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Biological Performance of some Allelopathic Rice Entries against Barnyardgrass Weed (*Echinochloa crus-galli*) as Integrated with Weed Control by Herbicides on Rice Productivity

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ABSTRACT

Two field experiments were carried out at Rice Research and Training Center, Sakha, Kafr El-Siekh in 2006 and 2007 seasons. The objective of the study was to investigate the performance of five allelopathic rice lines as compared to a nonallelopathic one as integrated with three weed control treatments on barnyardgrass control and rice productivity. The used allelopathic lines were GZ 1368-5-4, AYT, RP 2291-92-4, GZ 6861-16-2-4-1 and GZ 6944-33-1-4-1, while the nonallelopathic one was Giza 176. The tested weed control treatments were check (untreated), half and recommended (1.512 kg ai/fed) rate of thiobencarb 50% herbicide while the herbicidal treatments were applied 9 days after rice sowing. All tested allelopathic rice entries significantly reduced dry weight of barnyardgrass (*Echinochloa crus-galli*) and recorded larger number ofpanicles/m^2 and higher grain yields as compared to the nonallelopathic cultivar (Giza 176). AYT and RP 2291-92-4 lines were more suppressive for weed dry weight than others. GZ 6861-16-2-4-1 and AYT produced the highest yields. Both thiobencarb treatments resulted in significant suppression in weed dry weight compared to the untreated check. The application of thiobencarb resulted in increasing number of panicles/m^2 and rice grain yield. Under the untreated plots, the weed suppressive lines produced rice grain yields higher significantly than that produced by Giza 176 cultivar. However, with presence of the recommended herbicidal rate, Giza 176 cultivar showed superiority in number of panicles/m^2 and grain yield especially in the first season.

Key Words: Biological performance, Allelopathic rice, *Echinochloa crus-galli*, Weed control.

INTRODUCTION

Allelopathy is defined by Rice (1984) as any direct or indirect harmful or beneficial effect by one plant on another through production of chemical compounds that escape into the environment.

Despite the decades of herbicide use, weeds continue to be a major agricultural problem (Firbank and Watkinson 1986). In direct-seeded rice (*Oryza sativa* L.) this still true (Hill *et al.*, 1994). Both weed problems and herbicide use expected to increase as direct-seeded rice is adopted to reduce labor costs (De Datta 1986). In Egypt, weed competition is the most important yield-reducing factor causing 36-90% yield reduction especially in direct-seeded rice (Hassan 1999).

The indiscriminate use of herbicides during a short span of last decades has resulted to a various problems including the emergence of resistant weeds to herbicides, the shift of weed population similar to crops, and increment of the environmental pollution, etc. It has been attempt to suppress the weeds by increasing competitive strength of crop itself or by using bioherbicides, which are considered as parts of integrated weed management under the consideration of sustainable agricultural development (Kropff *et al.*, 1993).

Allelopathy is an important mechanism of plant interference mediated by the addition of plant produced phytotoxins to the plant environment. Chemicals with allelopathic potential are present in virtually all plant parts in most tissues, including leaves, stems, flowers, roots, seeds, and buds. Under appropriate conditions, these chemicals may be released into the rhizosphere in sufficient quantities to affect neighboring plants (Putnam, 1986). Allelopathic crops offer potential for development of model herbicides as well as providing a source of germplasm that could be manipulated to enhance weed suppression in an environmentally compatible manner (Khush, 1996 and Watson, 1996).

For rice, allelopathy subjected to continued research for a decade and progress has been made in range of field studies (Dilday *et al* 1998, Olofsdotter 2001 and Hassan & Shebl, 2004). Many rice entries have been reported to produce weed suppressing allelochemicals (Mattice *et al* 1998 and 2001).

Echinochloa sp. in rice represents a major problem, especially in direct-seeded rice because of its ability to emerge throughout 3-5 days after sowing which complicates its control and the problem becomes more complicated in direct-seeded rice (Ampong-Nyarko and De Datta 1991). Weed suppressive varieties with an acceptable yield potential are needed for reducing herbicide reliance in weed control in rice and also for reducing labor costs and pollution of the environment in Egypt.

The present study aimed to explore the biological weed suppression by some allelopathic rice entries to integrate weed control system in rice.

MATERIALS AND METHODES

Two field experiments were conducted during 2006 and 2007 summer seasons in the experimental farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh Governorate to detect the biological suppressive abilities of some rice entries against *Echinochla crus-galli* (barnyardgrass) in broadcast-seeded rice at reduced herbicide rates. The used herbicide was Saturn (thiobencarb 50%).

The soil of the experimental field was clay and previous crop was clover during the two seasons. The experimental field was plowed two times, harrowed and well leveled. Phosphorus fertilizer was 15 kg P2O5/fed incorporated before the second plowing. Nitrogen fertilizer and all other agricultural practices were done as recommended with broadcast-seeded rice while rice seeds were broadcasted by hand at 60 kg seeds/fed. Within the first month after sowing, soil was kept around saturation statues, continuous flooding was followed after this period while water was hold 15 days before harvest.

A split-plot-design with four replicates was used while six rice entries, namely, (1) Giaz176 (as non allopathic one), (2) GZ 1368-5-4, (3) AYT, (4) RP 2291-92-4, (5) GZ 6861-16-2-4-1 and (6) GZ 6944-33-11-4-1 (as allopathic entries) obtained from RRTC were distributed in the main plots. The sub-plots were assigned for three weed control treatments (1-check, 2- thiobencarb (Saturn 50%) 0.756 kg ai / fed and 3- thiobencarb 1.512 kg ai/fed). The herbicidal treatments were applied 9 days after sowing (DAS) using knapsack sprayer in 120 liter of water per feddan while water in the field was drained 2 days before spraying. The sub-plot area was 12m^2 (3x4m) and was homogeneously infested by 0.5 grams/m^2 of barnyardgrass seeds before flooding for broadcasting rice seeds. Other germinated weeds were eliminated continuously by hand.

Data recorded:

Weed samples of 50x50 cm^2 were taken two times from each sub-plot 80 DAS. *E. crus-galli* samples were air dried for 48 hours and drying was continued in the laboratory using an oven at 70 °C for 48 hours and dry weight was recorded as g/m^2.

At maturity of rice (135 DAS), panicles were counted in samples of 50x50 cm^2 two times from each sup-plot and were recorded as number of panicles /m^2.

For rice grain yield at harvest, 10m^2 excluding the outer borders were harvested and threshed and rice grains were weighed. Moisture content in rice grains was determined and adjusted to 14% and grain yield was recorded as t/ha.

All collected data were subjected to statistical analysis according to Gomez and Gomez (1984), Duncan multiple range test was used for comparison between means.

RESULTS AND DISCUSSION

1- Effect of rice varieties on *Echinichloa crus-galli* and rice yield:

a- *Echinochloa.crus-galli*:

Data in Table (1) represent dry weight of *E..crus-galli* as influenced by the allelopathic suppressive rice varieties as compared to Giza 176 cultivar as non allelopathic one during 2006 and 2007 seasons.

Dry weight of *E. crus-galli* was significantly reduced with the presence of all allelopathic rice entries as compared to the case of Giza 176 rice cultivar. The reduction of weed dry weight under growing the allelopathic rice entries was true during the two seasons of study. On the other hand, between the allelopathic rice entries both AYT and RP 2291-92-4 showed their superiority in suppressing dry weight of *E. crus-galli* followed by GZ 6861-16-2-4-1 and GZ 1368, with no significant difference between the last two entries. The considerable reduction of *E. crus-galli* dry weight

Table (1): Dry weight (g/m^2) of *E. crus-galli*, panicles/m2 and grain yield as influenced by varieties/line, 2006.

	Rice lines/varieties	Dry weight of *E. crus-galli*	No of panicles/m^2	Grain yield t/fed.
2006	Giza 176	350.08a	322.67 e	1.713 c
	GZ. 1368-5-4	139.56c	351.67 c	2.188 b
	AYT	97.25d	360.67 b	2.284^{ab}
	RP 2291-92-4	107.75d	345.00 d	2.182b
	GZ. 6861-16-2-4-1	144.74c	386.67a	2.302 a
	GZ. 6944-33-1-1-4-1	169.96 b	344.00 e	2.164 b
2007	Giza 176	205.33 a	271.33 b	1.650 b
	GZ. 1368-5-4	85.33 b	375.67 a	2.408 a
	AYT	71.33 bc	381.33 a	2.519 a
	RP 2291-92-4	58 00 c	379.00 a	2.507 a
	GZ. 6861-16-2-4-1	81.00 b	396.33 a	2.500 a
	GZ. 6944-33-1-1-4-1	85.00 b	376.67 a	2.406 a

Means followed by the same alphabetically letter(s) are not different significantly at 5% level according Duncan multiple range test.

grown the allelopathic rice entries may referred to their ability to release certain allelochemicals in the root zone which may prevent or suppress weed germination and growth as reported by Seal *et al.* (2004). In addition, Mattice *et al.* (1998) reported that the allelopathic compounds which adversely affect weeds growing with rice are likely to be exuded from the rice roots. This finding is confirmed by Chou and Lin (1976). The obtained results are similar to those obtained by Hassan & Shebl, (2004).

b- No of panicles/m^2 of rice

In respect to the number of panicles/m^2, data cited in Table (1) showed that significant differences were observed in this trait due to varietal differences of rice entries. All allelopathic rice entries surpassed giza 176 cultivar in panicles number/m^{2}during 2006 and 2007 seasons. In addition, Gz 6861-16-2-4-1 line recorded the largest number of panicles per unit area followed by AYT line during the two seasons of study. However, no significant differences were observed between the allelopathic rice entries during 2007 season in the recoded number of panicles/ m^2. The superiority of the allelopathic rice entries in number of panicles per unit area may attribute to their abilities in biological suppression of *E. crus-galli* than Giza 176 cultivar. These findings were confirmed by those reported by Hassan and Shebl (2004) and shebl *et al* (2007).

C-Rice grain yield:

Concerning rice grain yield, data in Tables (1) showed that grain yield of rice was significantly influenced by the genetic variation of rice entries. All allelopathic entries produced significantly higher grain yield than that was produced by Giza 176 cultivar. GZ 6861-16-2-4-1 and AYT produced the higher grain yields during 2006 and 2007 seasons. The high yielding ability of the allelopathic rice entries may be related to their abilities in suppressing *E. crus-galli* and producing large numbers of panicles per unit area. (Hassan & Shebl, 2004).

2- Effect of weed control treatments:

a- Echinocloa crus-galli:

Data in Table (2) cleared that dry weight of *E.crus-galli* was considerably affected by weed control treatments during the two seasons of study. The application of both reduced rate or full rate of thiobencarb resulted in significant reductions in dry weight of *E.crus-galli* as compared to that recorded with the untreated check plots. Moreover, no significant differences were noticed between applying half or full recommended rate of the herbicidal treatment in dry weight of *E.crus-galli.* This trend was true during the two seasons of study. The reduction on dry weight of *E.crus-galli* as a result of thiobencarb application may be referred to the negative effect of the herbicide on weed germination and its growth as mentioned by Ebaid and Shebl (2006). On the other hand, the non significant differences between dry weight of *E.crus-galli* under the reduced and full rates of the herbicidal treatments may be attributed to the biological weed suppression by the allelopathic activities of rice entries which may enhanced the herbicidal efficacy against the weed. Similar results were obtained by Shebl *et at.* (2007).

b- Rice panicles:

As shown in table (2), the number of panicles/m^2 was significantly affected by weed control treatments. This trait was greatly increased by the application of the reduced or full recommended rate of thiobencarb as compared to the untreated check during the two seasons of study. On the other hand, using the full rate of the herbicide resulted in significant increases in rice panicles per unit area during the two seasons.

C-Rice grain yield:

Concerning rice grain yield, data in Table (2) cleared that the production of rice grains was noticeably influenced by the application of the herbicidal treatments. Applying the reduced rate or the recommended one of thiobencarb, greatly increased rice grain yield comparing to the untreated check. Plots received the full recommended herbicidal treatment produced grain yield significantly more than that produced by those received the reduced herbicide rate. The obtained trend was confirmed during 2006 and 2007 seasons. The positive response of the produced grain yield of rice in treated plots by herbicidal treatments may be referred to the negative influence of thiobencarb on

Table (2): Dry weight (g/m^2) of *E. crus-galli*, panicles/m2 and grain yield as influenced by rice weed control treatments, 2006, 2007.

	Weed control treatments	Dry weight Of *E. crus-galli*	No of Panicles /m^2	Grain yield t/fed.
2006	Weedy check	344.73^a	188.67^c	1.261^c
	Thiobencarb (0.756 kg ai./fed)	84.47^b	403.50^b	2.462^b
	Thiobencarb (1.512 kg ai./fed)	75.48^b	463.17^a	2.693^a
2007	Weedy check	192.83^a	234.5^c	1.646^c
	Thiobencarb (0.756 kg ai./fed)	53.67^b	379.33^b	2.613^b
	Thiobencarb (1.512 kg ai./fed)	46.5^b	476.33^a	3.083^a

Means followed by the same alphabetically letters are not different significantly at 5% level according Duncan multiple range test.

E. crus-galli infestation and growth which may reduce its competition with rice as mentioned by Ampong- Nyarko and De Datta(1991) and Ebaid and Shebl (2006).

3- Effect of interaction between rice entries and weed treatments:

a- *Echinochloa crus-galli*:

Data presented in Table (3) indicated that dry weight of *E.crus-galli* exhibited significant differences due to the interaction between rice entries and different weed control treatments during 2006 and 2007 seasons. Under weedy check plots, the presence of the allelopathic rice entries significantly suppressed dry weights of *E.crus-galli* than that observed with Giza 176 rice cultivar. This trend was true under the application of reduced and even with the full recommended rate of the herbicidal treatment during the two seasons of the study. On the other side, it could be observed that with Giza 176 cultivar, there was significant reduction in dry weight of *E. crus-galli* as a result of increasing herbicide rate from half to the full recommended rate. On contrast, with growing the allelopathic lines, no significant difference was noticed with increasing herbicide rate. This finding was stable during first and second seasons of the study. The significant reduction in weed dry weight under growing the allelopathic rice entries even under using half rate of thiobencarb or with the untreated plots may explains the high biological suppressive action of these entries against *E. crus-galli*. These findings are confirmed by those obtained by Hassan *et al.* (1998) who recorded 81-85% suppression in *E. crus-galli* dry weight due to growing allelopathic rice entries. Additionally, Shebl *et al.*, (2007) found that some selected allelopathic rice entries achieved more than 80% control against *E. crus-galli* and recorded significant reduction in dry weight of *Echinochloa* sp. than Giza 176 cultivar. The allelopathic suppressive effect may results from biochemical interaction between plants caused by toxic chemicals released throughout volatilization, leaching and root exudation as mentioned by Chou (1995).

b- Rice panicles:

Number of panicles/m^2 was considerably influenced by the interaction of rice entries and weed control treatments (Table 4). It is obvious that under the untreated check plots, all allelopathic rice entries significantly recorded higher number of panicles than that pronounced with Giza 176 rice cultivar. On the other hand, under the application of reduced herbicidal rate, GZ6861-16-2-4-1 as allelopathic rice line achieved the largest number of

Table (3): Dry weight (g/m^2) of *E. crus-galli*, as influenced by rice varieties/lines and weed control treatments, 2006 and 2007 seasons.

	Rice lines/varieties	weed control treatments		
		Check	Thiobencarb (0.756 kg ai./fed.)	Thiobencarb (1.512 kg ai./fed.)
2006	Giza 176	750.63^{a}	170.76^{e}	128.86^{f}
	GZ. 1368-5-4	267.35^{d}	84.50^{g}	66.82^{ghij}
	AYT	190.19^{e}	46.31^{j}	55.25^{ij}
	RP 2291-92-4	196.60^{e}	58.44^{hij}	68.22^{ghij}
	GZ. 6861-16-2-4-1	311.15^{c}	66.04^{ghi}	57.03^{hi}j
	GZ. 6944-33-1-1-4-1	352.43^{b}	80.76^{gh}	76.70^{ghij}
2007	Giza 176	473^{a}	85^{e}	58^{fg}
	GZ. 1368-5-4	142^{c}	63^{f}	51^{fgh}
	AYT	121^{d}	45^{fgh}	48^{fg}h
	RP 2291-92-4	101^{e}	34^{h}	39^{gh}
	GZ. 6861-16-2-4-1	151^{bc}	51^{fgh}	41^{fgh}
	GZ. 6944-33-1-1-4-1	169^{b}	44^{fgh}	42^{fgh}

Table (4): No of panicles/m2 as influenced by rice varieties/lines and weed control treatments, 2006 an 2007.

	Rice lines/varieties	weed control treatments		
		Check	Thiobencarb (0.756 kg ai./fed.)	Thiobencarb (1.512 kg ai./fed.)
2006	Giza 176	76^{h}	358^{e}	507^{a}
	GZ. 1368-5-4	201^{g}	402^{cde}	452^{bc}
	AYT	211^{fg}	415^{cde}	456^{bc}
	RP 2291-92-4	195^{g}	399^{e}	441^{cd}
	GZ. 6861-16-2-4-1	241^{f}	434^{cd}	485^{ab}
	GZ. 6944-33-1-1-4-1	208^{g}	386^{e}	438^{cd}
2007	Giza 176	18^{j}	339^{efgh}	457^{abcd}
	GZ. 1368-5-4	296^{fghi}	370^{efg}	461^{abcd}
	AYT	286^{ghi}	379^{def}	479^{abc}
	RP 2291-92-4	291^{fghi}	380^{def}	466^{abcd}
	GZ. 6861-16-2-4-1	268^{hi}	415^{bcde}	506^{a}
	GZ. 6944-33-1-1-4-1	248^{i}	393^{cde}	489^{ab}

Table (5): Grain yield t/ fed as influenced by rice varieties/line and weed control treatments, 2006 and 2007.

	Rice lines/varieties	weed control treatments		
		Check	Thiobencarb (0.756 kg ai./fed.)	Thiobencarb (1.512 kg ai./fed.)
2006	Giza 176	0.019 g	2.071 d	3.050 a
	GZ. 1368-5-4	1.376 ef	2.565bc	2.625 b
	AYT	1.503 e	2.602 b	2.747 b
	RP 2291-92-4	1.534 d	2.327 c	2.387 c
	GZ. 6861-16-2-4-1	1.550 e	2.667 b	2.689 b
	GZ. 6944-33-1-1-4-1	1.287 f	2.543 bc	2.662 b
2007	Giza 176	0.011 g	1.932 e	3.007 abc
	GZ. 1368-5-4	1.420 f	2.712 d	3.089 a
	AYT	1.546 f	2.752 d	3.259 a
	RP 2291-92-4	1.808 e	2.659 d	3.055 ab
	GZ. 6861-16-2-4-1	1.604 ef	2.830 bcd	3.066 ab
	GZ. 6944-33-1-1-4-1	1.403 f	2.796 cd	3.019 abc

Within seasons means followed by the same alphabetically letters are not different significantly at 5% level according Duncan multiple range test.

panicles/m^2 followed by AYT and GZ1368 lines with the same level of significance in the first season. However, no significant difference was found between all rice entries under this treatment during the second season. In addition, when the full rate of thiobencarb was applied, Giza 176 showed its superiority, equaled GZ6861-16-2-4-1 in 2006 season and equaled with all allelopathic entries during 2007 season. The superiority of allelopathic rice entries in producing larger number of panicles under the untreated check plots and with reduced herbicidal rate may clarify the role of these entries in biological weed suppression and enabled rice plants to produce more panicles. Similar results and explanation were reported by Hassan and Shebl (2004) and Shebl *et al.* (2007).

c- Rice grain yield:

Data in Table (5) showed that grain yield of rice entries was greatly affected by the interaction between varieties and weed control treatments. Under weedy check plots, all allelopathic entries gave grain yield of rice more than one ton/ fed while Giza 176 produced only few kilograms. The inferiority of Giza 176 cultivar in grain yielding with no herbicidal application, may refer to its poor ability in weed suppression, consequently, the yield is greatly reduced due to weed competition. On the contrary, allelopathic entries provided high yielding ability even with no herbicide use due to its high biological suppression against *E.crus-galli* avoiding rice plants from severe weed competition. In addition, plots received half rate of thiobencarb produced grain yields from allelopathic entries were significantly more than Giza 176 cultivar. Moreover, when the full rate of thiobencarb was applied, Giza 176 yielded high grain yield in the first season while no significant difference was observed between all rice entries during the second season of study.

The non significant differences between allelopathic and non allelopathic lines under the application of full herbicide dose may be attributed to the main role of the herbicide in weed control regardless to the role of rice genotype itself. On the other hand, the integration between the allelopathic rice genotypes and the reduced rate of the herbicide resulted in satisfactory grain yield.The superiority of the allelopathic rice entries high yielding and the low reduction of grain yield when the reduced herbicide rate was used or even under weedy check plots could be referred to the ability of these entries to suppress *E.crus-galli* through some released biochimechals which may inhibit weed germination and growth as mentioned by Seal *et al.* (2004) who identified many allelopathic compounds from allelopathic rices. The obtained results are confirmed by those found by Shebl *et al.* (2007).

Based on the obtained results under this study, it could be concluded that the allelopathic rice entries could share in biological weed control to improve integrated weed management in rice.

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