THE EFFECT OF WEEDS ON RICE IN PADDY FIELD

1. WEED SPECIES AND POPULATION DENSITY

W. L. Chang

Introduction

Weeds in transplanted rice are customarily controlled by hands in Taiwan. Recently, however, due largely to the rapid industrial development, farm labors needed for hand weeding are becoming increasingly scarce. As a result, interest in controlling weeds with herbicides in transplanted rice has greatly increased among rice farmers. The understanding of the factors affecting the degree of damage caused by different weed species in transplanted rice is necessary if chemical weed control is to be practiced effectively and economically. For this reason, a series of experiments were conducted at the Chiayi Agricultural Experiment Station to obtain the necessary information. This paper presents results of the first experiment which evaluates the effect of population density of several major weeds in transplanted rice.

Materials And Methods

The experiment was conducted on the clay pots in the screen house of the Chiayi Agricultural Experiment Station in the first and second crops of 1968. The variables included two levels of fertility, five species of weeds, and three population densities for for each weed species. Two levels of fertility were low and high by applying 80, 40, 40, and 160, 80, 80, kg per ha of N, P_2O_5, and K_2O, respectively. Five species of weeds used in this experiment were *Echinochloa crusgalli, Monochoria vaginalis, Cyperus difformis, Marsilea quadrifolia,* and *Spirodela polyrhiza.* Three population densities of weeds were 0, 3 weeds per pot or about 100 weeds per m^2, and 6 weeds per pot or about 200 weeds per m^2.

One Seedling of the japonica rice variety, Chianung 242 was transplanted in each clay pot with surface area of 314 cm^2 Weeds were planted around rice seedling right after the transplanting of rice. For *Echinochloa crusgalli, Monochoria vaginalis,* and *Cyperus difformis* weeds with four to five leaves were used whereas cutting with one node was used for *Marsilea quadrifolia.* For *Spirodela polyrhiza,* fully developed weeds were used.

The experiment was laid out in a randomized complete block design with three replications. The plots were represented by individual pots. Data for grain yield and components of yield were recorded for the evaluation of the damage of rice caused by weeds which was expressed in the percentage of weed-free check treatment.

The first crop was transplanted in March 14, 1968 and harvested in July 9, 1968. The second crop was transplanted in July 19, 1968 and harvested in October 28, 1968. The climatic data of the station for 1968 are presented in Table 1.

Table 1. Climatic data of the Chiayi Agricultural Experiment Station.

Month	Rainfall (mm)	Number of rainy day	Relative humidity (%)	Number of sunshine hours (hrs/month)	Solar radiation gr-cal/cm² /month	Temperature (°C)		
						Maximum	Minimum	Mean
January	11.1	5	76	77.6	7,084.0	21.0	12.3	16.6
February	161.0	20	87	38.3	4,822.9	16.7	11.4	14.1
March	178.4	9	70	116.2	8,092.2	24.4	15.6	20.0
April	19.6	6	71	88.6	10,722.1	26.4	18.1	22.3
May	245.4	9	69	58.6	9,208.5	30.1	22.3	26.4
June	589.2	18	70	70.3	8,294.5	30.8	23.4	27.1
July	292.8	13	68	132.0	9,809.3	32.2	25.4	28.8
August	244.4	15	68	77.8	9,562.5	32.1	25.7	28.9
September	227.6	9	74	85.4	8,186.5	30.6	24.2	27.4
October	127.2	6	70	122.8	8,544.6	27.9	19.8	23.9
November	0	0	61	115.1	7,677.4	27.0	16.8	21.9
December	0	0	63	112.7	6,686.1	26.0	15.9	20.9

Results And Discussion

The effect of Weed on Rice Yield

The grain yield of rice in the plots infested with different weed species and population densities was expressed in percentage of weed-free treatments (Table 2). It was observed that *Echinochloa crusgalli* reduced the grain yield of rice by 84.9%. A yield damage of 90% was also reported for this weed (IRRI, 1968). *Cyperus difformis, Marsilea quadrifolia, Monochoria vaginalis,* and *Spirodela polyrhiza* reduced the grain yield of rice by 71.7, 62.0, 61.7, and 9.0%, respectively. Difference in grain yield of rice among five species of weeds was highly significant (Table 3). As *Echinochloa crusgalli* and *Cyperus difformis* usually grow as tall as rice plants, it appears that effective competition of these weeds with rice for solar energy may have resulted in the significant yield reduction of rice. Black *et al.* (1969) proposed that competitive ability depends on the net capacity of a plant to assimilate carbon dioxide and use the photosynthate to extend its foliage or increase its size. They also reported that the so-called "efficient" plants possess the ability to fix CO_2 at higher rates and become relatively more competitive as light intensity increases. Since rice was found to be a "non- efficient" plant whereas *Echinochloa crugalli,* an "efficient" one, it is not surprising to note that rice suffered a great loss of yield when it was grown with *Echinochloa crusgalli.*

Table 2. Yield performance of rice in percentage of weed-free treatment

Weed species	Crop season	High fertility (%)			Low fertility (%)			Average (%)		
		100 weeds /m²	200 weeds /m²	Mean	100 weeds /m²	200 weeds /m²	Mean	100 weeds /m²	200 weeds /m²	Mean
Echinochloa Crusgalli	First	14.5	8.2	11.4	23.1	9.8	16.5	18.8	9.0	13.9
	Second	13.0	9.4	11.2	28.6	13.9	21.3	20.0	11.7	15.9
	Mean	13.8	8.8	11.3	25.9	11.9	18.9	19.8	10.4	15.1
Monochoria vaginalis	First	68.8	64.3	66.6	74.6	34.7	54.7	71.7	49.5	60.6
	Second	16.0	15.5	15.8	18.8	13.5	16.2	17.4	14.5	16.0
	Mean	42.4	39.9	41.2	46.7	24.1	35.4	44.6	32.0	38.3
Cyperus difformis	First	26.4	18.6	22.5	50.9	42.2	46.6	38.7	30.4	34.6
	Second	19.1	12.4	15.8	46.5	9.8	28.2	32.8	11.1	22.0
	Mean	22.8	15.5	19.2	48.7	26.0	37.4	35.8	20.8	28.3
Marsilea quadrifolia	First	43.5	38.3	40.9	54.9	12.7	33.8	49.2	25.5	37.4
	Second	47.8	25.7	36.8	45.3	35.5	40.4	46.6	30.6	38.6
	Mean	45.7	32.0	38.9	50.1	24.1	37.1	47.9	28.1	38.0
Spirodela polyrhiza	First	91.5	89.6	90.6	89.6	73.4	81.5	90.6	81.5	86.1
	Second	94.8	96.7	95.8	104.9	86.5	95.7	99.9	91.6	95.8
	Mean	93.2	93.2	93.2	97.3	80.0	88.7	95.3	86.6	91.0
Average	First	48.9	43.8	46.4	58.6	34.6	46.6	53.8	39.2	46.5
	Second	38.1	31.9	35.0	48.8	31.8	40.3	43.5	31.9	37.7
	Mean	43.5	37.9	40.7	53.7	33.2	43.5	48.7	35.6	42.2

Marsilea quadrifolia and *Monochoria vaginalis* never grow too tall and they compete for light with rice only during the early stage of rice growth. Therefore, the effect of these weeds on rice may come largely from competing the utilization of soil nutrients with rice plants. An investigation conducted by the International Rice Research Institute also indicate that the nitrogen content of *Monochoria vaginalis* was higher than that of *Echinocnloa crusgalli*(IRRI, 1968). *Spirodela polyrhiza*, a floating weed commonly found in the paddy field, caused very slight damage to rice and treatments infested with this weed did not differ significantly with weed-free treatment in their grain yield of rice. Although this weed is not easily killed by chemicals, the control of this weed is probably of minor importance from the practical standpoint.

Table 3. Combined analysis of variance for grain yield of rice in the first and second crops of 1968.

Source of variation	D.F.	S.S.	M.S.	F.	L.S.D. 5%	L.S.D. 1%
Treatment	59	21,746.44	368.58	21.19**	1.21	1.32
Crop seasons (CS)	(1)	529.76	529.76	30.46**	3.92	6.84
Fertility levels (FL)	(1)	1,593.70	1,593.70	91.64**	3.92	6.84
Weed species (WS)	(4)	3,248.52	812.13	46.70**	2.44	3.47
Population densities (PD)	(2)	9,789.28	4,894.64	281.46**	3.07	4.78
CS x FL	(1)	1.61	1.61	0.09	3.92	6.84
CS x WS	(4)	1,190.66	297.67	17.12**	2.44	3.47
CS x PD	(2)	524.75	262.38	15.09**	3.07	4.78
FL x WS	(4)	441.59	110.40	6.35**	2.44	3.47
FL x PD	(2)	536.93	268.47	15.44**	3.07	4.78
WS x PD	(8)	3,112.28	389.04	22.37**	2.01	2.66
CS x FL x WS	(4)	102.69	25.67	1.48	2.44	3.47
CS x FL x PD	(2)	35.06	17.53	1.01	3.07	4.78
CS x WS x PD	(8)	160.13	20.02	1.15	2.01	2.66
FL x WS x PD	(8)	346.91	43.36	2.49*	2.01	2.66
CS x FL x WS x PD	(8)	132.57	16.57	0.95	2.01	2.66
Error	116	2,017.53	17.39			

* Significant at 5% level. ** Significant at 1% level

Population density of 100 and 200 weeds per m^2 reduced 51.3 and 64.4% of grain yield respectively when compared with weed-free plots, showing that weed population of higher than 100 weeds per m^2 was capable of causing drastic reduction in grain yield of rice. Population density of higher than 100 weeds per m^2 may occur frequently for broadleaved and sedge weeds but is rarely found for grassy weeds even in the heavily infested paddy field. For example, 480, 200, and 80 weeds per m^2 were counted in the unweeded plots for broadleaves, sedges, and grasses (Chang, 1969). This situation makes the selection of herbicides highly important. It is necessary that herbicides should be selected on the actual infestation of weeds in the paddy field to insure best control of weeds. It also appears useful for more expensive grass-controlling herbicides to be combined with cheaper phenoxy herbicides to obtain a better control of weeds in rice fields of Taiwan.

The reduction of grain yield caused by *Echinochloa crusgalli* and *Cyperus difformis* was greater in high fertility treatments while *Monochoria vaginalis*, and *Spirodela polyrhiza* reduced more yield in low fertility treatments. The fertility levels x weed species interaction was also highly significant (Table 3), indicating that the degree of damage caused by weeds differed with levels of fertility. It appears that weeds such as *Echinochloa crusgalli* and *Cyperus difformis*, which compete highly with rice for light are likely to

comete more severely with rice in the paddy field applied with high rate of fertilizers. In the paddy field applied with low rate of fertilizers, however, weeds such as *Monochoria vaginalis* and *Marsilea quadrifolia,* which compete more for soil nutrients may have more Profound effect on rice.

The effect of weeds on rice also varied with crop seasons as reflected by a highly significant crop seasons x weed species interaction. *Echinochloa crusgalli* and *Marsilea quadrifolia* reduced yield more or less similarly in both crops but *Monochoria vaginalis* and *Cyperus difformis* were found to cause heavier demage to rice in the second crop than in the first one. Since temperature during the early stage of rice growth varies greatly with crop seasons (Table 1), difference in weed damage to rice with crop seasons may be related to the response of weed growth to temperature. *Echimochloa crusgalli* grows equally well under both cold and warm growing conditions but *Monochoria vaginalis* apparently requires high temperature for its good establishment. In the first crop, *Monochoria vaginalis* grows poorly because of low temperature and is not likely to have severe competition with rice. However, in the second crop when high temperature becomes available for its growth, it competes vigorously with rice for essential growth factors. As shown in Table 2, *Monochoria vaginalis* caused only 39.4% yield reduction in the first crop but in the second one, it raised the percentage of yield reduction to as high as 84.0% which was comparable to that of *Echinochloa crusgalli,* the most destructive weed of rice. As *Monochoria vaginalis* is the most predominant weed of transplanted rice in Taiwan, its potentiality as a serious weed in the second crop can not be underestimated.

The Effect of Weeds on Yield Components of Rice

The average performance of the four components of grain yield of rice in the percentage of weed-free treatment is shown in Figure 1. The number of panicles per plant suffered the greatest damage which was followed by the number of grains per panicle but the100-grain weight and the fertility percentage were only slightly affected, indicating that the reducton of grain yield of rice caused by weeds may be largely attributable to the decrease in the number of panicles per plant and the number of grains per panicle. Since weed competition with rice was reported to be most serious during the first 30 days after emergence of weeds (Show and Danielson, 1961), and this period also corresponds to the active tillering stage of rice plants, it is quite understandable that the number of panicles per plant was most susceptible to the attack of weeds among four components of yield.

The number of panicles per plant was most severely affected by *Echinochloa crusgalli* while *Spirodela polyrhiza* showed only slight suppression of rice tillering in both crop seasons. *Cyperus difformis, Marsilea quadrifolia,* and *Monochoria vaginalis* reduced more tillers in the second crop than in the first one, suggesting that competition was more serious in the second crop when high temperature was available for weed growth during the tillering stage of rice. The significant difference in the reduction of the number of panicles per plant in different crop seasons for *Monochoria vaginalis* agreed closely with that of the reduction of rice yield. This observation appears sufficient to emphasize the importance of this weed in the second crop of rice. Population density of 100 weeds per m^2

caused a drastic reduction in the number of panicles per plant for most weed species but difference between 100 and 200 weeds per m^2 was rather small except that of *Marsilea quadrifolia* under low fertility level. *Echinochloa crusgalli* and *Cyperus difformis* reduced more tillers in high fertility while *Marsilea quadrifolia* and *Monochoria vaginalis* caused more reduction of tillers in low fertility level.

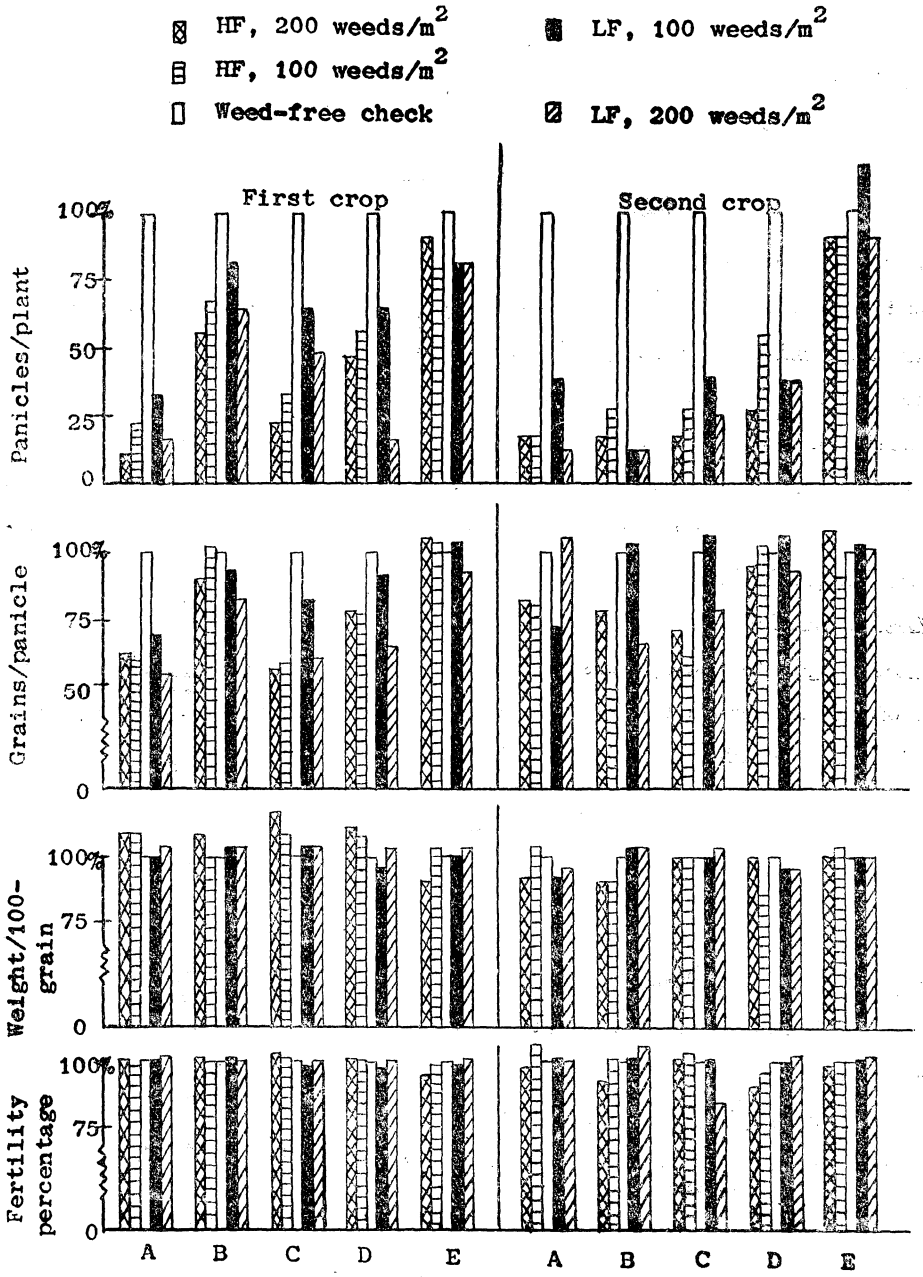


Figure 1. Average performance of yield components in the percentage of weed-free check.

A: *E. crusgalli*, B: *M. vaginalis*, C: *C. difformis*, D: *M. quadrifolia* E: *S. polyrhiza*. HL: High fertility, LF: Low Fertility.

The effect of weeds on the number of grains per panicle was similar to that of the number of panicles per plant in the first crop. The response of this trait was rather irregular in the second crop simply because plants with less tillers produced more grains on each panicle. Thus, the number of grains per panicle may not be a clear indication of the real damage of weeds when the number of panicles per plant or hill has been greatly affected. There was practically no trace of weed damage on 100-grain weight and the percentage of fertility. Apparently, the wave of weed competition was too weak to hit these two characters which develop at relativey late growing stage of rice.

Summary

The effect of weeds on rice was evaluated on five species of weeds at 3 population densities and two fertility levels in the first and second crops of 1968. *Echinochloa crusgalli*, *Cyperus difformis*, *Marsilea quadrifolia*, *Monochoria vaginalis*, and *Spirodela polyrhiza* reduced grain yield of rice by 84.9, 71.7, 62.0, 61.7, and 9.0%, respectively, Population density of 100 and 200 weeds per m^2 reduced 51.3 and 64.4% of grain yields, respectively when compared with weed-free treatment. *Echinochloa crusgalli* and *Cyperus difformis* reduced more grain yield of rice at high fertility level while *Monochoria vaginalis* and *Marsilea quadrifolia* caused more damage at less fertilized field. *Echinochloa crusgalli* and *Marsilea quadrifolia* reduced grain yield of rice more or less similarly in both crops but *Monochoria vaginalis* and *Cyperus difformis* caused heavier damage in the second crop. The number of panicles per plant suffered the greatest damage, followed by the number of grains per panicle but the 100-grain weight and the fertility percentage were only slightly affected.

Literature Cited

1. Black, C. C., T. M. Chen, and R. H. Brown. 1969. Biochemical basis for plant competition. Weed Sci. 18(3) : 338-344.
2. Chang, W. L. 1969. Performance of granular herbicides for transplanted rice. Jour. Taiwan Agr. Res. 18(4) : 11-18.
3. Shaw, W. C. and L. L. Danielson. 1961. The control of weeds in seed crops. *The Yearbook of Agriculture* 1961 : 287-289.
4. The International Rice Research Institute. 1968. Annual Report, 1967. 308 pp.

水田雜草對水稻之影響

I. 雜草種類與雜草密度

張　萬　來

摘　要

嘉義農業試驗分所曾於民國57年第1、2期作在網室內舉行盆栽試驗，調查不同密度之主要水田雜草在不同肥力下對水稻爲害之程度，初步結果顯示稗草、三角草、田字草、鴨舌草及浮萍分別減產84.9、71.7、62.0、61.7 與9.0%。雜草密度每平方公尺100支與200支者較無草之對照處理分別減產51.3及64.4%，稗草與三角草在重肥區爲害情形勝於輕肥區，惟鴨舌草與田字草則恰恰相反。稗草與田子草之爲害情形，第1期作與第2期作相若，但鴨舌草與三角草之爲害情形則以第2期作較爲嚴重。產量構成因素中以每株穗數爲害最重，每穗粒數次之，而百粒重與稔實率則未見其害。