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Studies on competitive ability of rice and barnyardgrass II. Effect of barnyardgrass density on growth and yield of rice

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Abstract. Experiments were conducted in the experimental farm of Taiwan Agricultural Research Institute to study growth and yield response of rice (*Oryza sativa* L. cv. Tainung No.67) to barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] density. Barnyardgrass was planted interlined to rice 1.5 to 13.0 plants per meter of row in the second crop of 1993 and 0.5 to 11.0 plants per meter of row in the first crop of 1994. It was shown that growth characters of rice measured at 50% of heading were affected by barnyardgrass density in the first crop but not in the second crop. Tiller and leaf numbers and leaf area were decreased in rice grown in more than 3 plants per meter row of barnyardgrass. Season-long interference of barnyardgrass at the maximum density reduced rice yield by 50 and 64% for the second and the first crops, respectively. Among yield components, the percent filled grain was decreased significantly in both crops, dropping from 66.91 to 53.87% in the second crop and from 82.85 to 73.06% in the first crop at 7 plants per meter of row of barnyardgrass. For the first crop of 1994, tiller number, grain number per plant and 1000-grain weight were also decreased at this density.

Key words: Rice, Barnyardgrass, Competition, Interference, Growth, Yield.

水稻與稗草競爭關係之探討（二）稗草密度對水稻生育之影響

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摘要：本文研究旨在探討水田中稗草族群密度對水稻生長及產量之影響，

田間試驗係於臺灣省農業試驗所農場進行，包括1993年二期作及1994年一期作。稗草植株植於水稻行間，密度分別為每公尺1.5~13.0株（二期作）及0.5~11.0株（一期作）。依水稻50%抽穗期取樣結果，稗草族群密度高低不顯著影響二期作水稻所調查的生長性狀，但可明顯改變一期作水稻的生長表現；當稗草密度達每公尺3株以上時，水稻之分蘗數、葉片數、及葉面積均減少，致使稻株地上部植株生質量降低。收穫時發現，稗草每公尺7株全期干擾時，二期作顯著減產35%，一期作則減產48%；在最大稗草密度競爭狀況，一、二期作分別減產64及50%。產量構成要素中以稔實率受稗草密度影響最大，在高稗草密度（7株／公尺）分別由66.91%降至53.87%（二期作）及82.85%降至73.06%（一期作）。另一期作之分蘗數、每株充實粒數及千粒重也在此高密度下顯著減少。

關鍵語：水稻、稗草、競爭關係、干擾、生長、產量。

INTRODUCTION

Barnyardgrass, an annual C_4 grass and a cosmopolitan weed species with a range from 50° N to 40° S latitude (Maun and Barrett 1986), is a common weed found in row crops as well as forage crops. The barnyardgrass complex is widely distributed by the production of large numbers of small, easily dispersed seeds (Maun and Barrett 1986) and its profound adaptability (Barrett and Wilson 1981, 1983, Rumpho et al. 1984, Yang 1992) and contains numerous intraspecific taxa (Barrett and Wilson 1983). Due to its unique ability to germinate and survive for long periods of time in anaerobic condition (Kennedy et al. 1980), it is also a major weed problem in flooded paddy field throughout the world.

In a 4-year study, Smith (1968) showed that competition from barnyardgrass for 51 days or more reduced rice yield every year and season-long competition reduced yield 79%. A later report further indicated that rice yield losses for season-long barnyardgrass competition of 38 to 64% depending on rice cultivars (Smith 1974). Weed competition studies in other crops revealed that barnyardgrass is capable of reducing yields of mung beans (Baylan 1985), alfalfa (Vengris 1966), tomato (Bhowmik and Reddy 1988) and sweet potato (Dawson 1965). However, there is no report in the literature of potential rice yield reduction by various densities of barnyardgrass. Such information is required by growers to plan their rotations and weed management strategies.

The present study was to investigate growth and yield response of rice plants to various densities of barnyardgrass, and to determine the relative difference between the first and the second cropping seasons.

MATERIALS AND METHODS

Competition experiments between rice and barnyardgrass grown together were studied on a loam soil with fair drainge at the experimental farm of Taiwan Agricultural Research Institute (TARI), Taichung Hsien, Taiwan. Seeds of barnyardgrass were collected and mixed in the first half of the year 1993. They were seeded with rice simutaneously and were planted to field between rice rows three days after rice transplanting and replanted a week later. The density of barnyardgrass was from 1.5 to 13 plants m row^{-1} in the second crop of 1993 and from 0.5 to 11 plants m row^{-1} in the first crop of 1994. Continuous hand cultivation kept the experimental plots free from naturally occurring weed infestations.

Rice was grown in rows 0.3 m apart with a plant distance of 0.15 m on August 6, 1993 and February 21, 1994. The pure stands of rice served as checks in evaluating rice response to the competition by barnyardgrass. Recommended fertilizer and pest control practices were followed.

Rice plants were sampled at 50% of heading to measure growth characters and were sampled again at harvest to determine yield components in both crops. An area of 10 m^2 plants were hand-harvested at maturity and dry weight of grain was used as a measure of yield.

Individual plots were 2m by 7 m and were arranged in a randomized complete block design with three replicates. Analysis of variance and the LSD test at the 5% level were applied for statistics. Linear correlation was also calculated to assess the relationship between barnyardgrass density and rice yield.

RESULTS AND DISCUSSION

As indicated in Tables 1 and 2, growth of rice plants was suppressed but not killed due to the competition by barnyardgrass. Tiller and leaf numbers and leaf area of rice measured at 50% of heading were reduced by barnyardgrass densities in the first crop yet the aboveground plant biomass was decreased in both cropping seasons. As shown in the literature (Nelson and Nylund 1962, Pavlychenko and Harrington 1934), plant that is able to establish itself first is usually a better competitor than the other. Early establishment of barnyardgrass may be advantageous in its competition with rice on natural resources such as soil fertility and climatic variables, and hence restricts the growth of rice.

Season-long interference of barnyardgrass reduced rice yield at densities more than 3 plants per meter of row in the second crop and 1 plant per meter of row in the first crop compared to weed- free plots (Table 3). For the second crop, reduction in yield ranged from 6% at 1.5 plants per meter of row to 50% at 13 plants per meter of row. For the first crop, yield was further reduced to 36% at density of 11 barnyardgrass plants per meter of row. Apparently, rice grown in both cropping seasons were all competed by barnyardgrass density (Fig. 1) and barnyardgrass was more competitive to rice in the first crop than in the second crop. In the similar study, Smith (1968)

Table 1. Changes of growth characters of rice 'Tainung No.67' to barnyardgrass densities measured at 50% of heading.

Barnyardgrass density	Plant height	Tiller number	Leaf number	Leaf area
pl (m row)$^{-1}$	cm	no. pl^{-1}	no. pl^{-1}	cm^2 pl^{-1}
2nd crop, 1993				
weed-free	86.0	17.0	91.3	1757
1.5	81.5	16.2	89.8	1755
2.0	80.8	16.8	80.0	1481
2.5	86.5	15.6	95.6	1529
3.0	85.3	18.0	96.1	1576
3.5	88.5	15.3	71.2	1376
4.0	81.7	15.3	68.4	1654
7.0	86.1	15.5	84.5	1652
13.0	80.0	17.2	77.9	1391
LSD(0.05)	9.2	4.5	17.0	396
1st crop, 1994				
weed-free	106.7	15.2	75.7	2446
0.5	108.8	13.6	59.5	1878
1.0	110.5	13.5	68.0	2042
2.0	117.2	12.5	72.2	2506
3.0	103.5	10.7	45.5	1288
5.0	104.7	9.7	51.7	1156
7.0	111.8	11.2	54.2	1623
8.0	108.0	10.5	49.2	1350
11.0	108.2	9.5	47.3	1395
LSD(0.05)	5.6	2.8	16.4	422

Table 2. Changes of the aboveground plant biomass of rice 'Tainung No.67' to barnyardgrass densities measured at 50% of heading.

Barnyardgrass density	Plant biomass	Barnyardgrass density	Plant biomass
pl (m row)$^{-1}$	g pl^{-1}	pl (m row)$^{-1}$	g pl^{-1}
2nd crop, 1993		1st crop, 1994	
weed-free	33.8	weed-free	46.3
1.5	31.4	0.5	37.2
2.0	30.5	1.0	39.5
2.5	30.5	2.0	37.5
3.0	31.0	3.0	28.6
3.5	26.4	5.0	27.9
4.0	26.2	7.0	28.8
7.0	27.5	8.0	25.4
13.0	25.7	11.0	26.6
LSD(0.05)	5.1	LSD(0.05)	7.5

Table 3. Grain yield of rice 'Tainung No.67' response to barnyardgrass densities.

Barnyardgrass density	Grain yield	Index	Barnyardgrass density	Grain yield	Index
pl (m row)$^{-1}$	g pl^{-1}	%	pl (m row)$^{-1}$	g pl^{-1}	%
2nd crop, 1993			1st crop, 1994		
weed-free	5.92	100	weed-free	7.51	100
1.5	5.55	94	0.5	6.13	95
2.0	5.49	93	1.0	5.50	73
2.5	5.50	93	2.0	5.49	73
3.0	4.91	83	3.0	4.05	54
3.5	4.74	80	5.0	4.12	55
4.0	4.97	84	7.0	3.92	52
7.0	3.82	65	8.0	3.79	50
13.0	2.95	50	11.0	2.70	36
LSD(0.05)	1.17		LSD(0.05)	1.39	

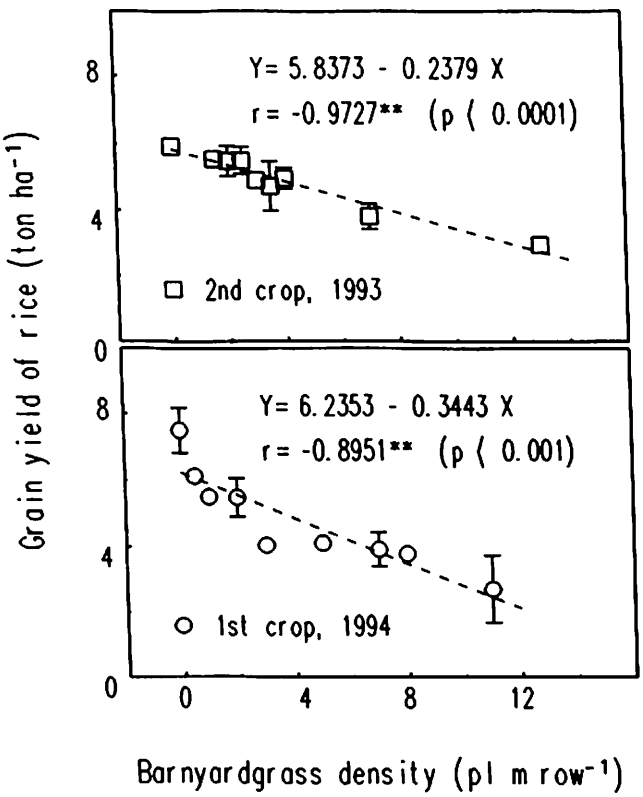


Fig. 1. Correlations between barnyardgrass density and rice yield in the second crop of 1993 and the first crop of 1994.

pointed out that rice yield was reduced by 25% in the density of 1 barnyardgrass plant per 930 cm^2.

By analyzing the yield components, percent filled grain, grain number per plant and 1000-grain weight were significantly reduced in both cropping seasons and additional reduction in tiller number was found in the first crop (Table 4). In other words, less panicle were produced by rice plants under the influence of barnyardgrass in the first crop, while percentage of effective tillers was no difference by weed densities.

The results of both crops conclusively indicate that it is very important to control barnyardgrass density for the better growth and yield of rice. It is worth while to apply weed management practices before the establishment of barnyardgrass stands.

Table 4. Changes of yield components of rice 'Tainung No.67' to barnyardgrass densities measured at harvest.

Barnyardgrass density	Tiller number	Effective tillers	Grains per plant	% filled grain	1000-grain weight
pl (m row)$^{-1}$	no. pl^{-1}	%	no. pl^{-1}	%	g
2nd crop, 1993					
weed-free	14.2	94.1	1041	66.9	25.6
1.5	13.5	93.8	969	65.3	25.8
2.0	14.1	96.6	956	65.4	25.8
2.5	13.5	93.3	970	66.3	25.6
3.0	14.2	93.9	858	64.3	25.8
3.5	13.8	91.8	837	60.4	25.5
4.0	12.8	93.1	901	63.6	24.8
7.0	12.5	95.1	678	53.9	25.3
13.0	13.2	94.3	543	43.8	24.4
LSD(0.05)	2.9	7.9	208	8.8	0.5
1st crop, 1994					
weed-free	14.5	96.5	1348	82.9	25.1
0.5	12.0	100.0	1019	79.3	24.9
1.0	12.3	100.1	1010	77.2	24.5
2.0	12.0	100.0	985	77.7	25.1
3.0	9.0	95.6	744	72.6	24.5
5.0	9.3	92.8	760	72.5	24.4
7.0	9.5	99.9	780	73.1	22.6
8.0	7.8	98.4	758	71.4	22.5
11.0	8.2	100.0	537	63.8	22.6
LSD(0.05)	2.0	5.9	268	6.3	0.2

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