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CHILEANJAR
CHILEAN JOURNAL of AGRICULTURAL RESEARCH

INTERFERENCE INTERACTIONS OF TWO SPECIES OF *Echinochloa* GENUS WITH RICE

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The aim of this study was to evaluate the relative competitive ability of barnyardgrass (BYG, *Echinochloa crus-galli* (L.) P. Beauv.) compared to rice barnyardgrass (ECPH, *E. oryzicola* (Vasinger) Vasinger) against rice (*Oryza sativa* L.) cv. Hashemi in a replacement series study. Experiment was arranged in randomized complete block design with three replicates using a factorial treatment arrangement. Factors were two species of *Echinochloa* genus (BYG and ECPH) and five rice:BYG or rice:ECPH mixture proportions (8:0, 6:2, 4:4, 2:6, and 0:8). Relative yield total of aboveground dry weight, root dry weight and leaf area indicated that BYG or ECPH were competing for the same resources with 'Hashemi'. In general, replacement series curves and relative crowding coefficient (RCC) values demonstrated that both BYG and ECPH were more competitive than 'Hashemi'. BYG had significantly higher aboveground dry weight, root dry weight, tiller number, leaf area, and plant height than ECPH, when grown with 'Hashemi'. This experiment confirmed that BYG was more competitive than ECPH against 'Hashemi'.

Key words: *Echinochloa crus-galli*, competitiveness, interference, *Oryza sativa*, *Echinochloa oryzicola*.

Rice (*Oryza sativa* L.) is a staple food for nearly one-half of the world's population. Weeds are one of the major constraints in rice production. One estimate at International Rice Research Institute (IRRI) suggested weed growth in weed-free plots reduced yield as much as 34% in transplanted rice (De Datta, 1991). Michael (1983) reported about 50 species of *Echinochloa* genus listed worldwide, and most are important, especially in rice fields, causing serious competition with high yield reduction. Two important species of *Echinochloa* genus in rice paddy field of Iran are barnyardgrass (*E. crus-galli* (L.) P. Beauv.) and rice barnyardgrass (*E. oryzicola* (Vasinger) Vasinger (=*Echinochloa phyllopogon* (Stapf) Stapf ex Kossenko). Barnyardgrass is hexaploid, $2n$ = 6X = 54 (Carretero, 1981). Barnyardgrass is a persistent annual grass that reproduces each year from seed stock deposited in previous summer and fall seasons (Holm *et al*., 1979). Season-long competition from *E. crus-galli* reduced rice yields by 38% to 64% depending on the rice cultivar (Smith, 1988; Stauber *et al*., 1991). *Echinochloa oryzicola* is tetraploid, $2n$ = 4X = 34 (Carretero, 1981), and almost exclusively grows as rice weeds. Yabuno (1966) reported that *E. oryzicola* is the most dominant and persistent weed in flooded rice of Japan. Yaghoubi *et al*. (2006) reported that 40 BYG and ECPH plants m^{-2} reduced rice grain yield as much as 60 and 65%, respectively.

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Received: 14 October 2011.
Accepted: 26 June 2012.

Crops and weeds compete for the same resources, nutrients, water, space, and light. Competition begins when crops and weeds grow in close proximity and the supply of any necessary growth factor falls below the demand of both. The overall effect of crop-weed competition is a reduction in the biomass of rice and a reduction in grain yield. Plant density and proportion of one species to another are key factors in plant competition (Harper, 1977). Harper (1977) intensively used the replacement series model to measure the aggressiveness of a species. Radosevich (1987) suggested that replacement method is most valuable for assessing the competitive effects of two species at a single total density and determining the relative effects of interferences within and between species.

It has been reported that the dominant species of *Echinochloa* genus in rice paddy field of Iran is changing from *E. crus-galli* to *E. oryzicola* (Yaghoubi *et al*., 2006) that has either mimicry or photoperiodic sensitivity synchronizing to that of rice (Yamasue, 2001). A lack of data exists concerning the competitive ability of ECPH compared to BYG against rice cultivars. Therefore, the aim of this study was to evaluate the relative competitiveness of ECPH compared to BYG against a native rice cv. Hashemi, which is intensively cultivated in north of Iran, in a replacement series study.

MATERIALS AND METHODS

Competition indices

The four models for interference, proposed by Harper

(1977) and adapted by Fleming *et al*. (1988), were used to evaluate the competitiveness of either BYG or ECPH against rice 'Hashemi'. These models described the possible outcomes of the interaction of two species when grown in a replacement series (Radosevich, 1987; Oberg *et al*., 1996). Replacement series diagrams were constructed for the response of aboveground dry weight, root dry weight, leaf area and tiller number to species proportion. The following indices were used in the present experiment.

The relative yield total (RYT)

Relative yield (RY) and relative yield total (RYT) for aboveground dry weight, root dry weight, leaf area and tiller number were calculated according to the following equations (Harper, 1977):

$$RY_r = (Yrb/Yrr) \text{ or } RY_b = (Ybr/Ybb) \quad [1]$$

where Yrb or (Ybr) = yield per pot of rice or (weed) when grown with weed (or rice) and Yrr or (Ybb) = yield per pot of rice (weed) in monoculture.

$$RYT = RY_r + RY_b \quad [2]$$

Harper (1977) advocated that RYT can be used to describe the mutual relationships of pairs of species that may or may not be making demands on the same resources in the environment. In two species mixtures, an RYT value close to 1.00 indicates that the two species make equal demands on the same limiting resources. RYT values greater than 1.00 indicate that species that still compete for the same resources may also make demands on different resources. RYT values less than 1.00 indicate mutual antagonism (Bi and Turvey, 1994).

The relative crowding coefficient (RCC)

Relative crowding coefficient (RCC), a measure of the relative dominance of one species over the other in a mixture, was calculated following Novak *et al*. (1993) as follows:

$$RCC = (((Wr75:25/Wb75:25) + (Wr50:50/Wb50:50) + (Wr25:75/Wb25:75))/3)/(Wr100:0/Wb100:0) \quad [3]$$

where Wr n:n is aboveground or root dry weight, leaf area and tiller number of rice at a ratio of n:n and Wbn:n is aboveground or root dry weight, leaf area and tiller number of BYG or ECPH at a ratio of n:n. The larger the RCC value, the greater the competitiveness with the other species. RCC values of approximately 1 indicate that the two species are equal competitors and values > 1 or < 1 indicate that a species is more or less competitive, respectively, than another species.

Experimental design, plant culture and management

A pot experiment was conducted at Rice Research Station in Tonekabon (36°54' N, 40°50' E; 20 m a.s.l.), north of Iran, from June to September of 2010. The experiment was conducted as a randomized complete block design with a factorial treatment arrangement and three replicates. Factors were two species of *Echinochloa* genus (*E. crus-galli* and *E. oryzicola*) and five rice:BYG or rice: ECPH ratios (8:0, 6:2, 4:4, 2:6, and 0:8). Actual plant numbers per pot for each mixture were 8:0, 6:2, 4:4, 2:6, and 0:8, respectively. Pots (35 cm average diameter by 30 cm deep) were arranged in a rectangular grid pattern with approximately 40 cm between edges of adjacent pots. Pots were filled to a depth of 25 cm with clay loam soil from the Tonekabon Rice Research station farm. Soil properties were 2.2% organic matter content, 37% clay, 44% silt, 19% sand, 6.8 pH, 29.9 cation exchange capacity (CEC) (meq 100 g). Rice seeds were sown in the nursery on 1 April 2010. According to rice:BYG or rice:ECPH ratio in each pot, three 'Hashemi' seedlings or one germinated BYG or ECPH seed were transplanted (or planted) in hills with a square arrangement, with hills equidistant from the sides of the pot and from each other, on 1 June 2010. Total fertilizer applied was 100 kg N ha^{-1}, 75 kg P ha^{-1}, and 150 kg K ha^{-1} with split application broadcast at transplanting stage (30% N and 100% PK), at panicle initiation (35% N), and 5 d before flowering (35% N). Consistent with the lowland paddy field practices in north of Iran, a permanent flood water level was maintained at 10 cm from approximately 7 d after transplanting until 20 d before harvesting stage. Moreover, during the growing season, all unwanted weeds except the planted BYG or ECPH were hand weeded.

Plant sampling

At maturity stage, plant height (from the soil surface to the top of the plant canopy) was measured. Plants were harvested by hand-cutting at soil surface and subsequently aboveground biomass of rice, BYG, and ECPH were separated, and tillers of each species were counted. Leaf area was measured with a leaf area meter (LI-3000A, LI-COR, Lincoln, Nebraska, USA). Roots of rice, BYG, and ECPH were washed gently and thoroughly to remove soil particles so that the root tissues remained intact and subsequently were separated. Rice, BYG and ECPH aboveground and belowground (root) biomass from each pot was placed in separate paper bags, dried at 72 °C for 96 h, and weighted. From the yield data, relative crowding coefficients of the species towards each other and RYT of each species combination were computed.

Statistical analyses

Data were subjected to ANOVA and means were separated using Fisher's Protected LSD at the 0.05 level. All statistical analyses were conducted by using SAS (SAS Institute, 2002). To determine whether RYT differed significantly from 1.0 or not, the following equation was used (Gealy *et al*., 2005):

$$\text{Cutoff} = 1 \pm (t^* \times \text{standard error of the mean}) \quad [4]$$

where t* = the two-sided critical value from the t-table with degree of freedom (df) equal to df associated with the term used as the error term in the F-test.

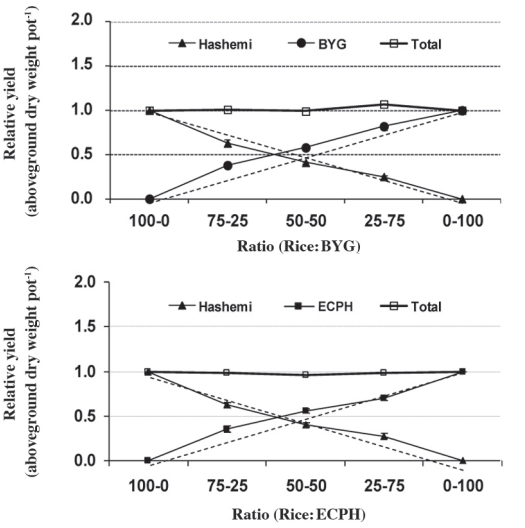
RESULTS AND DISCUSSION

Aboveground dry weight

Aboveground dry weight (g plant^{-1}) of 'Hashemi' reduced significantly when rice:BYG or rice:ECPH mixture proportion decreased. The highest aboveground dry weight for 'Hashemi' was obtained when grown alone. This indicates that 'Hashemi' grew better with intraspecific than with interspecific competition. Moreover, aboveground dry weight of 'Hashemi' when grown with BYG was usually less than that when grown with ECPH, specially in 6:2 rice:weed mixture proportion (Table 1). On the other hand, aboveground dry weight of both BYG and ECPH increased significantly when rice:weed mixture proportion decreased, but BYG, when grown at different mixture proportions, had greater aboveground dry weight than ECPH (Table 2). This result indicates that BYG or ECPH was more competitive than 'Hashemi' and gains resources at the expense of the rice cultivar. Moreover, this result suggests that BYG was a superior competitor to ECPH. Fleming *et al*. (1988) reported that the more aggressive species in a mixture increased in weight with increased proportions of the less aggressive species.

Replacement series diagrams for relative shoot dry weight illustrated the competition between 'Hashemi' and BYG or ECPH. As shown in the Figure 1, the intersection of the 'Hashemi' curve with that of either BYG or ECPH was to the left of the 50:50 mixture proportions (point of equivalency of the expected yield). This indicates that BYG or ECPH was more competitive than 'Hashemi'. The RYTs ranged from 0.96 to 1.07, but all were not significantly different from 1, on the basis of the cutoff of not > 1.10 or < 0.90. This indicates that 'Hashemi' and BYG or ECPH were competing for the same resources. This result was in agreement with some previous studies (Estorninos *et al*., 2002; Gealy *et al*., 2005).

The RCC was used to measure the competitiveness of one species upon another (Table 3). The greater RCC of BYG or ECPH over 'Hashemi' indicates and also confirms the results of RY for aboveground dry weight that both BYG and ECPH was superior competitor to 'Hashemi'. Moreover, the greater RCC of BYG over ECPH indicates the aggressiveness of BYG against ECPH in aboveground dry weights (Table 3). Fischer *et al*. (2000) reported that when competing for limited resources, the species with the greater RCC in the mixture is the stronger competitor.



The two straight dashed lines in each frame indicate the theoretically expected responses for two equally competitive species, which intersect at the point of equivalency (Harper, 1977).

Figure 1. Relative aboveground dry weights of 'Hashemi' rice (▲), barnyardgrass (BYG) (●) and rice barnyardgrass (ECPH) (■), and relative yield totals (RYT) (□) as influenced by rice:weed mixture proportions in a replacement series.

Table 1. Aboveground dry weight (ADW), root dry weight (RDW), tiller number (TN), leaf area (LA) and height (H) of 'Hashemi' rice as influenced by 8:0, 6:2, 4:4 and 2:6 rice:weed mixture proportions.

Rice cultivar	Weed species	Rice: weed ratios	ADW	RDW	TN	LA	H
			g plant^{-1}		N° plant^{-1}	cm^2	cm
Hashemi	BYG	8:0	24.83a	5.54c	15.91a	881ab	64.50a
		6:2	20.80b	5.46c	13.37c	579d	57.90c
		4:4	20.20b	5.75c	10.63e	557d	51.30e
		2:6	14.54d	7.56ab	8.07f	590dc	46.04f
Hashemi	ECPH	8:0	24.83a	5.54c	15.91a	881ab	64.50a
		6:2	20.50b	6.51bc	14.72b	613dc	61.90b
		4:4	19.98b	6.74bc	12.00d	661dc	55.30d
		2:6	17.36c	9.07a	10.20e	1065a	50.00e
LSD (0.05)		-	2.81	1.27	1.01	217	2.5

BYG: Barnyardgrass; ECPH: rice barnyardgrass.

Table 2. Aboveground dry weight (ADW), root dry weight (RDW), tiller number (TN), leaf area (LA) and height (H) of barnyard grass (BYG) and rice barnyardgrass (ECPH) as influenced by 8:0, 6:2, 4:4 and 2:6 weed:rice mixture proportions.

Weed species	Rice: weed ratios	ADW	RDW	TN	LA	H
		g plant^{-1}		N° plant^{-1}	cm^2 plant^{-1}	cm
BYG	8:0	38.28c	7.30de	15.2ab	2183d	92.79a
	6:2	41.82bc	7.71d	15.9a	2632c	89.77b
	4:4	44.30b	8.93c	14.93ab	3290b	77.83d
	2:6	58.09a	15.90a	13.13d	4622a	60.72f
ECPH	8:0	30.15de	5.54f	15.6a	1691e	83.44c
	6:2	28.03e	6.51e	14.33bc	1718e	79.40d
	4:4	33.74d	6.57e	13.19dc	2466cd	71.61e
	2:6	43.83b	11.66b	11.56e	3098b	60.64f
LSD (0.05)	-	3.84	0.89	1.14	400	3.00

BYG: Barnyardgrass; ECPH: rice barnyardgrass.

Table 3. Mean comparison for the effect of rice cultivar and species of *Echinochloa* genus (BYG or ECPH) on relative crowding coefficient (RCC) for aboveground dry weight (ADW), root dry weight (RDW), tiller number (TN), leaf area (LA) and height (H) .

Species in mixture	Relative crowding coefficient (RCC)				
	ADW	RDW	TN	LA	H
BYG	1.41a	1.28a	1.12a	2.45a	1.05a
Cv. Hashemi	0.71d	0.80c	0.90a	0.42c	0.94b
ECPH	1.29b	1.22a	1.09a	1.54b	1.09a
Cv. Hashemi	0.80c	0.98b	0.92a	0.70c	0.91b
LSD (0.05)	0.08	0.08	0.26	0.47	0.06

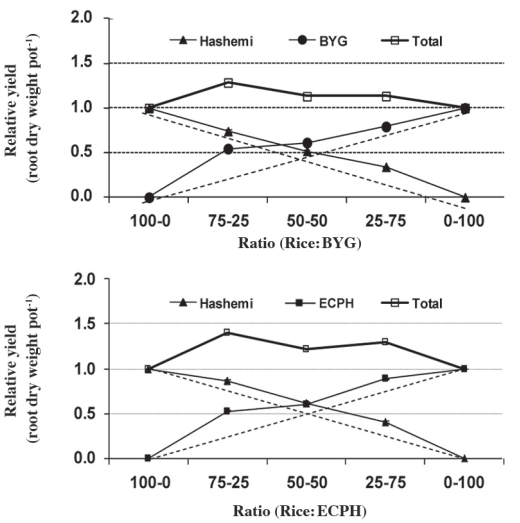
BYG: Barnyardgrass; ECPH: rice barnyardgrass.

Gealy *et al*. (2005) reported that rice cv. Lemont had lower RCC than BYG, while PI 312777 had similar RCC with BYG. Some researchers reported that differences in weed competitiveness exist between and within crops (Garrity *et al*., 1992; Fischer *et al*., 1997; Johnson *et al*., 1998; Fofana and Rouber, 2000; Ni *et al*., 2000; Fischer *et al*., 2001; Gealy *et al*., 2003; Anwar *et al*., 2010) and weeds species (Fleming *et al*., 1988; Vangessel and Karen, 1990).

Root dry weight

Root dry weight of 'Hashemi' increased dramatically at 2:6 rice:weed mixture proportion, but it did not vary statistically in the other mixture proportions (Table1). Maximum and minimum root dry weight for 'Hashemi' was recorded in 2:6 and 8:0 rice:weed mixture proportion, respectively. On the other hand, root dry weight (g plant^{-1}) of BYG or ECPH significantly increased as weed:rice mixture proportions increased (Table 2).

The competitiveness of each species of *Echinochloa* genus against 'Hashemi' on the basis of the relative root dry weight was evaluated using a replacement series diagram (Figure 2). As shown in the Figure 2, the lines for 'Hashemi' and BYG intersect at the left of the point of equivalency. In other words, the curve representing 'Hashemi' was concave and the curve for BYG was convex. This indicates that BYG was more competitive than 'Hashemi' and gains resources at the expense of the cultivar. On the other hand, the lines for ECPH and 'Hashemi' intersect at the point of equivalency of the expected yield, indicating equal competitive ability between 'Hashemi' and ECPH based on root biomass



The two straight dashed lines in each frame indicate the theoretically expected responses for two equally competitive species, which intersect at the point of equivalency (Harper, 1977).

Figure 2. Relative root dry weights of 'Hashemi' rice (▲), barnyard grass (BYG) (●) and rice barnyardgrass (ECPH) (■), and relative yield totals (RYT) (□) as influenced by rice:weed mixture proportions in a replacement series.

production. The RYTs for root dry weight of each species of *Echinochloa* genus and 'Hashemi' ranged from 1.13 to 1.39. In most cases, they were significantly higher than cutoff value (< 1.14 or > 0.86). This response probably occurred primarily because of the reduced interference in mixtures in relation to the monocultures due to the differences in paths of resource acquisition by C_3 rice plants and C_4 BYG or ECPH plants, respectively (Fischer *et al*., 2000).

The greater RCC of BYG or ECPH over 'Hashemi' indicates and also confirms the results of RY for root dry weight that both BYG and ECPH was superior competitor to 'Hashemi'. On the other hand, the RCC value for root dry weight did not significantly differ between BYG and ECPH (Table 3). This indicates similar competitive ability between them.

Tiller number

Tiller number of 'Hashemi' reduced significantly when rice:BYG or rice:ECPH mixture proportion decreased (Table 1). Also, 'Hashemi' had higher tiller density when planted as monoculture than when grown at the different rice:weed mixture proportions. Moreover, Tiller density of 'Hashemi' when grown with BYG was usually less than that when grown with ECPH (Table 1). These results indicate that 'Hashemi' grew better with intraspecific than with interspecific competition. On the other hand, tiller numbers of ECPH were significantly reduced as ECPH:rice ratio decreased, but tiller density of BYG was significantly decreased only at 2:6 BYG:rice mixture proportion (Table 2).

Replacement series diagrams based on relative tiller production illustrated the competitive effects between 'Hashemi' and BYG or ECPH (Figure 3). As shown in the Figure 3, two species of *Echinochloa* genus and Hashemi lines intersect almost at the 50:50 rice:weed mixture proportions. This result suggested that the weeds were as competitive as 'Hashemi' in tiller production. The RYTs for tiller number of BYG or ECPH and 'Hashemi' (ranging from 0.75 to 0.85) were lower than the cutoff values (0.94-1.06). Harper (1977) suggested that RYT value < 1 imply mutual antagonism.

The RCC value for tiller number did not significantly differ between BYG or ECPH and 'Hashemi' (Table 3). This indicates similar competitive ability between ECPH or BYG and 'Hashemi' and neither species were dominant in root biomass production.

Leaf area

Leaf area (cm^2 plant^{-1}) of 'Hashemi' decreased as rice:BYG mixture proportions decreased (Table 1). On the other hand, leaf area (cm^2 plant^{-1}) of 'Hashemi' significantly decreased at 6:2 and 4:4 rice:ECPH mixture proportions, but dramatically increased at 2:6 rice:ECPH mixture proportions. Moreover, leaf area of 'Hashemi' when grown with ECPH was significantly more than that

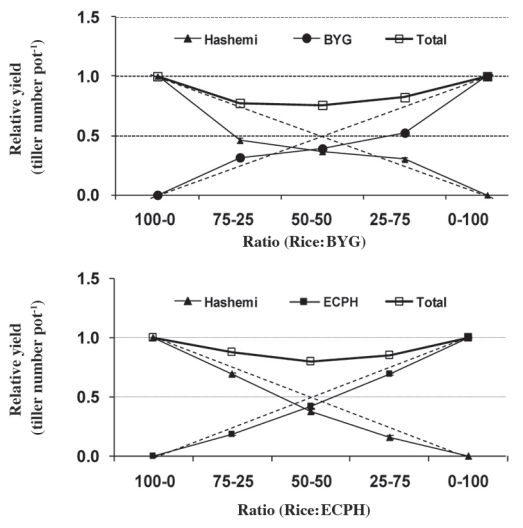
when grown with BYG. These data indicate that BYG was more competitive than ECPH against 'Hashemi'. On the other hand, leaf area of BYG or ECPH increased as weed:rice mixture proportions decreased (Table 2). Moreover, leaf area for BYG was higher than for ECPH, planted either alone or in the mixture (Table 2). This result also confirmed that ECPH is less competitive than BYG against 'Hashemi'. Dingkuhn *et al*. (1999) and Karimmojeni *et al*. (2010) reported that leaf area was positively correlated with competitiveness.

As shown in the Figure 4, the intersection of the 'Hashemi' curve with that of either BYG or ECPH was to the left of the 50:50 mixture proportions (point of equivalency of the expected yield). This indicates that both BYG and ECPH were more competitive than 'Hashemi'. The RYTs for leaf area of 'Hashemi' and both species of *Echinochloa* genus ranged from 1.02 to 1.14, but all were not significantly different from 1, on the basis of the cutoff of not > 1.17 or < 0.83. This indicates that 'Hashemi' and BYG or ECPH were competing for the same resources. This result was in agreement with some previous studies (Estorninos *et al*., 2002; Gealy *et al*., 2005).

The greater RCC of BYG over ECPH indicates that BYG was more competitive than ECPH (Table 3). Moreover, the greater RCC of BYG or ECPH over 'Hashemi' indicates that both BYG and ECPH was superior competitor to 'Hashemi'.

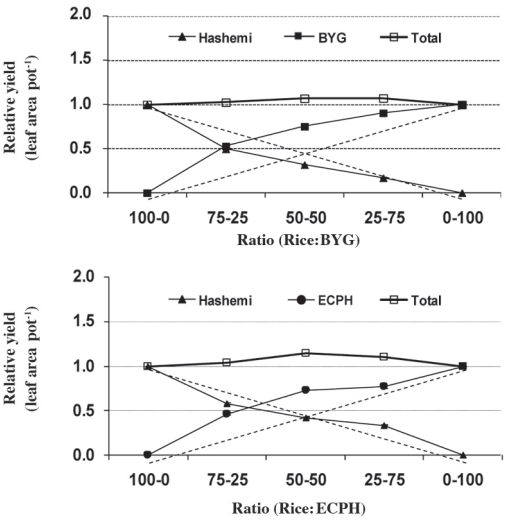
Plant height

'Hashemi' height was reduced significantly when grown with either BYG or ECPH (Table 1). On the other hand,



The two straight dashed lines in each frame indicate the theoretically expected responses for two equally competitive species, which intersect at the point of equivalency (Harper, 1977).

Figure 3. Relative tiller number of 'Hashemi' rice (▲), barnyard grass (BYG) (●) and rice barnyardgrass (ECPH) (■), and relative yield totals (RYT) (□) as influenced by rice:weed mixture proportions in a replacement series.



The two straight dashed lines in each frame indicate the theoretically expected responses for two equally competitive species, which intersect at the point of equivalency (Harper, 1977).

Figure 4. Relative leaf area of 'Hashemi' rice (▲), barnyardgrass (BYG) (●) and rice barnyardgrass (ECPH) (■), and relative yield totals (RYT) (□) as influenced by rice:weed mixture proportions in a replacement series.

both BYG and ECPH height were reduced when they grown with 'Hashemi' (Table 2). Moreover, both BYG and ECPH were taller when planted alone than when grown together with rice at all mixture proportions (Table 2). This indicates that both BYG and ECPH grew taller with intraspecific than with interspecific competition. Garrity *et al*. (1992) and Drews *et al*. (2009) reported that weeds reduced significantly rice plant height. Also, BYG was higher than ECPH when planted as monoculture. In this experiment, the taller echinochloa species, BYG, was more competitive than the shorter *Echinochloa* species, ECPH. Jennings and Herrera (1968), Garrity (1992) and Karimmojeni *et al*. (2010) reported that plant height can be positively associated with competitiveness, but Estorninos *et al*. (2002) suggested that plant height can be negatively associated with competitiveness.

There was no significant difference between the RCC of BYG and ECPH for plant height, but the greater RCC of BYG or ECPH over 'Hashemi' indicated that both BYG and ECPH was superior competitor to 'Hashemi' (Table 3).

Although in this experiment the competitive ability of the BYG was higher than that of ECPH, ECPH could be an important weed in rice paddy fields because: (i) EPCH seeds germinate and seedlings emerge very well under anaerobic conditions. (ii) ECPH has seemingly perfect mimicry of the rice plants throughout its development from seedling to heading. This helps the weed to escape manual weeding before rice heading. The weed starts heading coincidentally with the rice plants at the period when the growers are reluctant to walk in the rice paddy to weed because it may disturb crop growth and fertilization. When weeding is begun after heading of the rice plants,

the weed has already started shattering seeds (Yamasue, 2001).

CONCLUSIONS

The results of this experiment indicated that both *Echinochloa crus-galli* (BYG) and *Echinochloa oryzicola* (ECPH) were competing for the same resources with 'Hashemi'. In general, replacement series curves and relative crowding coefficient values indicated that BYG or ECPH was more competitive than 'Hashemi'. BYG had significantly higher aboveground dry weight, root dry weight, tiller number, leaf area, and plant height than ECPH, when grown with Hashemi. Moreover, this experiment demonstrated that BYG was superior competitor to ECPH.

Interacciones de interferencia entre dos especies del género *Echinochloa* con arroz. El objetivo de este estudio fue evaluar la capacidad competitiva relativa de *Echinochloa crus-galli* (L.) P. Beauv. (BYG) en comparación con *Echinochloa oryzicola* (Vasinger) Vasinger (ECPH) contra arroz (*Oryza sativa* L.) cv. Hashemi en un estudio de series de reemplazo. Los experimentos fueron arreglados en diseño de bloques completos al azar con tres repeticiones con un arreglo factorial. Los factores fueron dos especies del género Echinochloa (BYG y ECPH) y cinco mezclas de arroz:BYG o arroz:ECPH (8:0, 6:2, 4:4, 2:6 y 0:8). El rendimiento relativo total del peso seco sobre el suelo, peso seco de raíces y área foliar indicaron que BYG y ECPH estaban compitiendo por los mismos recursos con 'Hashemi'. En general, las curvas de serie de sustitución y el coeficiente relativo de competencia (RCC) demostraron que los valores BYG y ECPH fueron más competitivos que 'Hashemi'. BYG tuvo un peso seco sobre el suelo, peso seco de raíces, número de macollos, área foliar y altura de plantas significativamente superiores que ECPH cuando se cultivan con 'Hashemi'. Este experimento confirmó que BYG fue más competitivo que ECPH contra 'Hashemi'.

Palabras clave: *Echinochloa crus-galli*, competencia, interferencia, *Oryza sativa*, *Echinochloa oryzicola*.

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