

Weed and Herbicide Use in Taiwan

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INTRODUCTION

The total land area in Taiwan is about 36 thousand square kilometers. The size is about one-third that of South Korea. Approximately 900 thousand hectares was cultivated in 1989. Rice paddy fields made up 480,000 ha and upland crops were grown 415,000 ha. The average farm size was 1.23 ha in 1989 (Table 1).

Table 1. Land area in Taiwan in 1989.

Total land area :	3,600,000 ha
Cultivated land :	895,000 ha (25% of total land)
Paddy	480,000 ha (54% of cult. land)
Upland	415,000 ha (46% of cult. land)
Farm size/family :	1.23 ha

Source : Taiwan Agri. Yearbook 1990

The population in Taiwan was 20 million in 1989 with annual growth rate of 1.02%. The population density was 558 per square kilometer in 1989, which was higher than that of South Korea (430/sq.km). The farm population was about 3.67 million or 18.3% of total population in 1989 (Table 2).

Table 2. Twiwan farm population

Year	Total population	Growth rate	Farm population	% of total population
	Mil.	%	Mil.	%
1980	17.81	1.90	5.39	30.3
1985	19.26	1.29	4.49	24.3
1989	20.11	1.02	3.67	18.3

Source : Taiwan Agri. Yearbook 1990

Farm family income has increased from US\$ 5,490 in 1980 to US\$ 11,810 of 1988. The farm family income from on-farm sources almost tripled from 1980 to 1988. This was primarily due to the increased production of high value commodities such as live-

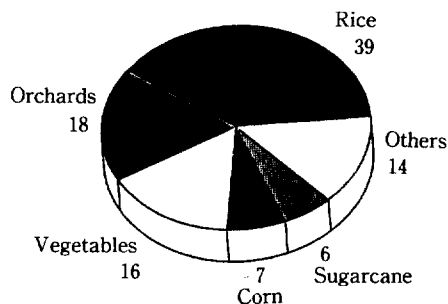
stock, dairy, orchard, etc. However, the farm family income still considerably lower than that of non-farm family (Table 3).

Table 3. Farm family income in Taiwan
K US\$/Household

GROUP	1980	1988
Farm family (A)	5.49 (100%)	11.81 (100%)
On-farm	1.63 (30%)	4.61 (39%)
Off-farm	3.86 (70%)	7.20 (61%)
Non-farm family (B)	7.40	16.60
(A)/(B)	74%	71%

Source : Taiwan Agri. Yearbook 1990

Rice is the biggest crop in terms of planted hectareage with two crops produced per year. The total crop hectareage was 1,216,000 ha in 1989, with rice ranked as number one (39%) followed by orchard (18%), and then vegetables (16%) (Figure 1).



Source : Taiwan Agri. Yearbook 1990

Fig. 1. Crop area in Taiwan, 1989
Total ha : 1,216 (X1,000)

MAJOR WEEDS IN CROP FIELDS

Paddy Field

In Taiwan, the first and second rice crop is transplanted in January to March and June to August, respectively.

The most important weeds in paddy fields are

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Table 4. Major weeds in paddy field¹⁾

1. <i>Monochoria vaginalis</i> (++)	6. <i>Lindernia cordifolia</i> (+)
2. <i>Cyperus difformis</i> (++)	7. <i>Alternanthera sessilis</i> (+)
3. <i>Echinochloa crus-galli</i> (++)	8. <i>Paspalum distichum</i> (+)
4. <i>Scirpus juncoides</i> (++)	9. <i>Sagittaria pygmaea</i> (+)
5. <i>Sagittaria trifolia</i> (++)	10. <i>Scirpus maritimus</i> (+)

¹⁾ (++) : Most important

(+) : Important

Source, Chiang M.Y. & Leu L.S. 1982.

Monochoria vaginalis, *Scirpus juncoides*, *Echinochloa crus-galli*, *Cyperus difformis* and *Sagittaria trifolia* due to their wide distribution and yield reducing capability (Table 4).

For the majority of weeds, their occurrence is similar between the first and second rice season. However, some weeds for example, *Sagittaria trifolia* and *Eleocharis acicularis* are more prominent during the first season, while others as *Monochoria vaginalis* and *Echinochloa colona* occur more during the second season (Table 5).

Geographic distribution of paddy weeds varies from northern to southern Taiwan; *sagittaria trifolia* is more common in northern Taiwan, while *Sagittaria pygmaea* and *Scirpus maritimus* are more common in central Taiwan, and *Echinochloa colona* is found

Table 5. Seasonal difference of paddy weeds

Characteristics	Weeds
More in 1st rice season	<i>Sagittaria trifolia</i> <i>Eleocharis acicularis</i> <i>Alternanthera nodiflora</i>
Similar in 1st and 2nd rice season	<i>Echinochloa crus-galli</i> <i>Scirpus juncoides</i> <i>Alternanthera sessilis</i> <i>Cyperus difformis</i>
More in 2nd rice season	<i>Monochoria vaginalis</i> <i>Echinochloa colona</i> <i>Rotala indica</i>

Source : Chiang M.Y. & Leu L.S. 1982.

Table 6. Geographic distribution of paddy weeds

Major infected area	Weeds
Northern Taiwan	<i>Sagittaria trifolia</i> <i>Blyxa echinosperma</i>
Central Taiwan	<i>Sagittaria pygmaea</i> <i>Scirpus maritimus</i>
Southern Taiwan	<i>Echinochloa colona</i> <i>Sphenoclea zeylanica</i>

more commonly in southern Taiwan (Table 6).

Upland

Major upland crops are corn, soybeans and peanuts. Major weeds in common upland crops, from spring to autumn, are *Chenopodium ficifolium*, *Amaranthus viridis*, *Eleusine indica*, *Digitaria sericea* and *Portulaca oleracea*. The dominant weeds in winter upland crop are *Polygonum lapathifolium*, *Stellaria aquatica* and *Chenopodium ficifolium* (Table 7).

Table 7. Major weeds in upland crop¹⁾

Weeds	Spring/ Autumn Upland	Winter Upland
1. <i>Chenopodium ficifolium</i>	+++	+++
2. <i>Amaranthus viridis</i>	+++	++
3. <i>Eleusine indica</i>	+++	++
4. <i>Digitaria sericea</i>	+++	++
5. <i>Echinochloa colona</i>	+++	++
6. <i>Portulaca oleracea</i>	+++	+
7. <i>Polygonum lapathifolium</i>	++	+++
8. <i>Stellaria aquatica</i>	+	+++
9. <i>Solanum nigrum</i>	++	++
10. <i>Cyperus rotundus</i>	++	+

+++ most important

++: very important

+: important

Source : Chiang M.Y. & Chiang Y.J. 1983.

Orchards

The major orchard crops are citrus, mangos, bananas, pear and lechee. The major perennial weeds in orchard are *Paspalum conjugatum*, *Panicum repens*, *Imperata cylindrica* and *Polygonum chinese*. The most common annual weeds are *Ageratum conyzoides*, and *Digitaria sanguinalis* (Table 8).

Table 8. Major weeds in orchards

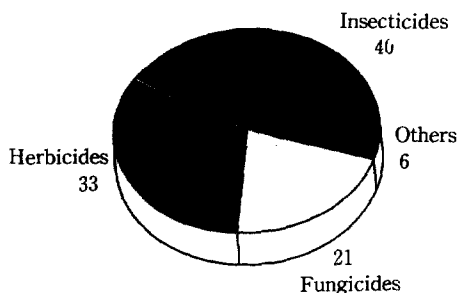
1. <i>Paspalum conjugatum</i>	6. <i>Bidens bipinnata</i>
2. <i>Eleusine indica</i>	7. <i>Erechtites valerianafolia</i>
3. <i>Digitaria sanguinalis</i>	8. <i>Imperata cylindrica</i>
4. <i>Ageratum conyzoides</i>	9. <i>Polygonum chinese</i>
5. <i>Panicum repens</i>	10. <i>Borreria latifolia</i>

Source : Plant Protect. Manual 1990

HERBICIDE USE

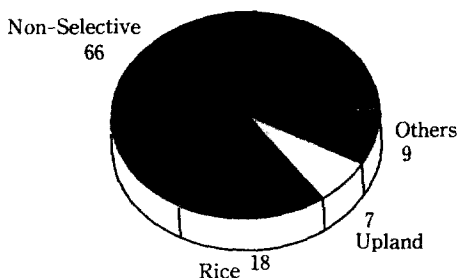
Pesticide sales

Pesticide sales value was US\$ 183 million at ex-formulator level in 1989. Insecticides ranked number one (40%), followed by herbicides (33%) and then fungicides (21%) (Figure 2). Herbicides sales have increased rapidly from 23% (1,000 K NT\$) of total pesticide sales value in 1984 up to 33% (1,600 K NT\$) in 1989. Figure 3 shows percentage of herbicides sales value in 1989. Non-selective herbicides, like glyphosate and paraquat shared 66% of total herbicides sales value.



Source : Taiwan Agrochem. Indu. Asso. 1990

Fig. 2. Pesticide sales value in 1989
Total US\$ 183 Mil. (ex-formulator)



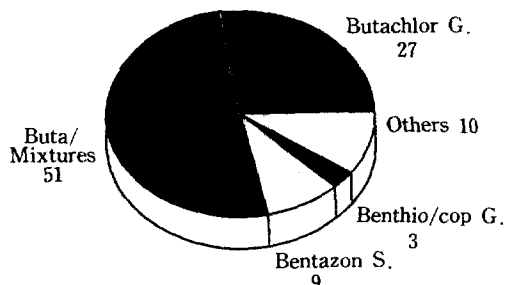
Source : Taiwan Agrochem. Indu. Asso. 1990

Fig. 3. Herbicide sales value in 1989
Total US\$ 61 Mil. (ex-formulator)

Paddy Rice

About 50 herbicides are registered for use in rice ; thirty-six are registered in for DAT (days after transplanting) treatment, 17 for DBT (days before transplanting) treatment, 7 in wet-bed direct-seeded rice and 5 in nurseries. Farmers favor granular herbi-

cides formulations applied as pre-emergence treatments 2 to 6 days after transplanting depending on products used and rice season. Butachlor and a mixture of butachlor plus chlomethoxynil are the most commonly used herbicides in rice. The official recommendation of major rice herbicides, in order of sales value in 1989, are listed in Table 9. Rice herbicide sales value in 1989 are shown in Figure 4.



Source : Taiwan Agrochem. Indu. Asso. 1990

Fig. 4. Rice Herbicide Sales in 1989
Total US\$ 11.7 K (ex-formulator)

Upland crops and Vegetables

In upland crops, a wide range of herbicide are officially recommended, 17 in soybeans, 15 in peanuts and 6 in corn. In vegetables, 9 different herbicides are recommended in cabbages, 4 in both tomato and watermelon, and 3 in both onion and garlic. Fluazifop-butyl and pendimethalin are the most broadly used herbicides in upland crops and vegetables. The registration status of major upland crop/vegetable herbicides, in order of sales value, in 1989, are shown in Table 10. The sales value in 1989 are shown in Figure 5.

Orchards

In Taiwan, most orchard plantations are on slope land ; orchard farmers normally apply postemergence herbicides 3 to 4 times a year primarily from March to October when weeds problems are most serious. Soil applied residual herbicides are seldom used in orchards. In citrus, the number one fruit crop, 13 different herbicides are registered. Glyphosate is registered in 16 crops/sites in Taiwan. The registration status of non-selective herbicide are shown in Table 11 and the sales value in 1989 are shown in Figure 6.

Table 9. Official recommendation of major rice herbicide

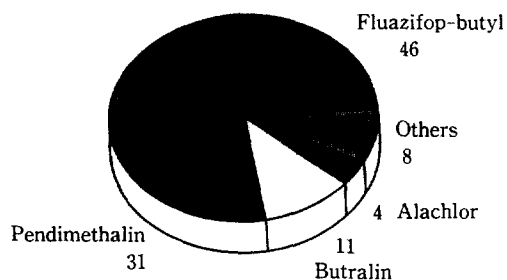
Products	Nursery	Transplanted field		Direct Seeded field
		DBT	DAT	
Butachlor G.	○	○	○	○
Buta/Chlormethoxynil G.	○	○	○	○
Bentazon S.	○		○	○
Buta/Oxadiazon EC.		○		
Buta/CNP G.		○	○	
Buta/SK-223 G.			○	
Buta/Bifenox G.		○	○	
Benthiocarb/CNP G.	○		○	○
Oxadiazon EC.		○		
Pretilachlor/Bifenox G.			○	

1) DBT : Days before transplanting

DAT : Days after transplanting

Table 10. Registration status of major upland crop/vegetable herbicides

Products	Peanuts	Soybean	Corn	Cabbage	Tomato	Garlic
Fluazifop-butyl	○	○		○	○	○
Pendimethalin	○	○	○	○	○	○
Butralin	○					
Alachlor	○	○		○	○	
Oxyfluorfen		○		○		○
Qulzalofof-ethyl	○					
Linuron	○	○				
Metolachlor	○	○	○			
Metobromuron	○	○	○			

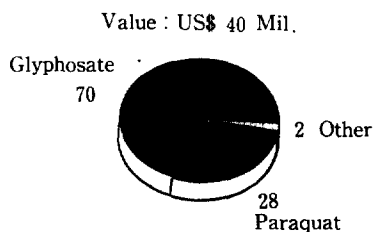


Source : Taiwan Agrochem. Indu. Asso. 1990

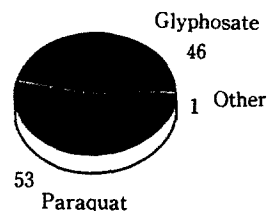
Fig. 5. Herbicide Sales in Upland/Vegetables 1989, Total US\$ 4.22 (ex-formulator)

FUTURE TREND OF RICE HERBICIDE APPLICATION AND DEVELOPMENT

There are three rice cultural practices in Taiwan, transplant rice, direct seeded rice and ratoon rice. Due to shortage of rural labor, transplant rice hectare is gradually decreasing. Meanwhile the cultivated



Quantity : 6, 259 M. T.



Source : Taiwan Agrochem. Indu. Asso. 1990

Fig. 6. Non-Selective Herbicide Sales in 1989 (ex-formulator)

Table 11. Resistration shakes of non-selectlve her-
bicide

Products	Registered crop/site
Glyphosate 41%S.	Citrus, bananas, pears, plums, mangos, loquats, lichees, guavas, grapes, tea, paddy levee, sugarcane, pre-plow paddy, pre-plow sugarcane field, aquatic weeds, and non-crop land.
Paraquat 24% S.	Citrus, sugarcane, tea, pre-plow paddy, and non-crop land.
Imazapyr 23.1% S.	Non-crop land
Sulfosate 40.8% S.	Non-crop land
Bialaphos 20% Wp	Non-crop lond

area of ratoon rice increased rapidly from 15, 000 ha in 1989 to 35, 000 ha, 7% of total rice area, in 1990. This type of ratoon rice farming eliminates or reduces the need of land preparation, transplanting and herbicide application. This change in cultural practice could potentially result in a major reduction in herbicide use in rice in Taiwan. Direct seeded rice is grown on less than 5% of rice hectarage. Inconsistent seeds germination in first crop season rice due to low temperature conditions, crop safety, efficacy of herbicides application and bird damage are major constraints for direct seeded rice adaptation.

Apple snails (*Pomacea canaliculata* (Lamarck)) cause rice damage in the early rice growth stage after transplanting in Taiwan. Therefore, herbicide plus molluscicide package mixtures are needed and will

probably be developed to control weeds and apple snails at the same time in paddy fields. Environmental safety will continue to be an important factor in the use and regulation of current and the future pesticides.

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