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Genetic behavior of rice (*Oryza sativa*) genotypes under normal and infested weed conditions

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ABSTRACT

A field study was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt during 2016-17 summer, to estimate general (GCA) and specific (SCA) combining ability effects as well as identify type of gene action controlling the inheritance of the studied traits under normal and infested weed conditions. Seven a diverse rice (*Oryza sativa* L.) parent's were crossed using half diallel cross method without reciprocals to produce 21 F_1 crosses during 2016 season. The seven parents and their 21 F_1 crosses were evaluated under normal and infested weed conditions using a randomized complete block design (RCBD) with three replications during 2017. Highly significant differences were observed among genotypes, parents and crosses for all the studied traits. Moreover, general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all the studied traits under both conditions. The best general combiner for earliness and short stature was Sakha 103 variety. The highest desirable SCA effects were obtained by the crosses; Egyptian Yasmin × Dullar, Sakha 104 × Egyptian Yasmin, Egyptian Yasmin × Rikuto Norin 22 and Giza 177 × Rikuto Norin 22 for flag leaf area, No. of panicles/plant and grain yield/plant. These crosses could be utilized in rice breeding program for improving grain yield trait under normal and infested weed conditions.

Key words: Combining ability, Normal and infested weed conditions

Rice (*Oryza sativa* L.) is one of the most important crops in the world and is the main nutritional staple food for more than half of the world's population (Yuan 2014). Therefore, increasing its productivity is important in breeding programs. Reduced plant height, moderate tillering, large and compact panicles, increased grain number per panicle and high grain yield are the most important rice characters should be studied through breeding programs (Wayne and Dilday 2003, Paterson *et al.* 2005). In Egypt, rice productivity has remarkably increased year after year according to the percentage replacement of the rice area with the modern varieties to realize a maximum yield average (10 t/ ha) in the year 2018, about 30% of the irrigation water consumption was saved every year (Aidy and Maximos 2006). However, the weeds grown in rice fields are the main suppressor of rice growth and significantly affecting rice grain yield. Also the chemical treatments or herbicides for weed control are very dangerous due to the pollution and high production costs. Allelopathy is the result of biochemical interactions between plants and represents an economic way to control weeds in rice fields.

Diallel analysis is one of the most informative methodologies for generating information about type of gene action involved in the expression for the trait of interest. Estimates of additive and non-additive gene action are important in early stages of breeding procedures. Selection would be successful during the early generations when additive gene action is predominant. The present investigation aimed to study genetic behavior for growth and grain yield traits under normal and infested weed conditions, as well as yield reduction for different genotypes as affected by weed competition and to identify the most desirable genotypes for rice breeding program under this conditions.

MATERIALS AND METHODS

The present study was carried out at the experimental farm of the Rice Research and Training Center (RRTC), Sakha, Kafer EL-Shiekh, Egypt, during the two successive seasons 2016-17. Seven rice genotypes with a wide range of weed control were selected for this study, viz. Sakha 103, Sakha 104, Sakha 106, Giza 177, Egyptian Yasmin, Dullar and Rikuto Norin 22. In 2016 season, all possible cross combinations excluding the reciprocals were made among the seven parents giving a total of 21 F_1 crosses. In 2017 season, the 28 entries (7 parents and 21 F_1`s) were evaluated under normal (weed control by using 2L satren/fed) and infested weed (without weed control or no herbicide) conditions. The experimental design was randomized complete block design (RCBD) with three replications. Each entry was represented by 3 rows per

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replicate. The row was 5 m long with 20 cm spacing between rows and 20 cm between hills. Single seedling was planted in each hill. Data were collected for days to heading, plant height (cm), flag leaf area (cm^2), number of panicles/plant and grain yield/plant (g) as recommended by Standard Evaluation System (SES) of IRRI (2008).

Statistical analysis: The ordinary analysis of variance of RCBD was done according to Steel *et al.* (1997). General and specific combining ability effects were estimated according to Griffing (1956), method-2, model-1. The reduction percentage of means due to weed competition for all studied traits was calculated according to Mahajan *et al.* (2014).

RESULTS AND DISCUSSION

Analysis of variance: Analysis of variance for all the studied traits under normal and infested weed conditions was done. The results showed that the mean squares of genotypes and their partitioning; parents and crosses were highly significant for all the studied traits, indicating a wide diversity among the genetic materials used in this study. Moreover, mean squares due to parents *vs.* crosses (P vs. C) as an indication to average heterosis were highly significant for all the studied traits, except No. of panicles/plant under infested weed conditions. General and specific combining ability mean squares were found to be highly significant for all studied traits under both conditions, indicating the importance of both additive and non-additive genetic variances in determining the performance of these traits. The ratio of GCA/SCA was found to be less than unity for all the studied characters, indicating the preponderance of non-additive genetic variance in the inheritance of these traits. Therefore, selection procedure in late or advanced generations will be very important to improve these traits.

Reduction percentage of all genotypes as affected by weed competition: Weed competition caused reduction in all the studied traits of all the tested genotypes. The means of reduction percentage were (12.50 and 21.57) for days to heading, (5.96 and 12.70) for plant height, (18.95 and 27.89) for flag leaf area, (12.01 and 21.44) for No. of panicles/plant and (17.97 and 18.49) for grain yield/plant in parents and F_1 crosses, respectively. Such reductions in rice grain yield and other agronomic traits under weedy conditions were also reported by Mahajan *et al.* (2014) and Dass *et al.* (2017)

The parental genotypes (Rikuto Norin 22, Dullar and Egyptian Yasmin) and the F_1 crosses (Sakha 103 × Rikuto-Norin 22, Sakha106 × Egyptian Yasmin, Egyptian Yasmin × Rikuto-Norin 22 and Dullar × Rikuto-Norin 22) recorded the minimum reduction for grain yield and most of the studied traits. These results indicated that these genotypes had highly competitive to suppress the weeds and could be used in rice breeding program to improve allelopathic activity.

General combining ability effects (GCA): Estimates of general combining ability ($\hat{g}_i$) effects of the parental genotypes for all studied traits under both conditions are presented in Table 1. High significant positive values of ($\hat{g}_i$) effects would be of interest for all studied traits, except days to heading and plant height, whereas the significant negative values would be useful from the breeder point of view.

Concerning days to heading, the parents Sakha 103, Sakha 106 and Dullar showed highly significant and negative ($\hat{g}_i$) effects under the both conditions, indicating that these parents could be considered as good combiners for earliness. Regarding plant height, the parents Sakha 103, Giza 177 and Rikuto Norin 22 showed highly significant and negative ($\hat{g}_i$) effects, indicating that this parents could be considered as a good combiner for developing short stature genotypes under both conditions. Regarding flag leaf area, the parents Egyptian Yasmin, Dullar and Rikuto Norin 22 showed highly significant positive ($\hat{g}_i$) under the two conditions, proved to be good combiners for this trait. Concerning No. of panicles/plant, the parental genotypes Sakha 104 and Egyptian Yasmin showed highly significant positive ($\hat{g}_i$) under both conditions and considered as good combiners for increasing number of panicles/plant. The parental genotypes Sakha 104, Egyptian Yasmin, Dullar and Rikuto Norin 22 seems to be good combiners for grain yield/plant under both conditions (normal and weed infestation).These parents could be considered as excellent parents in breeding program to develop new rice cultivars

Table 1 Estimates of general combining ability effects ($\hat{g}_i$) for all the studied traits under normal and infested weed conditions.

Parent		Days to heading (day)		Plant height (cm)		Flag leaf area (cm^2)		No. of panicles/plant		Grain yield/plant (g)	
		Normal	Infest.	Normal	Infest.	Normal	Infest.	Normal	Infest.	Normal	Infest.
Sakha 103		-1.50**	-4.07**	-5.70**	-9.27**	-4.87**	-4.04**	-1.56**	-2.95**	-0.89**	-2.56**
Sakha 104		2.32**	4.71**	-1.46**	0.87**	-4.29**	-3.76**	2.39**	1.94**	1.93**	0.48**
Sakha 106		-1.05**	-3.63**	-1.67**	-3.54**	-2.45**	-1.43**	-1.30**	-1.00**	1.48**	-0.74**
Giza 177		-0.42*	-3.49**	-3.34**	-4.36**	0.66**	-0.37**	-0.73**	-0.25	1.08**	-0.43**
Egyptian Yasmin		5.80**	5.13**	2.44**	2.80**	6.96**	4.35**	3.54**	2.74**	0.72**	1.60**
Dullar		-3.79**	-0.91**	13.00**	14.50**	2.08**	2.41**	-0.65**	0.08	2.23**	1.19**
Rikuto Norin22		-1.35**	2.26**	-3.27**	-0.99**	1.91**	2.84**	-1.69**	-0.56**	0.66**	1.70**
LSD	0.05	0.35	0.35	0.21	0.28	0.15	0.08	0.42	0.32	0.21	0.28
	0.01	0.47	0.46	0.28	0.37	0.21	0.11	0.56	0.43	0.28	0.37

*and ** significant at 0.05 and 0.01 probability levels, respectively.

Table 2 Estimates of specific combining ability effects ($\hat{g}_i$) for all the studied traits under normal and infested weed conditions.

Cross	Days to heading (day)		Plant height (cm)		Flag leaf area (cm^2)		No. of panicles per plant		Grain yield/plant (g)	
	Normal	Infest.	Normal	Infest.	Normal	Infest.	Normal	Infest.	Normal	Infest.
Sakha 103 × Sakha104	- 1.88**	-7.89**	4.33**	- 3.08**	-3.50**	- 1.53**	- 0.90	- 0.66	2.81**	1.92**
Sakha 103 × SAkha106	-0.51	-0.10	1.70**	- 1.79**	5.46**	4.38**	2.96**	2.74**	1.72**	0.05
Sakha 103 × Giza 177	-0.14	- 1.37**	0.74**	- 1.85**	2.63**	2.58**	1.56**	0.78	2.43**	1.34**
Sakha 103 × E.yasmin	- 2.36**	- 6.09**	- 3.27**	- 6.68**	1.89**	- 0.87**	2.29**	1.23**	-2.78**	-1.57**
Sakha 103 x Dullar	6.23**	9.88**	- 4.80**	- 13.96**	1.26**	0.23	0.81	- 0.04	- 1.10**	2.32**
Sakha 103 × Rikuto Norin 22	2.12**	-4.26**	- 1.46**	-4.79**	1.01**	- 0.71**	-0.15	- 0.44	1.84**	4.43**
Sakha 104 × Sakha106	0.68	- 0.23	1.76**	- 0.15	5.87**	4.18**	-1.49**	- 1.68**	0.97**	-1.89**
Sakha 104 × Giza 177	- 1.62**	- 0.75	7.79**	7.54**	-0.01	2.82**	5.28**	3.98**	1.89**	1.38**
Sakha 104 × E.yasmin	0.82	- 1.29**	8.88**	6.09**	5.44**	- 3.92**	10.01**	8.69**	- 3.17**	- 4.38**
Sakha 104 × Dullar	3.42**	- 0.99*	- 17.67**	- 18.90**	-1.84**	-0.12	- 1.80**	- 2.28**	- 1.00**	- 1.00**
Sakha 104 × Rikuto Norin 22	- 0.03	- 6.92**	0.09	- 5.09**	-1.88**	- 1.14**	- 1.43**	- 2.22**	0.39	-1.50**
Sakha 106 × Giza 177	1.42**	1.57**	- 1.73**	- 4.38**	-1.78**	0.12	- 0.04	-1.74**	2.86**	- 3.48**
Sakha 106 × E.yasmin	- 2.81**	- 3.58**	4.62**	-0.14	1.84**	-1.86**	1.37*	0.11	- 1.97**	2.77**
Sakha 106 × Dullar	0.79	- 4.93**	- 1.60**	- 12.08**	- 0.22	- 0.92**	-0.78	- 3.25**	- 4.72**	- 4.84**
Sakha 106 × Rikuto Norin 22	- 2.99**	- 8.18**	2.40**	- 4.61**	1.39**	4.29**	- 2.41**	- 4.09**	4.43**	5.52**
Giza 177 × E.yasmin	- 0.77	- 4.70**	6.56**	- 2.57**	-4.73**	- 8.96**	- 2.21**	- 2.95**	- 8.25**	- 5.98**
Giza 177 × Dullar	- 0.51	- 6.48**	- 3.12**	- 14.79**	-0.39*	- 3.23**	- 0.69	- 3.04**	1.43**	1.81**
Giza 177 × Rikuto Norin 22	- 0.62	-5.14**	- 4.39**	- 9.14**	7.23**	5.39**	2.35**	2.06**	3.19**	3.43**
E.yasmin × Dullar	- 3.06**	- 1.02*	- 8.77**	-7.23**	3.70**	4.25**	1.72**	1.56**	16.41**	13.01**
E.yasmin × Rikuto Norin 22	- 2.51**	0.31	10.67**	-0.35	3.93**	4.80**	1.75**	1.07**	11.36**	12.00**
Dullar × Rikuto Norin 22	0.08	3.00**	- 1.38**	2.99**	6.13	7.27**	7.27**	7.45**	1.19**	1.75**
LSD 0.01	0.87	0.86	0.52	0.70	0.38	0.20	1.04	0.79	0.52	0.68
0.05	1.16	1.15	0.69	0.93	0.51	0.26	1.38	1.05	0.69	0.91

*and ** significant at 0.05 and 0.01 probability levels, respectively.

with strong allelopathic activity under weedy conditions. These results are in good agreement with those reported by Abd El-Aty (2001).

Specific combining ability effect (SCA): Estimates of specific combining ability ($\hat{g}_i$) effects of the 21 F_1 hybrid rice combinations for all the studied characters under both conditions are shown in Table 2. Five crosses Sakha 106 × Rikuto Norin 22, Sakha, 103 × Sakha 104 and Sakha 103 × Egyptian Yasmin had significant or highly significant negative ($\hat{g}_i$) effects for days to heading towards earliness. With respect to plant height, nine crosses out of the 21 F_1 crosses showed highly significant desirable ($\hat{g}_i$) effects in both conditions. The crosses Sakha 104 × Dullar , Giza 177 × Dullar and Sakha 103 ×Dullar had the highest desirable ($\hat{g}_i$) effects and considered good specific combiners for short plant stature. Concerning flag leaf area, eight crosses gave highly significant positive ($\hat{g}_i$) effects under normal and weed infested conditions. Nine crosses exhibited highly significant and positive ($\hat{g}_i$) effects for number of panicles/plant under both conditions. The best hybrid combinations which gave the highest values were Dullar × Rikuto Norin 22, Egyptian Yasmin × Dullar, Egyptian Yasmin × Rikuto Norin 22 and Sakha 104 × Egyptian Yasmin. These crosses could be used in breeding program to improve this trait under weed infestation. Regarding to grain yield/plant 10 hybrid combinations showed highly significant and positive ($\hat{g}_i$) effects under both conditions. The highest desirable ($\hat{g}_i$) effects were detected by the crosses Egyptian Yasmin × Dullar, Egyptian Yasmin × Rikuto Norin 22 ,Sakha 106 × Rikuto Norin 22 and Dullar × Rikuto Norin 22 indicating that these crosses are the best combinations for improving grain yield.

The best specific combiners for grain yield and most of the studied traits under both conditions were Egyptian Yasmin × Dullar, Dullar × Rikuto Norin 22 and Egyptian Yasmin × Rikuto Norin 22. These superior crosses could be of interest in rice breeding program for developing varieties with high grain yield under both conditions.

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