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COMBINING ABILITY STUDIES FOR GRAIN YIELD AND SOME ASSOCIATED CHARACTERS IN SOME RICE LINES

Sultan, M.S[1]; M. I. Abo Youssef[2]; M. A. Abdel-Moneam[1]and M.M. El-Shenawy [2]

[1]Agronomy Department, Fac. of Agric. Mansoura University, Egypt.
[2]Rice Research Section, Field Crops Res. Inst., ARC, Giza, Egypt.

ABSTRACT

This study was conducted at Rice Research and Training Center (RRTC), of Farm Sakha - KafrelSheikh, Egypt, during the summer seasons of 2010 , 2011 and 2012 to investigate the combining ability of some parental lines in their crosses. Three cytoplasmic male sterile (CMS) lines as female parents and seven restorer lines as male parents were hybridized to produce 21 F_1 hybrids in a line x tester mating model (Kempthorne, 1957). The General and specific combining ability effects of the genotypes for the characters under study were estimated. The results showed that the characters were controlled by general combining ability (GCA) and specific combining ability (SCA) . The CMS and restorer lines showed favorable effects for GCA of yield and yield components. The results indicated that most characters were largely governed by additive gene action. finally, the hybrid combination IR69625A× Giza 179 could be used as a promising hybrid for early maturing and high yielding varieties.

Keywords: Rice, hybrid rice ,combining ability, cytoplasmic male sterility, line x tester model, yield and yield components

INTRODUCTION

Rice (*Oryza sativa L*.) is the world leading cereal crop for human utilization, with cultivated area of almost 150 million hectars and a total production of almost 600 million ton annually (Khush, 2005). The world population is expected to reach 8 billion by 2030 and rice production must be increased by 50% in order to meet the growing demand for the world (Khush and Brar, 2002).

In order to obtain good hybrids, it is essential to understand the nature of gene action that, controls yield and its components. Combining ability estimation is a powerful tool available to select the desirable parents and crosses for the exploitation of heterosis. General combining ability (GCA) effects largely involve additive gene effects, while, specific combining ability (SCA) effects represent only non-additive gene action including dominance. The presence of non-additive genetic variance offers scope for exploration of heterosis (Yadav *et al*., 1999). The parents with good GCA and SCA could be used to produce good hybrids (Yang *et al*., 2000). In addition, heterosis and combining ability of hybrid rice were studied by Zhang *et al*., (2002). Line x tester analysis provides information about GCA and SCA effects of parents and is helpful in estimating various types of gene actions (Rashid *et al*., 2007). Identification of suitable parents through line x tester analysis in rice has been studied by Singh and Kumar (2004).

Hybrid rice varieties can out yield conventional cultivars by at least 15 % under the same input levels. Hence, this technology can be used to break

the current yield plateau in rice, where yield levels of the conventional cultivars released reached stable levels (El-Mowafi *et al*., 2005).

The main objective of this investigation was to estimate the GCA and SCA effects and identify promising parental lines that can be combined in high yielding early rice hybrids.

MATERIALS AND METHODS

Three cytoplasmic male sterile lines (CMS) vis., IR69625A, IR70368A as wild abortive type (WA) and K17A as (K-type) were used as female lines and crossed with seven restorer lines, viz., Giza 178 R, Giza 179R, Giza 181R, Giza 182 R, Sakha 105R, HR195R and promising line GZ 6296-12-1-2-1-1R to produce 21 hybrid combinations in line x tester model the hybrid were evaluated with parents in a randomized complete block design with three replications at Rice Research and Training Center during 2010,2011and 2012 seasons. The data were recorded on days to flowering, number of fertile tillers per plant , panicle length, seed set percentage(out crossing rate%), 1000–grain weight and grain yield per plant as recommended by IRRI(1996).The days to heading, panicle length (cm) and seed set % were recorded on the A-line, while number of fertile tillers per plant, 1000–grain weight and grain yield per plant were recorded using correspondent B-lines(maintainer lines) that are self fertile. Combining ability analysis was carried out as the method of Kempthorne (1957).

The estimates of GCA effects:

-GCA effects of each line were calculated according to the following equation:

$$g_i = \frac{Y_{i..}}{tr} - \frac{Y..}{Ltr}$$

Where:

$Y_{i..}$: Total of the i^{th} line over testers,

Y..: Grand total .

L, t and r: Number of lines, testers and replications, respectively.

- GCA effects of testers were calculated as follows:

$$g_j = \frac{\sum Y.j.}{Lr} - \frac{Y..}{Ltr}$$

Where:

Y. j. : Total of i^{th} tester over lines.

-The estimates of SCA effects:-

The values of SCA effects were determined as follows:

$$Sij = \frac{Yij.}{r} - \frac{Yi..}{rt} - \frac{Y.j.}{rL} + \frac{Y..}{L+r}$$

Where:

Yij. = Value of i^{th} line with i^{th} tester

The estimates of standard error (S.E) pertaining to GCA effects of lines and testers and SCA effect of different combinations were calculated as follows:

$$\text{SE (GCA for lines)} = \sqrt{\frac{Me}{rt}}$$

$$\text{SE (GCA for testers)} = \sqrt{\frac{Me}{rL}}$$

$$\text{SE (SCA effects for combinations)} = \sqrt{\frac{Me}{r}}$$

$$\text{LSD} = t_{\substack{0.05 \\ 0.01}} \times SE$$

RESULTS AND DISCUSSION

Analysis of variance:

The analysis of variance revealed that the variations among genotypes (parents lines with their crosses) were highly significant for all the studied characters in both seasons and in their combined analysis (Tables 1 and 2). The parents, crosses and their interaction (parents vs. crosses) showed significant or highly significant mean squars for all studied traits except for parents in number of fertile tillers per plant and P vs. Cr in grain yield /plant which were not significant at the second season. The mean square values of lines, testers and line x tester (Tables 1 and 2) also were show significant or highly significant for all the studied characters in both seasons and their combined analysis except for testers for number of fertile tillers per plant in the second season, line x tester for number of fertile tillers per plant in both seasons and line x tester for 1000-grain weight in the second season that were not significant .The significance of the mean squares due to lines and testers indicated a prevalence of additive variance. Several studies reported the predominance of dominant gene action for the majority of the yield traits (Peng and Virmani 1990, Ramaligan *et al*. 1993 and Stayanarayana *et al*., 1998). Also EL-Mowafi 2001, Singh and Kumar 2004, EL-Mowafi *et al*., 2005 and Abd EL-Hadi and EL-Mowafi 2005 had reported the same trend of results.

T1

T2

Mean performances:

Mean performances of the three tested CMS (female parents) lines, seven testers as male parents and their F_1 hybrid combinations (21 hybrids) of the line x tester for heading date, panicle length and seed set % during 2011and 2012 seasons and their combined are shown in Table (3).

The results indicated that mean performances for the three agronomic traits, showed highly significant difference among genotypes. The CMS K17 line was the most earlier female parental line in heading (85.67 days) with high differences (13-15 days) comparing to the other CMS lines. While, Giza 179R was the earlier restorer line (90.50days) with high differences compared with all other testers. The hybrid rice combinations K17A × Giza 179 gave the lowest mean value (82.00 days), but IR70368A× Giza 181 (102.17) was the latest for heading date.

Table (3):The mean performance of lines, testers and their 21 F1 crosses for days to heading, panicle length and seed set % traits during 2011 and 2012 seasons and their combined data.

Genotypes	Days to heading (days)			Panicle length (cm)			Seed set %		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
CMS lines (female):									
IR69625A	99.33	101.67	100.50	24.00	23.83	23.92	12.40	13.83	13.12
IR70368A	99.00	98.67	98.83	22.00	24.87	23.43	11.78	12.00	11.89
K17A	85.33	86.00	85.67	22.17	23.70	22.93	13.67	13.67	13.67
Testers (Males):									
Giza 178R	98.67	97.67	98.17	20.67	22.67	21.67	95.36	95.35	95.36
Giza 179R	91.00	90.00	90.50	23.33	22.00	22.67	97.05	97.57	97.31
GZ 6296	93.00	94.67	93.83	23.55	22.33	22.94	93.43	96.13	94.78
Giza 181R	103.67	103.33	103.50	20.11	21.67	20.89	89.63	88.16	88.89
Giza 182R	92.33	95.00	93.67	21.47	21.10	21.28	91.65	92.76	92.21
Sakha 105	91.00	92.00	91.50	25.00	24.83	24.92	95.19	95.42	95.30
HR195R	104.00	104.67	104.33	25.33	25.67	25.50	94.26	93.63	93.95
Hybrid combinations :									
IR69625A× Giza 178	91.67	92.67	92.17	24.67	26.00	25.33	95.75	93.25	94.50
IR69625A× Giza 179	89.67	89.67	89.67	22.00	22.67	22.33	91.16	92.35	91.76
IR69625A× GZ 6296	90.33	91.00	90.67	22.90	24.00	23.45	89.11	90.56	89.83
IR69625A× Giza 181	99.33	99.00	99.17	24.33	26.00	25.17	93.30	92.04	92.67
IR69625A× Giza 182	92.33	95.00	93.67	24.07	25.67	24.87	91.79	93.60	92.70
IR69625A× Sakha 105	87.00	87.00	87.00	25.73	26.67	26.20	18.39	16.55	17.47
IR69625A× HR195	98.67	97.67	98.17	26.87	27.57	27.22	96.91	97.15	97.03
IR70368A× Giza 178	90.00	92.33	91.17	21.97	23.77	22.87	92.67	94.54	93.60
IR70368A× Giza 179	86.33	89.00	87.67	21.67	24.07	22.87	89.28	89.97	89.63
IR70368A× GZ 6296	98.00	97.33	97.67	24.20	24.00	24.10	82.78	88.60	85.69
IR70368A× Giza 181	102.67	101.67	102.17	25.00	26.67	25.83	91.80	91.97	91.88
IR70368A× Giza 182	90.33	89.67	90.00	23.33	24.07	23.70	76.48	79.81	78.14
IR70368A× Sakha 105	85.67	85.67	85.67	15.83	19.13	17.48	16.67	17.67	17.17
IR70368A× HR195	88.67	87.33	88.00	26.67	25.40	26.03	88.84	90.96	89.90
K17A × Giza 178	89.00	89.33	89.17	19.73	20.00	19.87	94.37	94.19	94.28
K17A × Giza 179	81.67	82.33	82.00	22.63	23.33	22.98	95.77	96.22	96.00
K17A × GZ 6296	92.00	95.67	93.83	23.53	24.00	23.77	90.68	91.08	90.88
K17A × Giza 181	94.00	95.33	94.67	24.67	25.10	24.88	92.14	92.55	92.35
K17A × Giza 182	86.67	84.67	85.67	24.00	25.33	24.67	83.80	83.92	83.86
K17A × Sakha 105	87.67	89.00	88.33	22.40	22.07	22.23	17.26	18.38	17.82
K17A × HR195	92.67	93.00	92.83	28.80	30.00	29.40	96.65	96.48	96.57
LSD 0.05	2.425	2.726	1.787	2.356	2.115	1.551	2.444	2.444	1.694
0.01	3.225	3.625	2.344	3.134	2.841	2.035	3.250	3.251	2.221

The mean values of panicle length for the female and male parents ranged from 20.89 cm to 25.50 cm of the parents; Giza 181 and HR195R, respectively, while, the F_1 mean values ranged from 17.48 to 29.40 cm for the hybrids IR70368A.×Sakha 105R and K17A×HR195R, respectively. For panicle length trait, the tester line HR195rwas produced the longest panicles (25.50 cm). In addition, the F_1 hybrid combinations K17A×HR195R recorded the highest mean panicle length (29.40 cm). Mean values of this trait were more than the longest panicle of the two corresponding parents. Most of these findings suggested the presence of dominance and over-dominance effects for longest panicle over the shortest panicles.

The seed set of CMS lines (female parent) was due to out crossing, thus these three lines are male sterile and the built grains come through cross pollination. Therefore, they showed low seed set % ranging from 11.89% for IR 70368A to 13.67% for K17A.

Also to seed set trait, the tester lines Giza 179R, Giza 178R and Sakha 105 revealed the highest mean values among parental lines with means of 97.31, 95.36 and 95.30 %, respectively. Consequently, the hybrid combinations IR69625A×HR195R, K17A×HR195R and K17A×Giza179R showed the highest mean values (97.03, 96.57 and 96.00 %, respectively). On the contrary, the hybrid combinations, IR69625A× Sakha 105R, IR70368A.×Sakha 105R and K17A×Sakha 105R gave the lowest mean values which ranged from 17.17 to 17.82 %, these results indicated that the cross between pure *Indica* (Female) and pure *Japonica* (male) showed complete to partial sterility in F_1 generation.

Mean performances of the three CMS (female parents) lines, seven testers as male parents and their F_1 hybrid combinations (21 hybrids) of the line x tester for number of fertile tillers / plant, 1000-grain weight and grain yield/plant in 2011and 2012 seasons and their combined as are presented in Table (4).

Concerning the number of fertile tillers / plant, the highest mean values were recorded for IR70368A, Giza 178R and HR195R among all parental lines (males and females) with mean values of 20.83, 22.67 and 24.17 tillerrs respectively. Moreover, the hybrid combinations; IR69625A× GZ6296-12-1-2-1-1R (23.83), IR69625A× Giza178R (23.00) and IR69625A× Giza182R (22.67) recorded the highest number of fertile tillers/ plant.

In the case of 1000- grain weight, collected data revealed that the parental lines IR70368A, Giza 179R, Sakha 105R and GZ 6296R showed the heaviest grains with the means of 23.83, 24.48, 24.00 and 23.93g, respectively. At the same time, the hybrid combinations K17A× HR195R, IR69625A× Giza179R, IR70368A× Gz6296R and K17A× Giza178r exhibited the heaviest grains with the means of 27.52, 26.27, 25.90 and 25.88 g, respectively. On the contrary, the tester line Giza178R and the hybrid combinations IR69625A× Giza181R recorded the lowest mean values with means 22.63 and 21.01g, respectively.

Highly significant differences were recorded for grain yield/plant trait. The IR69625A showed the highest mean value (14.00 g) as a female line and the male parent tester Giza179R, showed the highest mean value (50.33 g) for yield/plant. The most desirable mean values were recorded for the

hybrid rice combinations; IR69625A× Giza178R (51.67g), IR69625A× Giza179R (51.67g), K17A× Giza178r (45.33g) and IR69625A× HR195R (45.17g). Although, the first hybrid combination (IR69625A× Giza178R and IR69625A× Giza179R) were significantly different from others.

Table (4): The mean performance of lines, testers and their 21 F_1 crosses for no. of fertile tillers / plant, 1000-grain weight and grain yield/P traits during 2011 and 2012 seasons and their combined data.

Genotypes	No. of fertile tillers / plant			1000-grain weight (g)			Grain yield/P (g)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
CMS lines (female):									
IR69625A.	16.00	20.33	18.17	23.47	23.04	23.25	35.49	35.53	35.51
IR70368A.	21.33	20.33	20.83	23.50	24.17	23.83	38.63	38.23	38.43
K17A	18.67	21.33	20.00	23.58	23.28	23.43	34.28	32.98	33.63
Testers (Males):									
Giza 178	24.33	21.00	22.67	20.29	21.72	21.01	40.00	40.00	40.00
Giza 179	22.00	22.67	22.33	24.61	24.34	24.48	52.33	48.33	50.33
GZ 6296	24.67	20.00	22.33	23.83	24.03	23.93	40.67	41.00	40.83
Giza 181	25.33	21.00	23.17	22.33	22.00	22.17	38.33	36.67	37.50
Giza 182	24.00	20.67	22.33	23.27	23.07	23.17	40.67	38.67	39.67
Sakha 105	23.67	21.33	22.50	24.00	24.00	24.00	38.33	40.00	39.17
HR195	26.00	22.33	24.17	22.61	22.67	22.64	34.33	30.67	32.50
Hybrid combinations :									
IR69625A.× Giza 178	25.00	21.00	23.00	24.60	23.67	24.13	51.00	52.33	51.67
IR69625A.× Giza 179	21.33	20.00	20.67	26.20	26.33	26.27	51.67	51.67	51.67
IR69625A.× GZ 6296	23.67	24.00	23.83	24.00	24.00	24.00	43.33	41.33	42.33
IR69625A.× Giza 181	21.33	22.00	21.67	22.67	22.60	22.63	43.33	42.67	43.00
IR69625A.× Giza 182	24.67	20.67	22.67	23.80	24.60	24.20	35.33	41.00	38.17
IR69625A.× Sakha 105	21.67	20.00	20.83	24.53	24.63	24.58	14.33	15.67	15.00
IR69625A.× HR195	23.00	20.33	21.67	25.13	25.07	25.10	47.33	43.00	45.17
IR70368A.× Giza 178	22.00	20.33	21.17	25.67	26.07	25.87	43.00	41.33	42.17
IR70368A.× Giza 179	20.33	21.33	20.83	26.00	25.20	25.60	38.67	39.67	39.17
IR70368A.× GZ 6296	21.00	20.00	20.50	26.00	25.80	25.90	35.00	39.33	37.17
IR70368A.× Giza 181	20.00	21.00	20.50	24.33	25.43	24.88	36.00	38.33	37.17
IR70368A.× Giza 182	20.33	19.33	19.83	25.07	24.80	24.93	40.00	38.33	39.17
IR70368A.× Sakha 105	20.00	21.00	20.50	23.67	24.14	23.90	20.00	18.33	19.17
IR70368A.× HR195	20.33	21.00	20.67	25.40	26.20	25.80	40.67	39.33	40.00
K17A × Giza 178	21.00	19.33	20.17	25.73	26.03	25.88	46.33	44.33	45.33
K17A × Giza 179	18.67	20.33	19.50	24.53	25.53	25.03	40.00	39.67	39.83
K17A × GZ 6296	18.00	19.67	18.83	25.43	25.13	25.28	36.33	34.67	35.50
K17A × Giza 181	19.67	18.33	19.00	25.50	25.33	25.42	32.33	35.00	33.67
K17A × Giza 182	20.33	19.00	19.67	25.07	24.87	24.97	34.00	36.00	35.00
K17A × Sakha 105	18.00	20.00	19.00	24.22	26.33	25.28	15.33	18.33	16.83
K17A × HR195	20.67	20.33	20.50	28.30	26.73	27.52	37.78	39.67	38.73
LSD 0.05	2.064	2.246	1.495	1.417	1.424	0.984	4.929	4.180	3.167
0.01	2.740	2.988	1.960	1.885	1.340	1.290	6.556	5.562	4.153

Combining ability effects:

1-General combining ability effects (GCA)

Significant differences of GCA were observed among the (CMS) lines for the traits as shown in Table (5). The female parents (CMS) showed significant GCA values for days to heading. The results indicated that, K17A

was the best combiner for early heading with high significant and negative estimates of GCA effects. On the other hand, IR69625A showed high significant and positive estimates of GCA. Among the tester lines, the tester lines Giza 179 and Sakha 105 showed highly significant negative value for days to heading. These lines have to be good combiners for earliness and could be useful to breed early maturing rice cultivars .

The line IR69625A appeared to be a good combiner with new hybrid combinations for panicle length trait, while, K17A gave insignificant and negative estimate of GCA effects. Among the testers, HR195R, Giza181R had significant and positive estimate for panicle length trait, while, Sakha105R was the lowest combiner with significant and negative estimates.

Concerning the seed set %, IR69625A and K17A as female parents showed significant GCA estimates, while the tester lines; HR195R, Giza178R and Giza179R gave highly significant and positive values. Swamy *et al*., (2003) identified two good combiner parents for improved fertility percentage in rice. The results of EL-Mowafi (2001), Alam *et al.* (2004)and Abd EL-Hadi and EL-Mowafi *et al*. (2005) agreed with the present results.

Table (5):GCA estimates of the rice hybrid combinations (crosses) for days to heading, panicle length and seed set % traits in rice during 2011 , 2012 seasons and their combined.

Genotypes	Days to heading(days)			Panicle length (cm)			Seed set %		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
IR69625A.	1.556**	1.508	1.532**	0.795*	0.962**	0.879**	2.079**	1.175**	1.627**
IR70368A.	0.508	0.222	0.365	-0.905**	-0.676*	-0.791**	-3.337**	-1.967**	-2.652**
K17A	-2.063**	-1.730**	-1.897**	0.110	-0.286	-0.088	1.258**	0.792*	1.025**
Giza 178R	-0.937	-0.190	-0.564	-1.449**	-1.292**	-1.371**	13.994**	12.952**	13.473**
Giza 179R	-5.270**	-4.635**	-4.952**	-1.471**	-1.192**	-1.332**	11.805**	11.808**	11.807**
GZ 6296R	2.286**	3.032**	2.659**	-0.027	-0.548	-0.287	7.256**	9.041**	8.149**
Giza 181R	7.508**	7.032**	7.270**	1.095*	1.375**	1.235**	12.146**	11.148**	11.647**
Giza 182R	-1.381**	-1.857**	-1.619**	0.229	0.475	0.352	3.756**	4.736**	4.246**
Sakha 105R	-4.381**	-4.413**	-4.397**	-2.249**	-1.925**	-2.087**	-62.827**	-63.507**	-63.167**
HR195R	2.175**	1.032	1.603**	3.873**	3.108**	3.491**	13.869**	13.822**	13.845**
LSDL 0.05	0.648	0.720	0.477	0.629	0.565	0.414	0.652	0.652	0.452
0.01	0.860	0.960	0.626	0.835	0.752	0.543	0.867	0.867	0.593
LSDT 0.05	0.990	1.112	0.729	0.962	0.863	0.633	0.976	0.978	0.691
0.01	1.316	1.48	0.957	1.279	1.148	0.830	1.282	1.282	0.906

*** , ** Significant at 0.05 and 0.01 levels of probability, respectively**

The estimated values of GCA for each line and tester for fertile tillers/plant, 1000-grain weight (g) and grain yield/plant (g) are presented in Table (6). For fertile tillers/plant, the data showed that IR69625A as female line and Giza178R as male line were the best combiner with significant and positive estimates of GCA effects. On the contrary, K17A was the lowest combiner with high significant and negative value. The values of GCA for fertile tillers/plant are in agreement with the results reported by Mehla et al., (2000), Rosamma and Vijayakumar (2005) and Kumar et al., (2007).

The lines; K17A and IR70368A showed highly significant and positive value for GCA estimates for 1000-grain weight, also, the HR195R tester showed highly significant and positive value. For grain yield/plant IR69625A line gave highly significant and positive GCA value and so appeared to be good parental combiner in hybrid combinations for grain yield/plant. On the

other hand, Giza178R ,Giza179R and Giza181R as testers gave highly significant and positive estimate of GCA. The positive values of GCA mean increased for grain yield/plant which could be useful in breeding programs for high yield potential rice cultivars.

Table (6): GCA estimates of the parents lines for no. of fertile tillers / plant, 1000-grain weight and grain yield/P traits in rice during 2011 , 2012 seasons and their combined.

Genotypes	No. of fertile tillers / plant			1000-grain weight (g)			Grain yield/plant (g)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
IR69625A.	1.952**	0.714*	1.333**	-0.984**	-1.066**	-1.025**	3.677**	3.476**	3.577**
IR70368A.	-0.429	0.143	-0.143	0.483*	0.524**	0.504**	-1.037	-1.238*	-1.138*
K17A	-1.524**	-0.857**	-1.191**	0.500*	0.542**	0.521**	-2.640**	-2.238**	-2.439**
Giza 178R	1.667**	-0.206	0.730*	0.294	0.090	0.192	9.550**	8.381**	8.966**
Giza 179R	-0.889**	0.127	-0.381	-0.307	-0.209	-0.258	6.217**	6.048**	6.132**
GZ 6296R	-0.111	0.794*	0.341	0.104	-0.189	-0.043	0.994	0.825	0.910
Giza 181R	-0.667	0.016	-0.325	-0.874*	-0.712*	-0.793**	-0.006	1.048	0.521
Giza 182R	0.778	-0.762*	0.008	-0.396	-0.412	-0.404**	-0.783	0.825	0.021
Sakha 105R	-1.111*	-0.095	-0.603	-0.056	0.600	0.272	-20.672**	-20.175**	-20.423**
HR195R	0.333	0.127	0.230	1.237**	0.833**	1.035**	4.700**	3.048**	3.874**
LSDL 0.05	0.550	0.180	0.399	0.378	0.380	0.263	1.316	1.116	0.846
0.01	0.731	0.798	0.523	0.502	0.505	0.345	1.750	1.484	1.110
LSDT 0.05	0.842	0.60	0.610	0.578	0.580	0.401	1.960	1.671	1.293
0.01	1.119	0.798	0.800	0.768	0.771	0.527	2.588	2.192	1.695

*** , ** Significant at 0.05 and 0.01 levels, respectively**

2- Specific combining ability effects (SCA)

Estimates of SCA effects for each F_1 hybrid combination for days to heading, panicle length and seed set% are shown in Table (7). For days to heading. Seven crosses out of 21 hybrid combinations were found to show negatively significant or highly significant SCA effects. The useful observed negative significant values of SCA effects are(desirable) in some hybrid combinations. The best hybrids were IR70368A.× HR195 and IR69625A× GZ 6296R. For panicle length trait, seven cross combinations exhibited highly significant positive SCA effects, K17AxHR195R gave the highest significant SCA effects comparing to other hybrid combinations. Respecting seed set % trait, the data indicated that, five cross combinations IR69625A× Giza 182R, K17 x Giza 179R, IR70368A x Sakha 105R, IR70368A x Giza181R and IR70368A x Giza 178R exhibited highly significant and positive SCA estimates. Similar results were observed by EL-Mowafi (2001) and Abd El-Hady *et al*.(2013).

Estimates of SCA for each F_1 hybrid combination for number of fertile tillers/plant, 1000-grain weight (g) and Grain yield/plant (g) are presented in Table (8). Regarding to the number of fertile tillers/plant, the hybrid combination IR69625A x GZ6296R out of 21 hybrid combination showed positively significant SCA effects. For 1000 grain weight one cross combination (K17Ax HR195R) showed significant and positive SCA effects. Concerning, grain yield/plant, three cross combinations i.e. IR69625A× Giza 179R, IR70368A x Giza 181R and K17A x Sakha 105R combination showed positive significant or highly significant SCA estimates.

In conclusion, it is clear that the hybrid combination IR69625A× Giza 179R seemed promising hybrid for earliness and high grain yield.

Table (7):SCA estimates of the rice hybrid combinations (crosses) for days to heading, panicle length and seed set % traits in rice during 2011 , 2012 seasons and their combined.

Genotypes	Days to heading(days)			Panicle length (cm)			Seed set %		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
IR69625A× Giza 178R	-0.111	-0.286	-0.198	1.749*	1.783*	1.766**	-0.593	-1.917*	-1.255*
IR69625A× Giza 179R	2.222*	1.159	1.690**	-0.895	-1.651*	-1.273**	-2.988**	-1.670	-2.329**
IR69625A× GZ 6296R	-4.667**	-5.175**	-4.921**	-1.440	-0.962	-1.201**	-0.492	-0.700	-0.596
IR69625A× Giza 181R	-0.889	-1.175	-1.032	-1.129	-0.884	-1.006**	-1.192	-1.320	-1.256*
IR69625A× Giza 182R	1.000	3.714**	2.357**	-0.529	-0.317	-0.423	5.691**	6.653**	6.172**
IR69625A× Sakha 105R	-1.333	-1.730	-1.532*	3.616**	3.083**	3.349**	-1.125	-2.159**	-1.642**
IR69625A× HR195R	3.778**	3.492**	3.635**	-1.373	-1.051	-1.212**	0.699	1.113	0.906
IR70368A× Giza 178R	-0.730	0.667	-0.032	0.749	1.187	0.968**	1.743*	2.512**	2.127**
IR70368A× Giza 179R	-0.063	1.778	0.857	0.471	1.387	0.929**	0.545	-0.911	-0.183
IR70368A× GZ 6296R	4.048**	2.444*	3.246**	1.560	0.676	1.118**	-1.406	0.489	-0.458
IR70368A× Giza 181R	3.492**	2.778**	3.135**	1.238	1.421	1.329**	2.720**	1.746*	2.233**
IR70368A× Giza 182R	0.048	-0.333	-0.143	0.438	-0.279	0.079	-4.206**	-4.002**	-4.104**
IR70368A× Sakha 105R	-1.619	-1.778	-1.698**	-4.584**	-2.813**	-3.698**	-2.567**	2.104	2.336**
IR70368A× HR195R	-5.175**	-5.556**	-5.365**	0.127	-1.579*	-0.726*	-1.959*	-1.935*	-1.947**
K17A × Giza 178R	0.841	-0.381	0.230	-2.498**	-2.970**	-2.734**	-1.149	-0.594	-0.872
K17A × Giza 179R	-2.159*	-2.937**	-2.548**	0.424	0.263	0.344	2.443	2.580**	2.512**
K17A × GZ 6296	0.619	2.730**	1.675**	-0.121	0.286	0.083	1.898*	0.210	1.054
K17A × Giza 181R	-2.603**	-1.603	-2.103**	-0.110	-0.537	-0.323	-1.528	-0.426	-0.977
K17A × Giza 182R	-1.048	-3.381**	-2.214**	0.090	0.597	0.344	-1.485	-2.651**	-2.068**
K17A × Sakha 105R	2.952**	3.508**	3.230**	0.968	-0.270	0.349	-1.438	0.058	-0.690
K17A × HR195R	1.397	2.063**	1.730	1.246	2.630**	1.938**	1.260	0.823	1.041
LSD 0.05	1.714	1.926	1.264	1.666	1.496	0.614	1.728	1.693	1.197
0.01	2.279	2.561	1.657	2.215	1.989	0.805	2.298	2.220	1.570

- **, ** Significant at 0.05 and 0.01 levels of probability, respectively**

Table (8): SCA estimates of the parents lines for no. of fertile tillers / plant, 1000-grain weight and grain yield/P traits in rice during 2011 , 2012 seasons and their combined.

Genotypes	No. of fertile tillers / plant			1000-grain weight (g)			Grain yield/P (g)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
IR69625A× Giza 178R	0.381	0.063	0.222	0.249	-0.524	-0.137	0.545	2.857	1.701
IR69625A× Giza 179R	-0.730	-1.270	-1.000	-0.083	0.248	0.083	4.545**	4.524**	4.535**
IR69625A.× GZ 6296R	0.825	2.063	1.444**	-0.161	0.088	-0.036	1.434	-0.587	0.423
IR69625A× Giza 181R	-0.952	0.841	-0.056	-0.516	-0.789	-0.653	2.434	0.524	1.479
IR69625A× Giza 182R	0.937	0.286	0.611	0.139	0.911	0.525	-4.788**	-0.921	-2.854**
IR69625A× Sakha 105R	-0.175	-1.048	-0.611	0.533	-0.067	0.233	-5.899**	-5.254**	-5.577**
IR69625A× HR195R	-0.286	-0.937	-0.611	-0.161	0.133	-0.014	1.729	-1.143	0.293
IR70368A× Giza 178R	-0.238	-0.032	-0.135	-0.148	0.290	0.071	-2.740	-3.429*	-3.085**
IR70368A× Giza 179R	0.651	0.635	0.643	0.783	-0.282	0.251	-3.740*	-2.762	-3.251**
IR70368A× GZ 6296R	0.540	-1.365	-0.413	0.372	0.298	0.335	-2.185	2.127	-0.029
IR70368A× Giza 181R	0.095	0.413	0.254	-0.317	0.454	0.069	-0.185	0.905	0.360
IR70368A× Giza 182R	-1.016	-0.476	-0.746	-0.061	-0.479	-0.270	4.593**	1.127	2.860*
IR70368A× Sakha 105R	0.540	0.524	0.532	0.732	0.043	0.387	-38.937**	-40.732**	-39.814**
IR70368A× HR195R	-0.571	0.302	-0.135	-1.361**	-0.324	-0.843*	-0.224	-0.095	-0.160
K17A × Giza 178R	-0.143	-0.032	-0.087	-0.101	0.234	0.067	2.195	0.571	1.383
K17A × Giza 179R	0.079	0.635	0.357	-0.700	0.033	-0.333	-0.805	-1.762	-1.283
K17A × GZ 6296R	-1.365	-0.698	-1.032	-0.211	-0.387	-0.299	0.751	-1.540	-0.394
K17A × Giza 181R	0.857	-1.254	-0.198	0.833	0.335	0.584	-2.249	-1.429	-1.839
K17A × Giza 182R	0.079	0.190	0.135	-0.078	-0.431	-0.255	0.195	-0.206	-0.006
K17A × Sakha 105R	-0.365	0.524	0.079	-1.265**	0.024	-0.620	1.417	3.127*	2.272*
K17A × HR195R	0.857	0.635	0.746	1.522**	0.191	0.857*	-1.505	1.238	-0.133
LSD 0.05	1.460	1.588	1.057	1.007	1.00	0.696	3.485	2.955	2.239
0.01	1.941	2.112	1.386	1.339	1.339	0.912	4.636	3.930	2.937

*** , ** Significant at 0.05 and 0.01 levels of probability, respectively**

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دراسة القدرة على التآلف لصفة محصول الحبوب وبعض الصفات المرتبطة به في بعض سلالات الأرز

محمود سليمان سلطان[١]، محمود إبراهيم أبو يوسف[٢] ، مأمون أحمد عبد المنعم[١] و مصطفى ممدوح عبد الحى الشناوى[٢]

١- قسم المحاصيل، كلية الزراعة، جامعة المنصورة، مصر

٢- قسم بحوث الارز، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، الجيزة، مصر

أجريت هذه الدراسة بمركز البحوث والتدريب في الأرز بسخا - كفر الشيخ. بغرض دراسة إمكانية استغلال القدرة على الائتلاف في بعض سلالات الأرز الهجين وذلك باستخدام تحليل السلالة x الكشاف لثلاث سلالات عقيمة ذكريا (CMS lines) استخدمت كأمهات وسبعة أصناف وسلالات مصرية وأجنبية معيدة للخصوبة (Restorer lines) كآباء خلال مواسم الزراعة٢٠١٠، ٢٠١١ و٢٠١٢م وذلك لمتابعة هذه الهجن وإنتاجها بشكل تجارى واسع كما تمت دراسة القدرة على الائتلاف والارتباط بين قوة الهجين وكلا من القدرة العامة على الائتلاف والقدرة الخاصة على الائتلاف لكلا الأبوين الداخلين في الهجين وكذلك دراسة فعل الجين لإمكانية متابعة التربية والانتخاب لهجن تستخدم في الأجيال الانعزالية المتقدمة لتحسين السلالات الأبوية في الصفات المرغوبة . وقد أوضحت نتائج تحليل القياسات الوراثية أن الفعل الإضافى (Additive) هو الذي يتحكم في صفات التراكيب الوراثية المستخدمة بصورة كبيرة وكذلك أوضحت النتائج أن القدرة العامة على الائتلاف (GCA) كانت أكثر تأثيرا. وأن أهم النتائج المتحصل عليها تفيد بأن هناك فروق معنوية بين السلالات المستخدمة والهجن الناتجة منها وأن الهجين (IR69625A× Giza 179) هو أفضل الهجن المتحصل عليها من حيث كمية محصول الحبوب. ولذلك يمكن الاستفادة من هذا الهجين كصنف أرز هجين مبكر في النضج ومتفوق في المحصول.

قام بتحكيم البحث

أ.د / عبد الرحيم عبد الرحيم ليلة	**كلية الزراعة – جامعة المنصورة**
أ.د / عبد العزيزجلال إبراهيم عبد الحافظ	**كلية الزراعة – جامعة كفر الشيخ**

Table (1): Mean squares (MS) of line x tester analysis for days to heading, panicle length and seed set % traits during 2011 and 2012 seasons and their combined data.

S.V.	DF		Days to heading			Panicle length			Seed set %		
	Single	Comb.	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
Years (Y.)	-	1	-	-	12.909	-	-	31.571**	-	-	20.038
Reps/ Y.	-	4	-	-	9.780	-	-	0.831	-	-	3.285
Genotypes (G)	(30)	(30)	100.141**	98.242**	195.463**	17.690**	15.057**	30.809**	2896.400**	2910.716**	5803.393**
Parents (P)	9	9	111.837**	108.107**	217.372**	9.377**	7.124**	13.502**	4626.238**	4610.207**	9234.498**
Parents vs. crosses	1	1	425.291**	455.011**	880.05**	13.304*	33.346**	44.392**	2381.464**	2543.047**	4923.128**
Crosses (Cr)	20	20	78.621**	75.963**	151.375**	21.651**	17.712**	37.918**	2143.719**	2164.329**	4303.409**
Lines (L)	2	2	72.825**	55.825**	127.627**	15.361**	15.373**	29.495**	178.918**	61.718**	225.357**
Testers (T)	6	6	174.106**	156.212**	327.86**	38.366**	28.307**	65.771**	7033.598**	7139.662**	14168.241**
L x T	12	12	31.844**	39.196**	67.09**	14.342**	12.804**	25.395**	26.247**	27.097**	50.669**
G x Y.	-	(30)	-	-	2.920	-	-	1.939	-	-	3.727*
P xY	-	9	-	-	2.572	-	-	3.000	-	-	1.967
P vs. Cr x Y.	-	1	-	-	0.252	-	-	2.27	-	-	1.327
Cr x Y.	-	20	-	-	3.210	-	-	1.445	-	-	4.639**
L x Y.	-	2	-	-	1.023	-	-	1.239	-	-	15.279**
T x Y.	-	6	-	-	2.458	-	-	0.902	-	-	5.019*
L x T x Y.	-	12	-	-	3.95	-	-	1.751	-	-	2.675
Error	60	120	2.206	2.787	2.496	2.083	1.679	1.881	2.240	2.241	2.241

*** , ** Significant at 0.05 and 0.01 levels of probability, respectively**

Table (2): Estimates of the mean squares(MS) of line x tester analysis for no. of fertile tillers / plant, 1000-grain weight and grain yield/P traits during 2011 and 2012 seasons and their combined data.

S.O.V.	DF		No. of fertile tillers / plant			1000-grain weight			Grain yield/plant		
	Single	Comb.	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
Years (Y.)	-	1	-	-	35.274*	-	-	0.589	-	-	0.375
Reps/ Y.	-	4	-	-	3.452	-	-	2.831	-	-	16.17
Genotypes (G)	(30)	(30)	17.908**	3.732*	13.943**	6.435**	5.342**	11.011**	233.62 **	202.89**	428.24 **
Parents (P)	9	9	30.133**	2.226	17.943**	4.292**	2.508**	6.308**	80.254 **	70.234 **	145.68 **
Parents vs. crosses	1	1	52.026**	9.162*	52.423**	72.758**	76.077**	148.838**	87.858 **	7.025	72.286**
Crosses (Cr)	20	20	10.700**	4.138*	10.219**	4.083**	3.081**	6.236**	309.929**	272.376**	573.188**
Lines (L)	2	2	66.333**	13.286**	67.524**	15.241**	17.906**	33.093**	226.423**	195.571**	420.725**
Testers (T)	6	6	8.963**	1.942	3.952*	3.969**	2.725**	6.126**	871.324**	788.365**	1653.615**
L x T	1 2	1 2	2.296	3.712	3.802*	2.280**	0.789	1.815*	43.148**	27.183**	58.385**
G x Y.	-	(30)	-	-	7.696**	-	-	0.766	-	-	8.275
P x Y.	-	9	-	-	14.417**	-	-	0.492	-	-	4.812
P vs. Cr x Y.	-	1	-	-	6.074	-	-	0.012	-	-	22.602
Cr x Y.	-	20	-	-	4.619**	-	-	0.927	-	-	9.117
L x Y.	-	2	-	-	12.095**	-	-	0.054	-	-	1.269
T x Y.	-	6	-	-	6.953**	-	-	0.568	-	-	6.074
L x T x Y.	-	1 2	-	-	2.206	-	-	1.254	-	-	11.95
Error	60	120	1.599	1.893	1.746	0.754	0.761	0.757	8.73	6.978	7.856

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