eichhornia crassipes (Mart.) Solms) in the initial stage. The Figure in parentheses is the standard deviation of all quadrats.

The size of plant	Height (cm)	Number of plants No./50x50 cm^2	Total fresh weight g/50x50 cm^2
small	20 (1)	6	193 (9)
middle	58 (1)	9	3810 (84)
large	82 (2)	12	4450 (100)
largest	107 (1)	3	4940 (110)

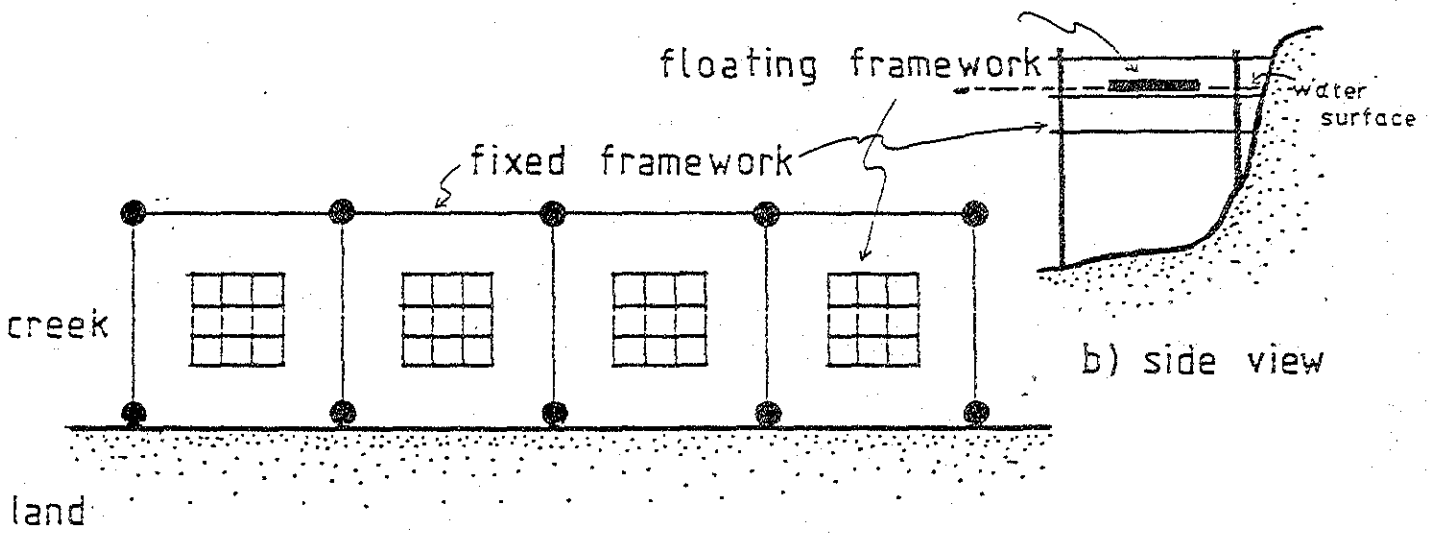


Fig. I-1. The bird's - eyes view and side view of the experimental equipment set up in the creek near NWSRI, for measuring the growth of the Water hyacinth (Eichhornia crassipes (Mart.) Solms) population.

RESULTS

The net production (Pn), and the increasing rate (IR) of biomass and the decayed part of the Waterhyacinth population is shown in Table I-4. The biomass of the populations composed of plants of small size ranged in the IR from 6.2 to 7.4 d.w.g/m^2/day. The average value (AV) and coefficient of variation (CV) of these values were 6.8 d.w.g/m^2/day and 6.6%, respectively. The decayed part of these populations ranged in the IR from 0.18 to 0.3 d.w.g/m^2/day. The AV and CV of these values were 0.22 and 25%, respectively. The Pn of these populations varied between 6.4 and 7.7 d.w.g/m^2/day. The AV and CV were 7.0 d.w.g/m^2/day and 6.4%, respectively.

The biomass of the populations composed of plants of middle size ranged in the IR form 10 to 117 d.w.g/m^2/day. The AV and CV of these values were 12 d.w.g/m^2/day and 21%, respectively, (Table I-4-b). The decayed part of these populations ranged in the IR from 2.6 to 3.8 d.w.g/m^2/day. The AV and CV of these values were 3.2 d.w.g/m^2/day and 16%,respectively. The Pn of these populations varied between 13 and 19 d.w.g/m^2/day. The AV and CV of these values were 15 d.w.g/m^2/day and 17%, respectively.

The biomass of the populations composed of plants of large size ranged in the IR from -1.7 to 18 d.w.g/m^2/day, (Table I-4-c). The AV and CV of these value were 13 d.w.g/m^2/day and 73%, respectively. The decayed part of these populations ranged in the IR from 2.2 to 7.6 d.w.g/m^2/day. The AV and CV of these values were 4.8 d.w.g/m^2/day and 44%, respectively. The Pn of these populations varied between 5.9 and 26 d.w.g/m^2/day. The AV and CV of these values were 18 d.w.g/m^2/day and 45%, respectively.

The biomass of the populations composed of plants of the largest size ranged in the IR from 15 to 21 d.w.g/m^2/day, (Table I-4-d). The AV and CV

of these values were 17 d.w.g/m^2/day and 17%, respectively. The decayed part of these populations ranged in the IR from 4.8 to 6.1 d.w.g/m^2/day. The AV and CV of these values were 5.3 d.w.g/m^2/day, respectively. The Pn of these values varied between 20 and 26 d.w.g/m^2/day. The AV and CV of these values were 23 d.w.g/m^2/day and 12%, respectively.

The above-mentioned results are summarized in Table I-5. In this experiment, the net production of the population of plants of different size between 21 and 100 cm in height, with varying from 0.186 to 1.26 d.w.kg/m^2 in biomass, ranged between 7.0 and 23 d.w.g/m^2/day. The percentages of the IR of the decayed part to the Pn in the populations of plants of small size, middle size, large size and the largest size were 3.1, 20, 27 and 23%, respectively.

The growth of the populations composed of plants of middle and large sizes during and after the experiment for measuring their net production is shown in Fig. I-2. The population of plants of middle size continued to increase in its total dry weight. Its value was 1.4 d.w.kg/m^2 at the end of this experiment, 36 days, and 2.3 d.w.kg/m^2 at 97 days. The population of plants of large size continued to increase in tis total dry weight but its increasing rate was reduced after the experiment. Its total dry weight was 1.4 kg/m^2 at the end of the experiment, 26 dyas, 1.6 kg/m^2 at 50 days and 2.1 kg/m^2 at 93 days.

The distribution ratio among organs of the dry matters newly produced by the Waterhyacinth population during the experimental is shown in Fig. I-3. The distribution ratio in roots of the newly produced matters varied from 41% to 51% in the small-size, the middle-size and the large-size of the population. In the largest-size population, its ratio in roots was only 7%. The accumulation of the matters in petioles varied from 28% to 49%

in att size populations. The distribution ratio in blades were relatively a little, and varied from 26% to -3%. The much amount of the newly produced matters by the Waterhyacinth population was distributed in its non-photosynthetic organs, namely organs sustaining the structure of foliage and organs absorbing the nutrients.

DISCUSSION

The results of net production from this experiment compared with the Pn of Waterhyacinth reported by other authors (Table I-6), these Pn values of the population composed of plants of middle, large and the largest sizes is similar to others. Furthermore, these Pn values gained from in this experiment are larger than those of the tropical rain forest which vary from 2.7 and 9.7 d.w.g/m^2/day is the most productive among the plant communities on the earth.

Table I-6. The net production of the Waterhyacinth (Eichhornia crassipes (Mart.) Solms) population in different area.

Net production d.w.g/m^2/day	Source
29	Wooten et al (1971) at Iowa
24.6	Boyd (1970)
13.7	Penfound (1956) at New Orens, Lousiana
40	Sato and Kondo (1983)
25.5	Sato and Kondo (1981)
7.0 - 23	This study

The relationship between the population height and the net production of the Waterhyacinth population is shown in Fig. I-4. There are the plus relation in the middle-size, the large size, and the largest-size of the population though their dry weight was almostly similar to each other. And this tendency is also found in the relationship between the height and the increasing rate on the biomass and the decayed part of these different size population, (Fig. I-5). This suggest that the population height of Waterhyacinth is significant as the factor influencing to its productivity.

Table I - 4. Net production, and the increasing rate of biomass and the decayed part of the Waterhyacinth (Eichhornia crassipss (Mart.) Solms) population, being investigated at the creek in Bangkok, from January to February, 1986. S.D. and C.V. show Standard diviation and Coefficient of variation, recpectively.

a) The population composed of plants of small size

Quadrat number	Increasing rate (d.w. $g/m^2/day$)		
	Biomass	Decayed	Total
1	6.88	0.302	7.18
2	6.20		(6.42)*
3	6.72	0.178	6.90
4	7.12	0.192	7.31
5	7.44		(7.66)*
6	6.44	0.212	6.65
Average	6.80	0.222	7.02
S.D.	0.45	0.056	0.45
C.V.	6.6 %	25 %	6.4 %

* The figure in parentheses is estimated value using the average increasing rate of decayed part.

b) The population composed of plants of middle size

Quadrat number	Increasing rate (d.w. g/m^2/day)		
	Biomass	Decayed part	Total
1	12.2	3.84	16.1
2	11.0	2.79	13.8
3	16.6	3.09	19.4
4	11.4	3.43	14.8
5	10.1	2.63	12.7
Average	12.3	3.16	15.4
S.D.	2.6	0.49	2.6
C.V.	21 %	16 %	17 %

c) The population composed of plants of large size

Quadrat number	Increasing rate (d.w. g/m^2/day)		
	Biomass	Decayed part	Total
1	17.8	6.23	24.0
2	−1.66	7.56	5.9
3	23.8	2.24	26.0
4	10.2	4.39	14.6
5	15.3	3.33	18.6
Average	13.1	4.78	17.8
S.D.	9.6	2.10	8.0
C.V.	73 %	44 %	45 %

d) The population composed of plants of the largest size

Quadrat number	Increasing rate (d.w. $g/m^2/day$)		
	Biomass	Decayed part	Total
1	20.8	4.97	25.8
2	15.4	6.08	21.4
3	15.8	4.75	20.1
Average	17.3	5.25	22.6
S.D.	3.0	0.68	2.8
C.V.	17 %	13 %	12 %

Table I - 5. Net production, and the increasing rate of biomass and the decayed part of the Waterhyacinth (Eichhornia crassipes (Mart.) Solms) population, being investigated at the creek in Bangkok, from January to February, 1986.

Characteristics of intial population		Growing period	Increasing rate		Net production
Height (cm)	Dry weight (kg/m^2)	(days)	Biomass ($d.w.\ g/m^2/day$)	decayed part ($d.w.\ g/m^2/day$)	($d.w.\ g/m^2/day$)
21	0.186	20	6.80	0.222	7.02
58	1.00	36	12.3	3.16	15.4
81	1.26	26	13.1	4.78	17.9
106	1.04	26	17.3	5.25	22.6

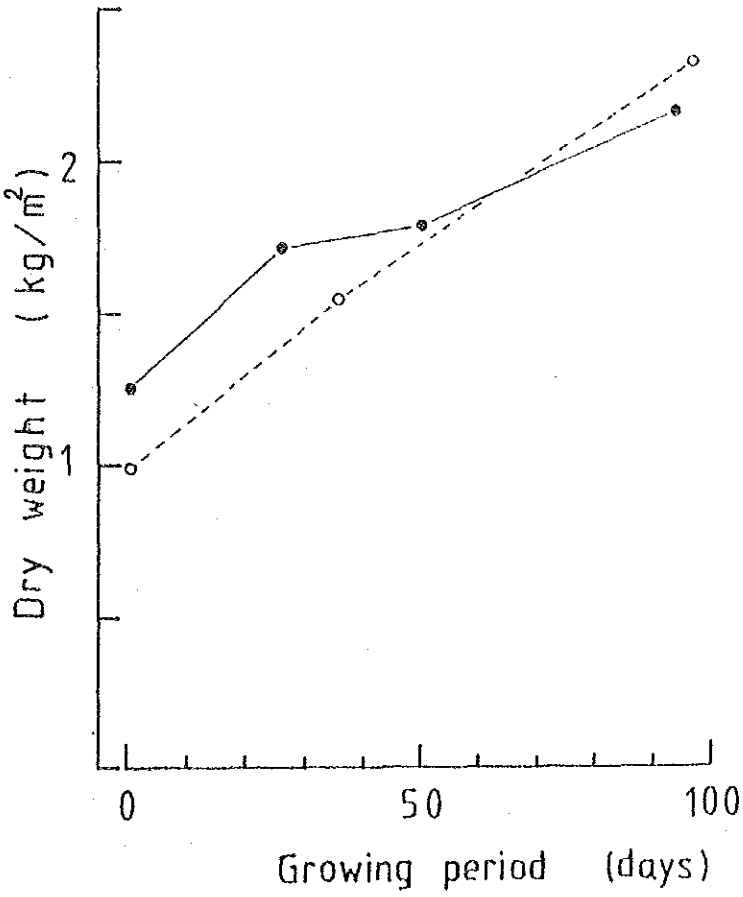


Fig. I-2. The change in the total dry weight of the Waterhyacinth (Eichhornia crassipes (Mart.) Solms) populations, cultured during the dry season, at the creek in Bangkhen, Bangkok, ● and ○ indicates the total dry weight of the populations composed of plants of large and middle size, respectively.

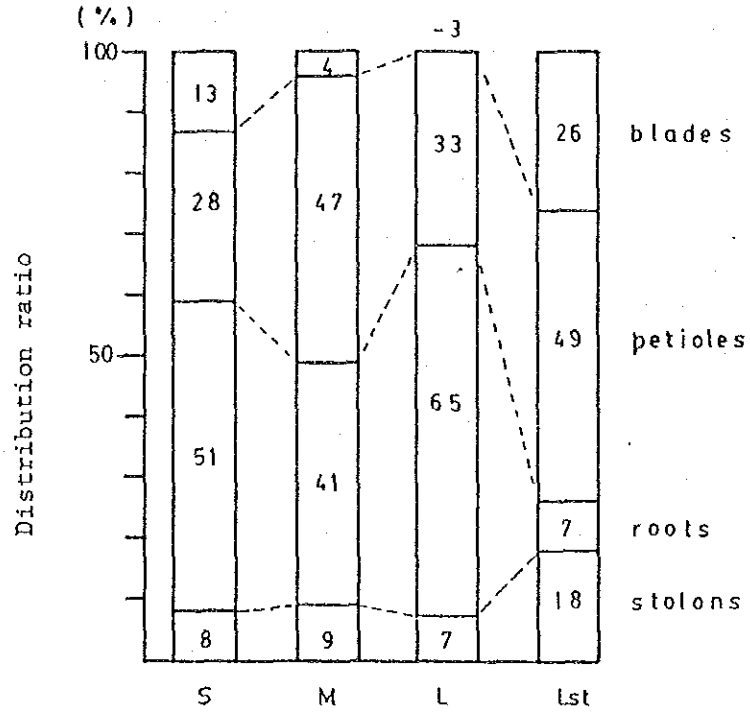


Fig. I-3. The distribution ratio in each organ of the dry matter produced by the Waterhyacinth (Eichhornia crassipes (Mart.) Solms), gained by the cultural experiment for about a month, in Feburary, 1986, at the creek in Bangkok. S,M,L and Lst indicate the small-size, the middle-size, the large-size and the largest size of the population, respectively.

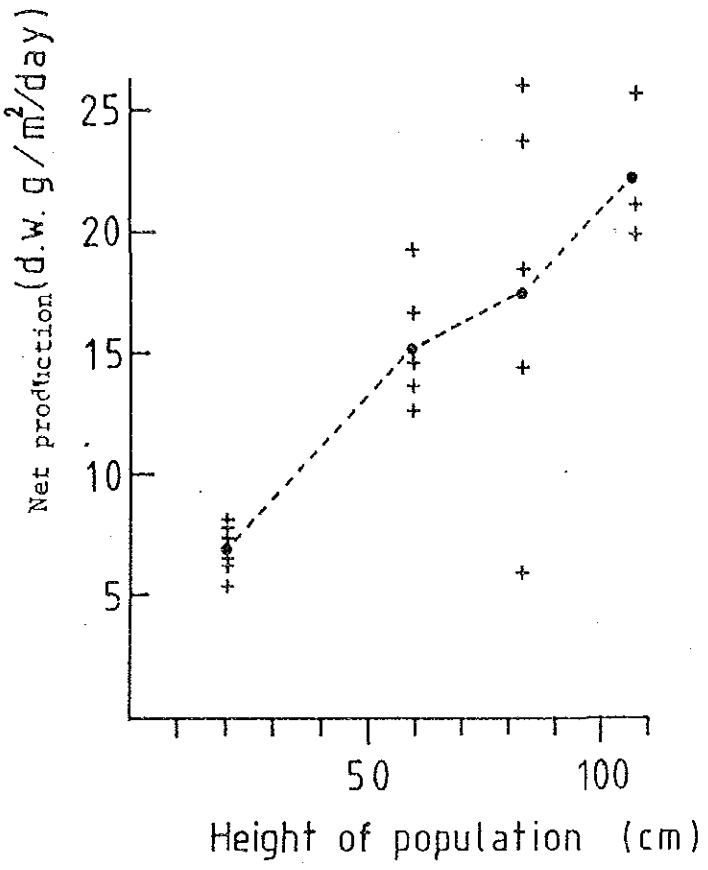


Fig. I-4. The relationship between the heigh and the Net production of the Waterhyacinth, (Eichhornia crassipes (Mart.) Solms) population, cultured during 20-36 days at the creek, in Bangkhen. + and • indicates each value and its average value of the increasing rate, vespectively.

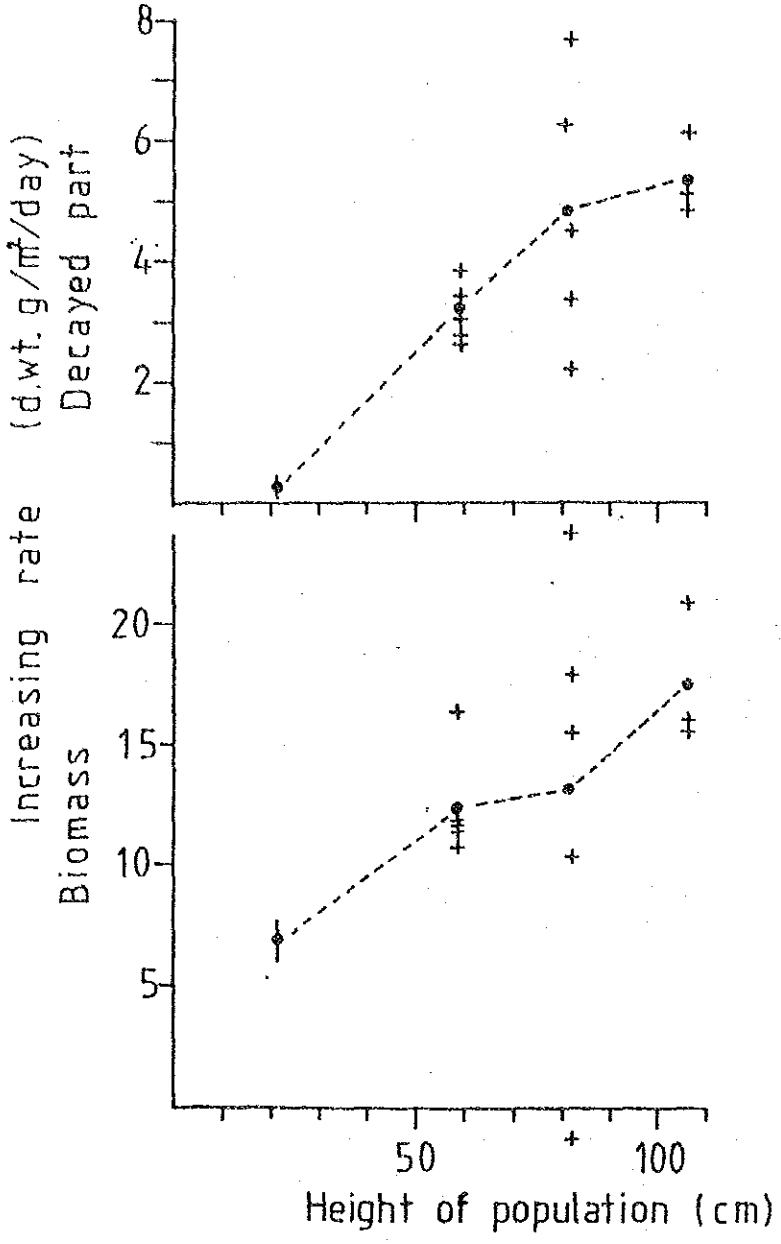


Fig. I-5. The relationship between the hight and the increasing rate on the biomass and the decayed part of the Waterhyacinth (Eichhornia crassipes (Mart.) Solms) population, cultured during 20-36 days at the creek in Bangkhen, + and • indicates each value and its average value of the increasing rate respectively.

II. THE PRODUCTIVE STRUCTURE OF THE WATERHYACINTH POPULATION

INTRODUCTION

As the above-mentioned Chapter I, the Waterhyacinth population has the higher productivity. However, the processes of the dry matter production and reproduction of this population sustaining the higher productively have not been made clear yet. In this chapter, the productive structure of the Waterhyacinth population is investigated as the first step to make clear these processes. And this investigation is also the first step of the another method for measuring the productivity of a plant population.

METHOD

The diagram of the productive structure of the Waterhyacinth population was obtained from a natural monospecific stand of uniform height. This investigation was carried out at the pond in Bangkok, February, 1986.

The method of this investigation is based on the stratified clip method (Monsi and Saeki, 1953). The waterhyacinth was harvested within 1x1 m^2. Blades and petioles (above-ground part) was cut vertically into 20 cm height layer from the base of petioles on the ground. Blades and petioles of each height layer and the underground section (roots and stolons) were weighed. Before harvesting, the relative light intensity was measured with two photo-meters in this population.

In this study, blades were regarded as a photosynthetic organ, and petioles were regarded as a non-photosynthetic organ.