Differential Competitiveness of *Echinochloa colona* Ecotypes

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ECHINOCHLOA COLONA 生態型의 競合力 差異

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ABSTRACT

The ability of three *Echinochloa colona*(L.) Link ecotypes to compete with rice(*Oryza sativa* L.) was evaluated. For all the ecotypes, *E. colona* was shorter and produced less leaf area and dry matter than rice at 15 days after seeding (DAS), whereas the reverse was observed from 30 to 60 DAS. Neither E. colona nor rice tillered druing the first 15 DAS, but *E. colona* had greater accumulative tiller length than rice from 15 DAS. Rice absorbed more nitrogen than *E. colona* at 15 DAS. *E. colona* absorbed greater amounts of nitrogen, phosphorus, and potassium than did rice between 30 and 60 DAS and increase in its density decreased the nutrients uptake of rice. Differences in the competitive ability of the ecotypes were related to the growth characteristics of the ecotypes and the period of competition between the two species. At the early growth stages the Pangasinan ecotype, which increased plant size rapidly and had a shorter life cycle, was more competitive against rice than the Leyte and South Cotabato ecotypes, which had a longer vegetative growth period. However, the reverse was observed at the later growth stages ot the ecotypes.

INTRODUCTION

Competition between crops and weeds varies with the species involved(7, 10). Crop cultivars also differ in their ability to compete with weeds (3, 5, 15). However, there has been little research on the differential competitiveness of weed ecotypes.

Ramakrishnan and Gupta (12) studied the effect of *Cynodon dactylon*(L.) Pers. ecotypes on crop competition. The growth of wheat (*Triticum aestivum* L.) was more adversly affected by an ecotype collected from a noncalcareous soil than by the others from highly calcareous soils. Solbrig and Simpson (14) demonstrated that individuals of one ecotype of *Taraxacum officinale* Weber always out-competed those of another ecotype. The competitive advantage was due to the greater vegetative growth of the more competitive ecotype than that of the less competitive ecotype, which flowered earlier and produced more seeds.

Chun and Moody (2) described ecotypic differences in growth and phenological characteristics of *E. colona* in the Philippines. The time required to panicle emergence varied by 18 days among the ecotyoes studied. Moody (9) stated that if weeds matured rapidly, they would compete with shorter duration rice culticars for a proportionately longer

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time than with longer duration culticars. Thus, the longer growth duration cultivar has a longer period and hence, possibly, a greater ability to compensate for competition from weeds. Growth duration appears to be an important factor affecting the competitive ability of a plant species.

This experiment was conducted to determine the differntial competitiveness of ecotypes of *E. colona* against rice.

MATERIALS AND METHODS

The experiment was conducted in the Agronomy greenhouse at the International Rice Research Institute (IRRI), Los Banos, Philippines. Competition between rice (cv. C171-136) and three *E. colona* ecotypes from Pangasinan, Leyte, and South Cotabato, which were selected on the basis of their life cycles and their growth patterns (2), was studied in a replacement series (4). Excess seeds of *E. colona* and rice were sown 0 and 2 cm deep, respectively, in a sandy clay loam soil (pH 6.3, organic matter 0.46%, total N 0.07%, and CEC 26 meq/100g) placed in a 25 cm diameter plastic pot. Nitrogen as urea was applied at 50 kg/ha 0 and 15 DAS and the soil was kept saturated during the experiment by frequent watering. The density combinations of *E. colona* versus rice used in the replacement series model were 0 : 6, 2 : 4, 4 : 2, and 6 : 0. The seedlings were thinned to the desired level 3 days after emergence. There were 16 replications.

At 15-day intervals, four replications were selected at random and harvested to determine plant height, accumulative tiller length (obtained by summing the lengths of all the tillers), leaf area, and dry weight (dried at 80℃ for 3 days) of the two competing species. The dry matter was analyzed for nitrogen, phosphorus, and potassium using the methods described by Varley (16).

The competitive interference of the individual species was determined using the relative crowding coefficient (4). The coefficient (k) was obtained using the equation

$$k_{wr}=\{(Y_wZ_w^{-1})\ (Y_rZ_r^{-1})^{-1}\}(M_wM_r^{-1})^{-1},$$

where Y_w and Y_r are the dry weights of *E. colona* and rice, respectively, in the mixture ; M_w and M_r are the dry weights of *E. colona* and rice, respectively, in monoculture ; Z_w and Z_r are the densities of *E. colona* and rice, respectively, in the mixture ; and k_{wr} is the relative crowding coefficient of *E. colona* with respect to rice.

RESULTS AND DISCUSSION

Rice height was not significantly affected by competition with the three *E. colona* ecotypes for the first 30 DAS (Table 1). Height was significantly reduced starting 45 DAS. Plants of the Pangasinan ecotype of *E. colona* were significantly taller than those of the Leyte and South Cotabato ecotypes at 15 DAS. The difference resulted from the different growth rates of the ecotypes, not from the differential responses to rice competition Plants of leyte and South Cotabato ecotypes grew faster than those of the Pangasinan ecotype from 15 DAS. Differences in height among the *E. colona* ecotypes at 30 and 45 DAS were not significant. At 60 DAS, plants of the Pangasinan ecotype were the shortest.

The height of rice and *E. colona* increased continuously throughout the competition period. For all the ecotypes, however, *E. colona* was shorter than rice at 15 DAS but taller from 30 to 60 DAS. *E. colona* height increases rapidly between 15 and 30 DAS. Similar trends were also observed with *Echinochloa crus-galli* (L.) Beauv. and rice (10, 13).

Rice leaf area decreased significantly at 45 DAS because of the competition with the ecotypes (Table 2). The competition with rice caused the leaf area of the South Cotabato ecotype to increase starting at 45 DAS. It was significantly greater when two plants, rather than four, were competing with rice because of intraspecific competition among the *E. colona* plants. Intraspecific competition was not observed, however, with the Pangasinan and Leyte ecotypes, indicating that the ecotypes had different competitive abilities against rice.

The maximum leaf area for *E. colona* was reached at 45 DAS. Thereafter, the leaf area of the three ecotypes decreased significantly as a result of

Table 1. Plant height of rice and *Echinochloa colona* ecotypes as affected by interspecific competition.*

Ecotype and density combination (rice vs. *E. colona*)	Plant height (cm)							
	Rice				*Echinochloa colona*			
	15DAS	30DAS	45DAS	60DAS	15DAS	30DAS	45DAS	60DAS
Pangasinan								
6 : 0	31.4a	64.9a	93.5abc	105.6ab	–	–	–	–
4 : 2	32.5a	68.9a	89.6bcd	105.7ab	26.4ab	84.9b	104.abc	116.8abc
2 : 4	33.0a	63.2a	84.3d	99.0b	28.5a	83.9b	94.3c	104.6bc
0 : 6	–	–	–	–	25.4abc	83.2b	102.4bc	103.4c
Leyte								
6 : 0	31.5a	63.0a	97.9a	112.0a	–	–	–	–
4 : 2	32.8a	62.5a	96.4ab	106.1ab	20.0d	85.9ab	109.5ab	135.9a
2 : 4	32.0a	62.6a	87.9cd	101.5ab	19.3d	83.4b	110.1ab	127.9a
0 : 6	–	–	–	–	19.3d	87.4a	106.4abc	130.2a
South Cotabato								
6 : 0	31.8a	61.4a	97.8a	106.2ab	–	–	–	–
4 : 2	31.7a	64.2a	91.6abcd	98.7b	21.4cd	86.4a-	117.6a-	125.0ab-
2 : 4	31.1a	65.6a	88.3cd	104.3ab	23.7bcd	87.4ab	114.0ab-	131.3a
0 : 6	–	–	–	–	21.7cd	86.1ab	112.4ab-	117.7abc

*In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
DAS=days after seeding.

Table 2. Leaf area of rice and *Echinochloa colona* ecotypes as affected by interspecific competition.*

Ecotype and density combination (rice vs. *E. colona*)	Leaf area (cm^2/plant)							
	Rice				*Echinochloa colona*			
	15DAS	30DAS	45DAS	60DAS	15DAS	30DAS	45DAS	60DAS
Pangasinan								
6 : 0	15.1a	128.3a	464.1a	435.6a	–	–	–	–
4 : 2	16.0a	132.7a	320.2bc	344.9ab	11.8a	315.1a	601.5bc	299.0cd
2 : 4	16.5a	132.3a	282.6c	252.7b	11.2ab	337.8a	480.4c	269.1d
0 : 6	–	–	–	–	9.7abc	309.7a	514.1c	254.9d
Leyte								
6 : 0	15.6a	119.9a	411.3ab	435.1a	–	–	–	–
4 : 2	16.5a	126.7a	399.9ab	370.1ab	7.1cd	324.8a	736.2b	637.8ab
2 : 4	14.6a	130.4a	319.0bc	301.0ab	5.3d	278.6a	792.7ab	588.6ab
0 : 6	–	–	–	–	5.7d	263.4a	601.1bc	452.6bcd
South Cotabato								
6 : 0	15.4a	132.7a	421.9ab	390.3ab	–	–	–	–
4 : 2	16.3a	122.4a	327.7bc	273.1b	7.9bcd	309.3a	978.5a	802.4a
2 : 4	16.6a	137.4a	275.3c	261.6b	6.7cd	333.6a	764.3b	552.6abc
0 : 6	–	–	–	–	5.5d	286.1a	656.8bc	463.6bcd

*In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
DAS=days after seeding.

senescence. The leaf area of rice did not change significantly from 45 to 60 DAS.

The accumulative tiller length of *E. colona* and rice demonstrated the differntial competitiveness of the ecotypes (Table 3). Accumulative tiller length of rice decreased because of competition. The Pangasinan ecotype, which grew faster caused a significant decrease in the accumulative tiller length of rice as early as 30 DAS. This effect occurred only after 45 DAS with the South Cotabato ecotype and after 60 DAS with the Leyte ecotype. As the density of *E. colona* increased, the accumulative tiller length of rice decreased. In contrast to that of rice, the accumulative tiller length of *E. colona* increased as a result of competition. The increase was greatest at 45 DAS for the Pangasinan ecotype and at 60 DAS for the other ecotypes. Accumulative tiller lengths were greater when two *E. colona* plants, rather than four, competed with rice. The reverse was observed with rice. This means that there was intraspecific competition between *E. colona* plants.

At 15 DAS, the dry weight of rice plants was greater than that of *E. colona* plants whereas at 30 DAS, the situation was reversed, indicating the extremely rapid growth of the weed between 15 and 30 DAS compared with that of rice (Table 4). For the first 15 DAS, the Pangasinan ecotype had the highest dry weight. At 60 DAS, however, the South Cotabato ecotype had the greatest weight. As a result, the dry matter production of rice was more affected between 45 and 60 DAS by competition from the South Cotabato ecotype than from the other ecotypes.

At each harvest, differences in dry matter production of rice and *E. colona* ecotypes at the different density combinations studied showed similar trends to those observed for plant height, leaf area, and accumulative tiller length. This indicates that the plastic response of the plants to competition is expressed by the interrelated growth of different parts of the plant.

Rice and *E. colona* competed strongly for nitrogen from 15 to 60 DAS(Fig. 1). Nitrogen uptake was greater in rice than in *E. colona* up to 15 DAS, but it rapidly increased in *E. colona* from 15 to 30 DAS. The result was a greater nitrogen content in *E. colona* than in rice at 30 DAS. Thereafter, the relationship did not change. Except for the amount of phosphorus absorbed by the Pangasinan ecotype at 60 DAS, the amounts of phosphorus and potassium taken up by *E. colona* were greater than those taken up by rice between 30 and 60 DAS (Figs. 2 and 3). Alkamper (1) reported that *E. colona* absorbed two or three times more nitrogen than rice at the highest fertilizer level used. Similar relationships were also observed for phosphorus and potassium uptakes.

The different amounts of nitrogen taken up by the ecotypes at 15 DAS were due to the different growth rates. The Pangasinan ecotype absorbed significantly more nitrogen than the Leyte and South Cotabato ecotypes. However, there was no significant difference in nutrient uptake between the ecotypes at 30 DAS because of the rapid increase in nutrient uptake by the Leyte and South Cotabato ecotypes between 15 and 30 DAS. The differential competitiveness of the *E. colona* ecotypes for nutrients was apparent from 45 DAS. Between 45 and 60 DAS, nutrient uptake was greatest in the South Cotabato ecotype and least in the Pangasinan ecotype.

Density had no significant effect on nutrient uptake for both rice and *E. colona* up to 30 DAS. From 30 to 60 DAS, nutrient uptake by rice decreased with increasing density of *E. colona* because of interspecific competition for nutrients between the two species. Alkamper (1) also observed a similar effect of density of nutrient uptake of *E. colona* when competing with rice. When two *E. colona* plants competed for nutrients with four rice plants, *E. colona* benefitted at the expense of rice. However, when four *E. colona* plants competed against rice, nutrient uptake of *E. colona* declined because of intraspecific competition between the *E. colona* plants.

From 45 to 60 DAS, the amounts of nitrogen, phosphorus, and potassium taken up by the *E. colona* ecotypes decreased. In contrast to *E. colona*, the nutrient uptake of rice did not change during this

Table 3. Accumulative tiller length of rice and *Echinochloa colona* ecotypes as affected by interspecific competition.*

Ecotype and density combination (rice vs. *E. colona*)	Accumulative tiller length (cm/plant)					
	Rice			*Echinochloa colona*		
	30DAS	45DAS	60DAS	30DAS	45DAS	60DAS
Pangasinan						
6 : 0	68.1b	150.0a-	137.6ab-	–	–	–
4 : 2	59.3bc	121.9ab-	110.9abc	156.9abc	529.0a-	651.4b
2 : 4	42.6c	79.8d	84.2c	165.9ab-	403.6abc	582.1b
0 : 6	–	–	–	166.8ab-	352.8bc-	513.7b
Leyte						
6 : 0	72.0ab	129.1abc	146.6a-	–	–	–
4 : 2	70.9ab	135.2ab-	130.8ab-	131.3c	435.3ab	728.4ab
2 : 4	80.1a	125.8ab-	104.3bc-	139.2bc-	408.2abc	323.3b
0 : 6	–	–	–	153.9abc	322.1c	510.7b
South Cotabato						
6 : 0	81.4a	122.8ab-	147.0a	–	–	–
4 : 2	72.1ab	102.1bcd	123.2ab	161.0abc	503.8ab-	920.7a
2 : 4	78.6ab	90.1cd-	111.5abc	178.6a-	375.0abc	630.0b
0 : 6	–	–	–	150.0abc	259.5c	512.4b

*In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
DAS=days after seeding.

Table 4. Dry weight of rice and *Echinochloa colona* ecotypes as affected by interspecific competition.*

Ecotype and density combination (rice vs. *E. colona*)	Dry weight (g/plant)							
	Rice				*Echinochloa colona*			
	15DAS**	30DAS	45DAS	60DAS	15DAS**	30DAS	45DAS	60DAS
Pangasinan								
6 : 0	65a	0.7a	2.9a	4.8a	–	–	–	–
4 : 2	74a	0.7a	2.9a	4.7ab	30a	1.9a	6.6bcd	7.7bc
2 : 4	66a	0.6a	2.1b	3.2d	33a	2.3a	5.4cd	5.6c
0 : 6	–	–	–	–	31a	2.0a	5.5bcd	4.7c
Leyte								
6 : 0	65a	0.7a	2.9a	4.5ab	–	–	–	–
4 : 2	75a	0.7a	2.8a	4.6ab	18c	1.6a	7.5ab	10.1b
2 : 4	67a	0.7a	2.4ab	3.4d	15c	1.4a	6.8abcd	8.7b
0 : 6	–	–	–	–	20bc	1.5a	5.1d	6.7c
South Cotabato								
6 : 0	70a	0.8a	2.8a	4.4b	–	–	–	–
4 : 2	75a	0.8a	2.4ab	3.4d	23b	2.0a	8.7a	14.5a
2 : 4	72a	0.7a	2.0b	3.8c	23b	2.2a	7.1abc	10.3b
0 : 6	–	–	–	–	24b	1.8a	5.7bcd	8.1b

*In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
DAS=days after seeding.
**Dry weights are in mg.

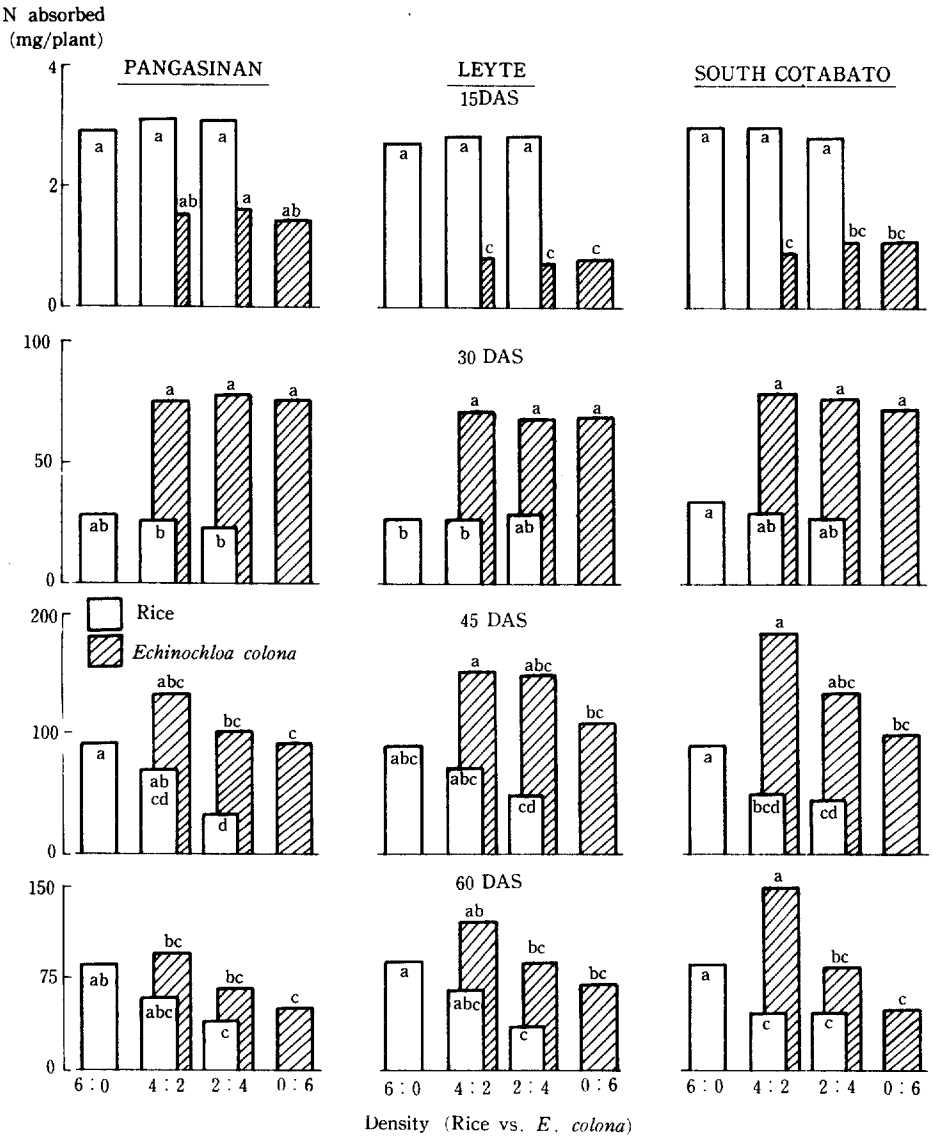

Fig. 1. Nitrogen uptake of rice and *Echinochloa colona* ecotypes as affected by interspecific competition (For each species at different growth stages, means followed by a common letter are not significantly different at the 5% level by DMRT. DAS=days after seeding).

period. Similar observations for nitrogen uptake between rice and *E. curu-galli* were made by Pons and Utomo (11)

The nutrient contents of plants vary with growth stage. At early growth stages they increase because nutrient uptake rate is higher than growth rate. As the plant increases in dry matter with decreasing nutrient uptake rate, a dramatic reduction in nutrient content occurs by dilution (8). Since the total nutrient uptake is determined by the percentage of nutrients in the dry matter and the dry matter produceed, decreases in nutrient contents of *E. colona* are attributed to the dilution effect. The uptake rate of individual nutrients is also dependent on the plant's growth stage. For rice, Yoshida (17) reported that the nitrogen and phosphorus contents

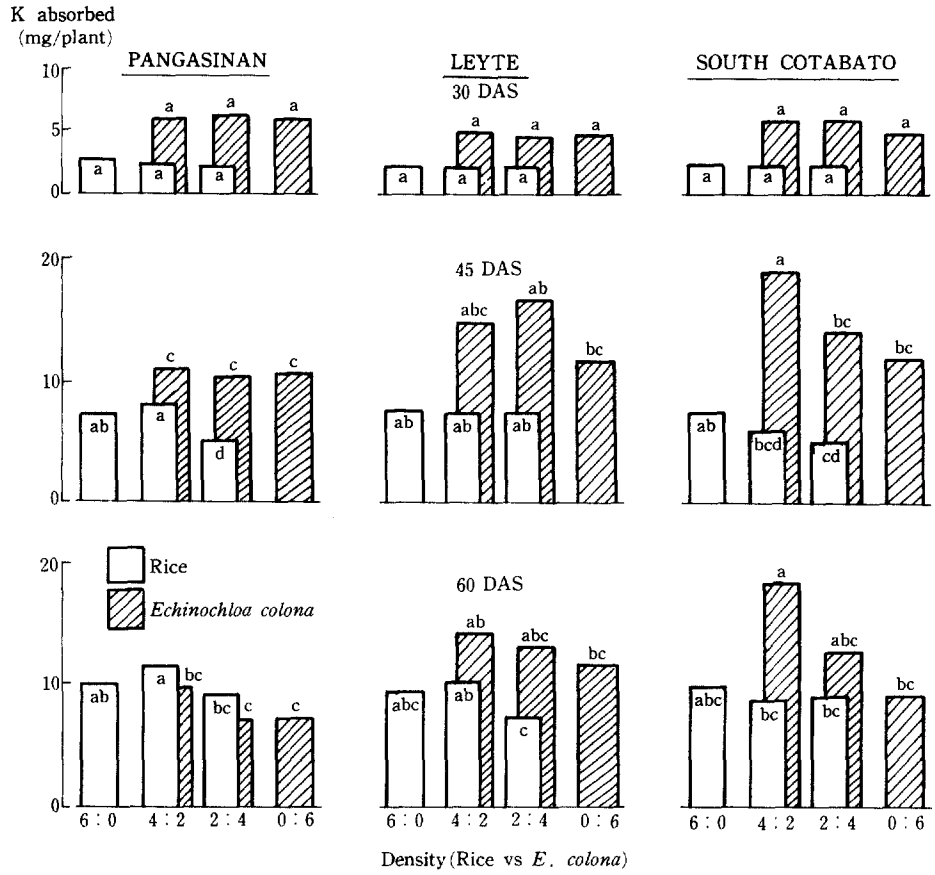

Fig. 2. Phosphorus uptake of rice and *Echinochloa colona* ecotypes as affected by interspecific competition (For each species at different growth stages, means followed by a common letter are not significantly different at the 5% level by DMRT. DAS=days after seeding).

(in terms of percentage) are generally high at the early stages and decline toward maturity, whereas the content of potassium is relatively stable until heading. In contrast to *E. colona*, which produced panicles within 45 DAS, rice remained vegetative throughout the experimental period. These facts explain why decreases in nutrient contents occurred in *E. colona* but not in rice during the experimental period.

The relative crowding coefficient (4) represents the competitive interference between two competing species. The k_{wr} of *E. colona* ecotypes tended to increase as the period of competition increased (Table 5). This was the result of increase in the competitive ability of *E. colona* relative to rice. However, the competitiveness of each ecotype against rice varied depending on the growth stage. At 15 DAS the k_{wr} of the Pangasinan ecotype was the highest whereas at 60 DAS that of the South Cotabato ecotype was the highest.

At 60 DAS, the k_{wr} of the South Cotabato ecotype was signigicantly greater when two plants, rather than four, competed with rice. The k_{wr}'s of four plants of the Pangasinan and Leyte ecotypes were not significantly greater than those of two plants. This was due to intraspecific competition between the plants. However, the intraspecific competition was greater in the South Cotabato ecotype than in

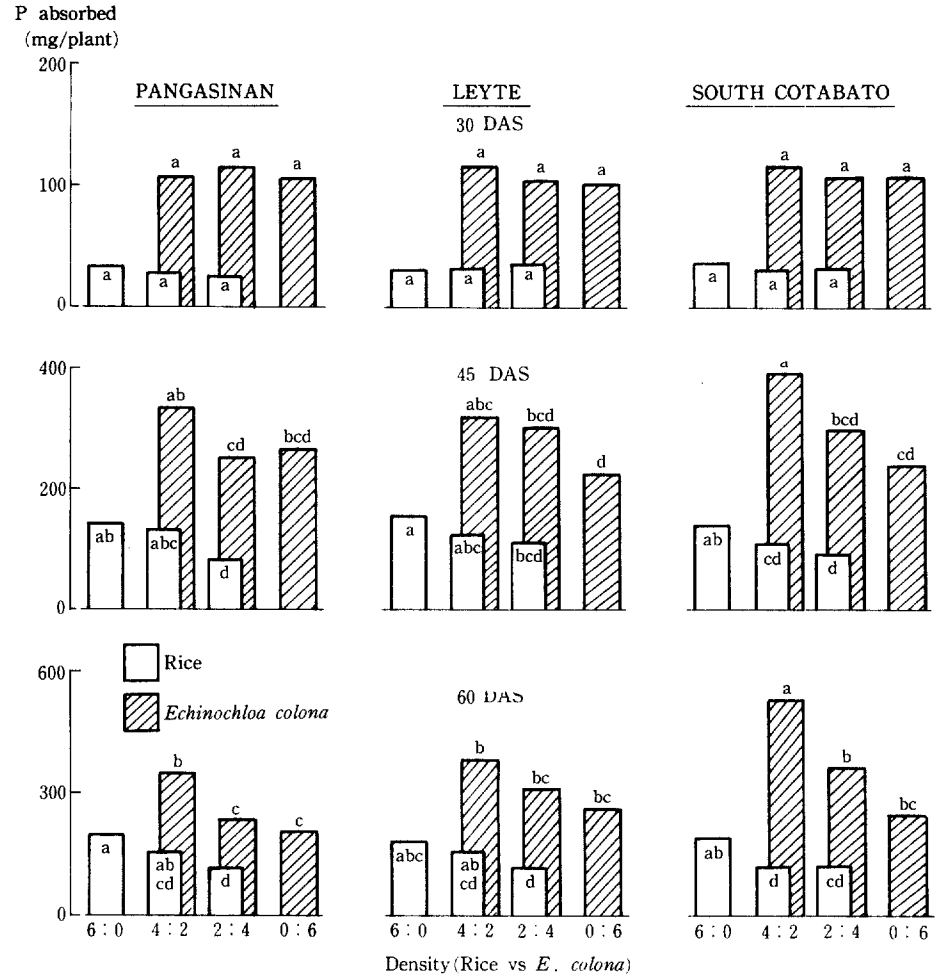

Fig. 3. Potassium uptake of rice and *Echinochloa colona* ecotypes as affected by interspecific competition (For each species at different growth stages, means followed by a common letter are not significantly different at the 5% level by DMRT. DAS=days after seeding).

the Pangasinan and Leyte ecotypes.

The differential competitiveness of *E. colona* ecotypes against rice was associated with their growth characteristics and varied with the relative period of competition between the two competing species. At the early growth stages, the Pangasinan ecotype which was more competitive, was taller, produced greater leaf area and dry matter, and had a greater nutrient uptake than the Leyte and South Cotabato ecotypes. By 45 DAS, however, the Leyte and South Cotabato ecotypes were more competitive with rice than the Pangasinan ecotype. Increase in the competitive ability of the Leyte and South Cotabato ecotypes was attributed to the continuous increase in vegetative growth. At 60 DAS the South Cotabato ecotype was the most competitive against rice.

Chun and Moody (2) reported that the growth duration of the Pangasinan, Leyte, and South Cotabato ecotypes, as measured by the number of days to panicle emergence, was 28, 44 and 45 days, respectively. The relative length of competition between the two species varied depending on the life cycle of the ecotypes. The Leyte and South

Table 5. Relative crowding coefficient in interspecific competition between rice and *Echinochloa colona* ecotypes.*

Ecotypic and density combination (rice vs. *E. colona*)	KWR Days after seeding 15	30	45	60
Pangasinan				
4 : 2	1.053b	1.142ab	1.232c	1.737b
2 : 4	1.279a	1.369a	1.397bc	1.786b
Leyte				
4 : 2	0.998b	0.964b	1.481abc	1.516b
2 : 4	0.995b	1.004b	1.928a	1.764b
South Cotabato				
4 : 2	0.904b	1.219ab	1.750ab	2.778a
2 : 4	0.978b	1.388a	1.807ab	1.706b

* In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. KWR=relative crowding coefficient of *E. colona* with respect to rice.

Cotabato ecotypes, with a longer life cycle, had a longer competitive period with rice than the Pangasinan ecotype with shorter life cycle. The longer the competitive period, the greater was the competitive interference (6, 9).

摘　要

*Echinochloa colona*의 生態型間 벼에 대한 競合力 差異를 調査하였다. 實驗에 使用한 세 生態型은 벼와 競合期間중 播種後 15일에는 벼에 비하여 草長, 葉面積 및 乾物重 등의 生育이 뒤떨어졌으나 播種後 30일에서 60일 사이에는 반대의 結果를 나타내었다. 播種後 처음 15일 동안에는 벼와 *E. colona* 모두 분얼되지 않하였으나, 그 이후부터는 *E. colona*의 분얼력이 벼보다 컸다. 播種後 30일에서 60일 사이에 *E. colona*는 窒素, 燐酸, 加里의 吸收는 벼보다 컸으며, *E. colona* 競合密度의 增加와 함께 벼의 養分吸收는 減少 되었다. *E. colona* 生態型의 競合力 差異는 生態型들의 生長特性과 競合期間과 關聯되어 있었다. 生育의 初期段階에는 草型이 크고 生育期間이 짧은 Pangasinan 生態型은 比較的 生育期間이 긴 Leyte와 South Cotabato 生態型보다 競合力이 컸으나, 生育이 進行된 生育後期에는 反對의 結果를 나타내었다.

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