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Combining ability and some genetic parameters for yield and its related traits of rice (*Oryza sativa* L.) under lysimeter condition

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ABSTRACT

Salinity is a major abiotic constraint faced by farmers in many rice-growing regions of the world and improving grain yield in rice is the most important breeding objective. Thirty-five crosses were generated in a line x tester mating design by crossing seven lines with five testers and were evaluated in a randomized complete block design at the greenhouse lysimeter of Rice Research Department, Sakha, Kafr El-Sheikh, Egypt, during the two rice-growing seasons of May, 2021 and 2022. Analysis of variance revealed a highly significant difference among testers and lines for all the studied traits. Variances of specific combining ability were higher in magnitude than the corresponding general combining ability. The lines Sakha 107, Sakha 104, and Giza 182 including testers SAL 010, and CSR 28 were the best general combiners for grain yield plant^{-1} under saline conditions. The variety Giza 179 followed by Sakha 107 was the best general combiner for 100-grain weight under both normal and saline conditions. Two crosses Giza 179/MTU 1010 and Sakha 107/SAL 010 exhibited highly significant positive estimates of specific combining effects for grain yield plant^{-1}, respectively. Estimates of narrow sense heritability for all the traits under study were low which indicated a preponderance of non-additive gene action governing these traits. By selecting the appropriate genotypes and phenotypes, the outcomes will be beneficial in breeding salt-tolerant cultivars at both the seedling and reproductive stages.

Keywords: Rice, combining ability, heterosis, genetic components, gene action and salinity stress.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the important cereal crops throughout the world. Soil salinity is the most detrimental of the major abiotic factors, reducing cultivated land, crop production, and quality worldwide (Shrivastava and Kumar, 2015). A significant challenge to sustainable agriculture and food security is posed by the fact that 11.5% of the world's irrigated land has become saline and 19.5% is damaged by salt (FAO, 2018). The salt-affected area is further expected to increase by 50% by 2050 due to irrigation with saline water, high sea levels, and global warming potential (Arun*et et al.,* 2016; Song *et al.,* 2018). The most salt-sensitive cereal crop, rice is exceedingly sensitive to salinity stress. Several studies have indicated that rice is tolerant during germination but becomes extremely sensitive during early seedlings. It again becomes more tolerant throughout vegetative growth, reverting to sensitivity during pollination and fertilization, before becoming more tolerant once more at maturity (Lauchli and Grattan 2007; UADA 2016). The production of food crops is seriously affected by salinity. By decreasing the osmotic potential of soil solutes and making it more difficult for roots to extract water from their surrounding media, salinity causes a water deficit even in well-watered soils (Sairam *et al.,* 2002). Salts affect plant growth due to increasing soil osmotic pressure thus interfering with plant nutrition. A high salt concentration in soil solution reduces the ability of plants to acquire water, which is referred to as the osmotic or water deficit effect of salinity.

A two-phase model was proposed to depict the response of plant growth to salinity (Imolehin and Wada 2000). The first phase is very rapid and growth reduction is ascribed to the development of a water deficit. The second phase is due to the accumulation of salts in the shoot at toxic levels and is very slow. Salinity affects photosynthesis by decreasing CO2 availability as a result of diffusion limitations and a reduction of the contents of photosynthetic pigments (FAO, 2000). Soil salinity is one of the most serious constraints for rice production worldwide. This problem is further worsening because of climate change causing sea level rise and more frequent coastal storm incidences leading to salt intrusion in agricultural lands. Besides, poor water management practices, like poor drainage in irrigated areas, cause secondary salinization (Wassmann *et al.,* 2004; Ismail *et al.,* 2007; Qureshi and Al-Falahi, 2015). Salt-affected areas are estimated at over 800 million hectares worldwide, which is equivalent to more than 6% of the world's total land area. The detrimental effect of salinity on plant growth and productivity is associated with the low water potential of the root medium since an increase in soil salt concentration decreases osmotic potential and the ability of plants to take up water. Earlier studies on cereal crops conducted at the seedling stage suggested salt exclusion from leaves as the most important tolerance mechanism (James *et al.,* 2011; Platten *et al.,* 2013; Adem *et al.,* 2014; Ismail and Horie, 2017).

Most rice genotypes exhibit variable responses to salinity stress, which is also dependent on the developmental stage to which genotypes are exposed (Ismail and Horie, 2017). Several studies reported that rice is tolerant during germination, and then becomes sensitive at the early seedling stage, whereas gains tolerance at the vegetative stage and then becomes sensitive at the reproductive stage. Moreover, salinity tolerance at the seedling stage in rice is poorly associated with tolerance at the reproductive stage (Singh and Flowers 2010; Palao*et al.,* 2013). Salinity tolerance at the reproductive stage is important in areas where high salt stress is expected later in the season because at this stage pollination and formation of grains occur that directly contribute to economic yield. Therefore, in view of the recent changes in climatic conditions and variability, there is an urgent need to exploit natural variation in rice for salt tolerance at the reproductive stage, for the development of more resilient, salt-tolerant genotypes. The present research work was carried out with the objectives to estimate combining ability based on mean performance, genetic components, heterosis, and heterobeltiosis for yield and its related traits of rice.

MATERIALS AND METHODS

Experimental design and parental lines:

The present experiment was conducted at the Rice Research Department, Sakha, Kafr El-Sheikh, Egypt. The experimental material consisted of twelve parental lines and their thirty-five F_1 crosses according to the line x tester mating design (Kempthrone, 1957), during the May, 2021 and 2022 rice growing seasons. Seven Egyptian commercial varieties i.e., Giza 177, Giza 178, Giza 179, Giza 182, Sakha 104, Sakha 107, and Sakha 108 used as lines were crossed with five international diverse genotypes i.e., A 69-1, MTU 1010, CSR 28, SAL 010, and IRRI 123 used as testers and donors for salinity tolerance during the 2021 rice-growing season.

Greenhouse lysimeter condition:

A lysimeter experiment was carried out during the rice-growing season of 2022. Thirty-five crosses were planted in May along with the twelve parents in two treatments; well-watered control and salt stress conditions with the drip direct-seeded establishment. One well-watered control treatment and the other salt stress treatment for comparison. Four concrete tanks (1.00-m depth, 1.00-m width, and 1.00-m length) within the greenhouse were used, with three replicates of two treatments in each tank. The plants were grown in lysimeter constructed from concrete beds 2 m long x 1 m diameter, filled with soil to 100 cm depth in three layers; 60 cm clay at the surface layer, 20 cm sand at the middle layer, and 20 cm gravel at the bottom layer. Thus, the resultant thirty-five crosses along with their parents were evaluated in a randomized complete block design with three replications at the greenhouse lysimeter. Each replicates comprised 3 rows for each genotype, each row was 1 m long, and 15 x 15 cm apart was maintained between rows and seedlings.

All agricultural practices such as sowing date, fertilizer application, and weed control were applied as recommended. Salinity, irrigation, and drainage cycle were accurately controlled. The saline soil conditions were adjusted to 9.40.6 dSm^{-1} in addition; the normal soil conditions were irrigated with tap water. The mean value of electrical conductivity (EC) of irrigation water is 0.77 dSm^{-1} for normal otherwise and 9.40 dSm^{-1} at 25 °C for the saline soil condition.

Data Collection:

Five hills were randomly selected and the observed results to yield and eleven different yield-related traits were recorded as follows; days to 50% flowering (day), total chlorophyll (µg/ml), flag leaf area (cm^2), plant height (cm), number of panicles $plant^{-1}$, panicle length (cm), panicle weight (g), spikelets fertility (%), 1000-grain weight (g), grain yield $plant^{-1}$ (g) and harvest index (%). The general reference for data collection was a standard evaluation system (SES) for rice (Virmani *et al.,* 1997; Anonymous, 2002).

Statistical analysis:

The mean data of all traits were subjected to analysis of variance (ANOVA), to estimate significant differences among the parents and their crosses as suggested by Steel and Torrie (1980). Better parent heterosis or heterobeltiosis was calculated in spite of the increase or decrease better parent (Fehr, 1987). BPH (%) = $((\bar{Fl})-(\bar{BP})/BP)$ X 100**.** Better heterosis significance was determined by t test (Wynne *et al*., 1970) BP (t)‾= (F_1)‾BP/√ (2/r) EMS). Where F_1 is the mean square error. Combining ability analysis GCA and SCA effects and their variances were determined by line x tester analysis (Singh and Chaudhary, 1985). The analysis was done using the Agrobase software statistical package. Calculate dominance and additive genetic variances (*δ2A* and *δ2D*) with inbreeding coefficient (*F=1*) whereas, each testers and line were inbred. The general and specific combining ability effects significance test were done by using *t*-test. Assessed additive vs. non- additive type of gene actions relative weight were defined by (Verma and Srivastra, 2004).

RESULTS

Analysis of variance:

The presence of genetic variability is pre-requisite for the selection of superior genotypes during crop improvement programs. Therefore, the assessment of the extent of variation present in the genetic material is important to estimate the magnitude of improvement that can be achieved in breeding material for various characters. The analysis of variance revealed highly significant differences among genotypes, crosses, lines, testers, and line x tester were observed in all studied traits under both none and salinity stress conditions. Variations among parents and parent *vs.* crosses were highly significant for most of the studied traits as presented in **Table (1)**. The significance of the line x tester for all the traits provided a direct test, indicating that non-additive variances were important for the majority of these traits.

Mean performance:

The mean performance of lines, testers, and their 35 F_1 crosses for different traits under both none and stress salinity are shown in Table (2). For days to 50% flowering and plant height traits, the lowest mean values are desirable. Two genotypes, Giza 177 and MTU 1010 recorded the desirable mean values of 80.67 and 116.67 days to 50% flowering among lines and testers. While the crosses with the lowest mean values were obtained from two combinations Giza 177/IRRI 123 and Giza 179/MTU 1010 of 82.00 days under salt condition. With regard to plant height traits, among lines and testers, the data showed that the genotypes Giza 177 and SA L010 recorded the desirable mean values of 60.00 and 81.00 cm under salt condition. As regards the flag leaf area under salinity stress condition, the two parental lines A 69-1 and CSR 28 showed the maximum mean performance values of 25.87 and 28.49 cm^2, respectively. While the two crosses Sakha 107/CSR 28 and Giza 177/CSR 28 recorded the highest mean values of 36.36 and 39.53 cm^2 for the same trait, respectively.

Concerning the number of panicles $plant^{-1}$, the three parental genotypes Giza 182, MTU 1010, and CSR 28 exhibited the highest mean values of 7.33 and 6.67 panicles $plant^{-1}$ under salinity stress. The two crosses Giza 179/CSR 28 and Giza 182/CSR 28 were identified as good-performing combinations and recorded the highest mean values of 12.67 panicles $plant^{-1}$ under the same condition. For panicle length under salt-stress condition, the three parental lines, A 69-1, CSR 28, and IRRI 123 exhibited the highest mean values of 22.67 cm. Among cross combinations, the highest mean values were observed in the two crosses Giza 178/CSR 28 and Giza 182/CSR 28 (24.67 and 25.00, receptively). Regarding the panicle weight, the parental genotype CSR 28 among lines and testers recorded the highest mean value of 2.78 g. In the meantime, the hybrid combination Giza 178/CSR 28 exhibited the highest mean value of 3.64 g under saline condition.

As regards the 100-grain weight under salt stress condition, the two parental lines SAL 010 and A 69-1 showed the maximum mean performance values of 2.37 and 2.60 g, respectively. While, the two crosses Giza 182/A 69-1 and Sakha 107/CSR 28 recorded the highest mean values of 2.65 and 2.68 g for the same trait, respectively. Additionally, in terms of the spikelets fertility percent under salt stress conditions, the two parental varieties, CSR 28 and Sakha 107 recorded the highest mean values of 83.89 and 84.57%, respectively. In this concern, the two crosses Sakha 108/SAL 010 and Giza 179/CSR 28 recorded the highest mean values of 85.57 and 89.41%, respectively under the same condition. For grain yield $plant^{-1}$, among lines and testers, the parental lines Giza 182 and CSR 28 recorded the highest mean value of 13.82 and 17.05 g, receptively. While the highest mean values were observed in the two cross combinations Sakha 107/CSR 28 and Sakha 107/SAL 010 of 23.68 and 25.94 g, respectively under salinity stress condition. Additionally, in terms of harvest index percentage under salinity stress condition, the two parental varieties, CSR 28 and A 69-1 recorded the highest mean values of 46.70 and 49.66%, respectively. In this concern, the two crosses Sakha 108/IRRI 123 and Sakha 108/CSR 28 recorded the highest mean values of 48.78 and 50.12% respectively, while the minimum value (24.37%) was obtained from the cross combination of Giza 179/IRRI 123. Among lines and testers, the two genotypes MTU 1010 and CSR 28 exhibited the highest total chlorophyll under salinity conditions. The differences among the crosses were highly significant, under the same condition the five crosses, Giza 182/CSR 28, Giza 182/IRRI 123, Sakha 107/CSR 28, Sakha 107/SAL 010, and Sakha 107/IRRI 123 revealed the highest total chlorophyll.

General Combining Ability (GCA) Effects:

For the illustrating genetic worth of parents for the hybridization program, the general combining ability effects of twelve parents for all traits are consolidated in Table (3). The negative estimates of GCA effects are desirable for earliness, and medium dwarf plant height. Among the studied lines and testers under salinity stress conditions, the parental line Giza 177 was observed to have good GCA effects and desirable direction for days to 50% flowering and plant height traits, followed by the parental line MTU 1010 for days to 50% flowering and the genotype IRRI 123 for plant height trait, which recorded significant and negative GCA effects under both normal and salinity condition. In the current study, parents with high mean and positive GCA are preferred for positive grain yield characteristics, whereas negative grain yield characteristics are preferred for parents with low mean and negative GCA, such as flowering days to 50 percent, and plant height. Among the studied lines and testers, CSR 28 and Giza 177 followed by the genotype Sakha 108 recorded significant positive GCA effects in the Flag leaf area under salinity condition. The two parents Giza 182 and CSR 28 were the best general combiners for a number of panicles plant^{-1} under salinity stress condition.

For panicle length, the variety Sakha 104 exhibited a good general combiner under salinity condition among the lines. While among testers in both conditions the genotype CSR 28 showed a high positive desirable effect. The two parents Giza 178 and CSR 28 were the best general combiners for a panicle weight under both normal and salinity stress condition. The parental variety Giza 182 and Sakha 107 had highly significant GCA effects for 100-grain weight and total chlorophyll under both conditions. In the same direction, Sakha 107 was identified as a good general combiner among testers for the grain yield plant^{-1} under normal and salinity conditions. Among the studied lines and testers under salinity stress condition, the parental line Giza 179 followed by the genotype Sakha 108 were observed to have good GCA effects and desirable direction for fertility percentage under salinity condition. For harvest index percentage the parental varieties Sakha 108 and CSR 28 were highly significant GCA effects under both conditions.

Specific Combining Ability (SCA) Effects:

Estimates of SCA effects of the F_1 crosses for studied traits are presented in Table (4). Under salt stress conditions, nine cross combinations exhibited negative and highly significant desirable SCA effects for days to 50% flowering. The cross combination Giza 182/IRRI 123 is a good specific combiner for days to 50% flowering trait under salt stress condition followed by the cross combination Sakha 107/IRRI 123. In addition, five crosses were found to be negative and highly significant desirable SCA effects on plant height trait. Where it was observed that seven cross combinations Giza 177/SAL 010, Giza 178/A 69-1, Giza 178/MTU 1010, Giza 179/MTU 1010, Sakha 104/A 69-1, Sakha 108/MTU 1010 and Sakha 108/CSR 28 exhibited desirable SCA effects in both conditions. The cross combination, Giza 177/CSR 28 recorded the highest significant SCA effect for the flag leaf area under salt stress condition followed by the combination Giza 179/MTU 1010. For the number of panicle plant^{-1}, eleven hybrid combinations showed positive significant and highly significant SCA effects under stress condition. While panicle length trait exhibited positive and highly significant SCA effects by three-hybrid combinations under the same condition. For panicle weight, ten hybrid combinations showed positive significant and highly significant SCA effects under stress condition. The cross combinations Giza 178/MTU 1010 and Sakha 108/IRRI 123 had highly significant SCA effects for 100-grain weight under both conditions. For spikelet fertility percentage, three hybrid combinations showed positive and highly significant SCA effects under salt stress condition.

About eleven of the crosses showed a significant desirable effect for yield per plant along with two important traits viz panicle weight and spikelet fertility percentage, which indicated that it would be a good idea to give preference to these crosses alongside these traits when selecting for yield under salinity. It is obvious that the best cross combination is not found between high/high general combiners but may also occur in other types of parental combinations.

Estimation of Heterosis:

Heterosis was computed as a percent increase or decrease in the first filial generation value over better parent (heterobeltiosis), and the relative magnitude of heterosis over a better parent was studied for all traits presented in Table (5). For days to 50% flowering and plant height, negative heterosis was desirable. It was seen that a significant positive and negative heterosis in the studied traits. None of the crosses in this investigation had demonstrated extreme heterosis for all the traits. The negative and highly significant mid-parent heterosis for the days to 50% flowering was found in hybrid Giza 177/IRRI 123 (-21.905%) under saline condition. Therefore, earlier maturing crosses proposed the possibility of growing early developing lines. It had also positive significant mid-parent heterosis and heterobeltiosis for different related characters, such as plant height, all hybrid combinations were found to be positive and highly significant heterotic effects except the hybrid Giza 178/MTU 1010 under normal condition, which detected that there is not any negative heterotic for the same trait. For the flag leaf area, the maximum significant and positive mid-parent heterosis and heterobeltiosis under saline stress condition were exhibited in cross Sakha 108/SAL 010 (67.857 and 65.165%, respectively).

For the number of panicles plant^{-1}, highest percentage of highly significant positive heterosis and heterobeltiosis were exhibited in the hybrid combination Sakha 107/IRRI 123 under saline conditions. In addition, regards panicle length, out of 35 cross combinations, seven combinations recorded positive, highly significant heterotic effects over the respective heterobeltiosis under stress condition. Where the hybrid Giza 178/CSR 28 recorded the highest significant heterotic effects under salt condition. With regard to panicle weight, the results revealed that nine of the cross combinations showed highly significant heterobeltiosis effects under stress condition. The maximum highly significant and positive heterobeltiosis for the 100-grain weight were found in hybrid Giza 178/MTU 1010 under the stress of salt condition. With regard to the spikelets fertility percentage trait, eight cross combinations exhibited a desirable and highly significant effect for heterobeltiosis under saline conditions. Heterosis is a very important consideration in breeding programs for the yield and yield components of the crop. Yield is part of plant breeding creation and its ultimate goal. In most crosses, highly significant and maximum positive heterosis was observed in grain yield plant^{-1} as a deviation from the heterobeltiosis under both non-stress and stress conditions. The three cross combinations Giza 182/SAL 010, Sakha 107/IRRI 123, and Sakha 104/SAL 010 recorded the highest heterosis values over heterobeltiosis (40.700, 59.436, and 60.792%, respectively). With regard to the harvest index, the results revealed that four of the cross combinations showed highly significant heterobeltiosis effects under salt stress condition. The maximum highly significant and positive heterobeltiosis for the total chlorophyll were found in cross Giza 182/IRRI 123 under the stress of saline condition.

Genetic components:

The phenotypic and genotypic coefficients of variation can be used for assessing and comparing the nature and magnitude of variability existing for different characters in the breeding materials. Heritability in a broad sense quantifies the proportion of heritable genetic variance to total phenotypic variance, while heritability in a narrow sense represents the ratio of fixable additive genetic variance to total phenotypic variance. The estimates of genetic parameters were computed for 11 traits of 35 crosses and their twelve parents in **Table (6)**. Expectedly, phenotypic variance (PCV) was slightly higher than the genotypic variance (GCV) for all the studied traits under normal and salinity conditions, revealing the very least influence of environment on the expression of these traits and selection through phenotype alone could be successful. High estimates of the PCV and GCV were recorded for days to 50% flowering and harvest index indicating the large scope of selection for these traits. While other characters had moderate or low PCV and GCV values indicating less variability and the need for the creation of variation through a breeding program for saline condition.

The non-additive ($\sigma 2D$) gene effect due to lines × testers interactions were found to be highly significant for all the traits representing the importance of specific combining ability and non-additive gene action, the above results suggested the importance of both additive and non-additive gene effects for agronomic traits. In the present study, high estimates of heritability in a broad sense were observed for all the studied traits.

Contribution of parental lines and their interaction:

The proportional contribution of lines, testers, and line × tester interaction for 11 traits were presented in Table (7). The maximum contribution of lines under saline condition was recorded in total chlorophyll (63.977%) followed by spikelets fertility percentage (63.252%), grain yield plant^{-1}(59.057%), and panicle length trait (46.944%). For testers, the maximum contribution was recorded for flag leaf area (55.281%) followed by plant height (38.251%). The proportional contribution on line × tester was found maximum for panicle weight (50.491%) followed by panicle/plant^{-1}(48.452 %) trait.

Table 1. Analysis of variance for lines, testers involving parents of the investigated traits.

Source of variation	d.f.	Days to 50% flowering (day)		Total chlorophyll (mg/g)		Flag leaf area (cm^2)		Plant height (cm)		Panicles $plant^{-1}$		Panicle length (cm)	
		Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Replications	2	2.645	0.645	0.265	0.066	0.834	0.050	2.582	2.383	0.645	0.050	0.135	0.305
Genotype	46	301.36**	850.77**	24.961**	15.78**	176.68**	78.211**	729.52**	449.78**	19.59**	14.457**	18.078**	40.143**
Parents	11	401.83**	1545.87**	5.049**	7.926**	90.08**	35.193**	474.19**	306.72**	7.12**	3.341**	20.391**	56.391**
Parx Crosse	1	328.85**	1487.622**	85.00**	6.282**	3685.62**	1758.43**	13011.86**	6231.41**	307.31**	273.29**	107.83**	158.22**
Crosses	34	268.05**	607.164**	29.64**	18.61**	101.50**	42.710**	450.88**	326.025**	15.16**	10.441**	14.690**	31.413**
Lines	6	574.59**	1259.375**	80.92**	67.45**	130.47**	21.983**	782.26**	713.254**	35.86**	17.587**	13.200**	83.565**
Testers	4	467.06**	1570.443**	27.95**	9.791**	478.54**	200.68**	1461.09**	1060.02**	35.92**	19.36**	42.41**	61.18**
Linesxesters	24	158.24**	283.56**	17.097**	7.863**	31.42**	21.56**	199.67**	106.88**	6.52**	7.167**	10.442**	13.414**
Error	**92**	**0.86**	**1.856**	**1.2366**	**0.3627**	**0.39**	**0.619**	**1.10**	**1.289**	**0.30**	**0.390**	**0.613**	**0.718**

Table 1. Continued

Source of variation	d.f.	Panicle weight (g)		100-grain weight (g)		Spikelets fertility (%)		Grain yield $plant^{-1}$ (g)		Harvest index (%)	
		Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Replications	2	0.038	0.0065	0.0037	0.0029	0.249	1.871	0.062	0.4585	0.1250	0.806
Genotype	46	1.2602**	0.7157**	0.1692**	0.2314**	26.23**	215.04**	66.371**	51.723**	102.25**	115.07**
Parents	11	0.4486**	0.4991**	0.1489**	0.2078**	6.122**	594.85**	63.502**	27.062**	116.989**	153.18**
Parx Crosse	1	11.248**	0.05612**	0.0724**	0.9167**	413.1**	408.74**	355.85**	179.70**	422.942**	0.031**
Crosses	34	1.229**	0.80518**	0.1787**	0.2188**	21.36**	86.47**	58.785**	55.94**	88.054**	106.13**
Lines	6	2.4718**	1.51421**	0.4469**	0.4793**	39.05**	309.93**	181.54**	187.20**	177.474**	154.98**
Testers	4	1.8120**	1.1171**	0.1896**	0.3255**	43.16**	87.84**	49.580**	111.16**	127.75**	240.26**
Linesxesters	24	0.8211**	0.57594**	0.1098**	0.1359**	13.30**	30.38**	29.631**	13.919**	59.082**	71.56**
Error	**92**	**0.03549**	**0.0037**	**0.0054**	**0.0042**	**0.155**	**1.117**	**0.349**	**0.7025**	**1.6953**	**0.890**

Table 2. Mean values of lines, testers and their crosses to studied traits.

Genotype	Days to 50% flowering (day)		Total chlorophyll (mg/g)		Flag leaf area (Cm²)		Plant height (cm)		Panicles plant^{-1}		Panicle length (cm)	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Lines												
Giza 177	94.67	80.67	14.47	8.38	27.63	16.51	94.67	60.00	11.33	4.33	22.33	10.33
Giza 178	104.33	91.67	14.87	9.03	29.83	18.79	103.33	86.33	10.67	4.67	23.67	12.33
Giza 179	95.67	82.33	16.58	10.44	26.37	19.67	93.67	70.00	10.67	6.33	25.00	15.00
Giza 182	95.67	84.00	17.27	10.52	28.70	19.80	97.33	88.33	13.00	7.33	21.67	18.33
Sakha 104	103.33	92.67	17.74	9.83	24.70	21.61	105.67	90.33	11.33	5.33	22.33	17.33
Sakha 107	97.33	85.67	14.80	10.26	26.67	18.67	98.67	85.67	12.67	5.67	23.33	17.33
Sakha 108	105.67	87.33	18.59	8.85	25.00	17.90	93.33	81.67	9.33	5.33	24.67	14.33
Testers												
A 69-1	131.00	138.33	16.70	11.44	37.43	25.87	122.33	94.67	12.00	6.33	27.67	22.67
MTU 1010	104.33	116.67	15.59	12.19	35.53	21.33	118.33	89.33	12.33	7.33	27.33	22.00
CSR 28	125.33	133.67	15.73	14.18	41.83	28.49	131.00	95.33	15.33	7.67	29.67	22.67
SAL 010	105.00	126.33	17.52	11.60	25.57	18.50	96.00	81.00	10.67	6.33	27.33	21.33
IRRI 123	112.67	129.33	16.63	11.56	29.70	19.87	110.67	84.67	12.67	6.33	27.33	22.67
Crosses												
Giza 177/ A 69-1	108.00	97.33	9.84	6.61	40.73	30.30	140.67	98.33	12.33	8.67	22.67	11.33
Giza 177/ MTU 1010	100.33	91.00	10.28	6.17	37.27	28.48	131.00	104.33	12.33	5.67	25.33	12.67
Giza 177/ CSR 28	110.00	100.00	14.94	9.44	49.80	39.53	110.67	101.33	15.67	6.67	28.33	20.33
Giza 177/ SAL 010	94.67	88.00	16.18	9.10	36.30	25.68	102.67	80.00	11.33	5.67	25.67	11.67
Giza 177/ IRRI 123	100.33	82.00	10.11	7.82	32.37	28.48	115.33	86.00	15.00	9.67	28.33	20.67
Giza 178/ A 69-1	120.67	111.00	9.38	7.95	40.23	30.52	118.67	101.67	14.33	8.67	26.33	20.33
Giza 178/ MTU 1010	109.00	100.00	8.44	7.85	38.80	28.83	100.33	89.67	11.67	9.67	27.00	22.33
Giza 178/ CSR 28	130.00	135.67	11.64	9.72	46.23	30.58	141.00	121.00	16.67	11.67	30.67	24.67
Giza 178/ SAL 010	102.67	111.00	17.01	11.41	33.03	25.39	111.67	90.00	14.67	9.33	25.67	17.67
Giza 178/ IRRI 123	109.00	99.00	11.32	7.42	34.10	22.77	114.67	87.00	14.67	7.33	25.67	19.33
Giza 179/ A 69-1	134.33	116.00	13.13	12.57	37.63	31.39	138.67	100.00	16.67	10.33	31.00	18.33
Giza 179/ MTU 1010	92.33	82.00	14.76	12.91	40.27	32.11	125.00	95.00	15.67	10.33	27.67	21.00
Giza 179/ CSR 28	118.00	126.00	9.89	8.08	43.30	29.71	137.67	103.00	21.33	12.67	28.00	22.33
Giza 179/ SAL 010	120.33	129.67	16.30	12.70	33.87	26.49	119.33	98.67	14.00	6.67	29.33	17.33
Giza 179/ IRRI 123	112.33	124.00	15.43	14.04	37.13	25.35	122.67	88.00	14.00	7.67	27.67	23.00
Giza 182/ A 69-1	109.33	121.00	14.96	10.50	45.10	30.38	134.67	100.00	17.67	10.00	25.00	21.00
Giza 182/ MTU 1010	118.67	108.33	16.21	13.74	42.57	27.28	125.00	104.00	17.67	10.67	26.67	21.67
Giza 182/ CSR 28	122.33	130.67	18.35	15.32	48.17	32.76	133.67	100.00	20.33	12.67	32.00	25.00
Giza.182/ SAL 010	109.67	107.33	12.19	9.76	39.10	25.48	111.67	88.67	16.67	9.00	23.67	18.67
Giza 182/ IRRI 123	106.33	91.67	16.61	14.39	34.10	27.58	118.67	90.00	16.67	12.33	28.33	23.00
Sakha 104/ A 69-1	100.67	120.33	14.52	10.08	49.07	27.42	141.33	98.00	13.67	9.33	30.00	22.33
Sakha 104/ MTU 1010	99.67	117.00	10.59	10.11	44.47	26.49	132.33	92.00	14.00	9.33	24.33	21.33
Sakha 104/ CSR 28	105.33	122.67	15.44	10.57	50.23	30.37	148.67	100.00	16.67	11.67	29.33	21.00
Sakha 104/ SAL 010	101.67	118.33	14.57	10.94	39.50	25.21	129.00	89.67	12.00	7.67	25.33	22.33
Sakha 104/ IRRI 123	105.33	111.33	14.72	12.38	40.17	27.43	127.00	93.00	14.67	7.00	28.00	23.33
Sakha 107/ A 69-1	108.33	116.00	15.44	12.79	49.03	30.22	137.33	109.00	16.00	7.67	26.67	23.00
Sakha 107/ MTU 1010	106.67	111.00	15.16	12.34	42.63	21.35	141.00	97.00	17.67	8.33	25.33	19.67
Sakha 107/ CSR 28	104.00	126.67	19.95	14.35	55.63	36.36	148.67	106.00	17.67	10.00	27.33	23.33
Sakha 107/ SAL 010	102.67	99.33	17.30	14.38	39.70	23.51	128.67	96.67	14.33	8.67	25.33	21.67
Sakha 107/ IRRI 123	100.67	116.67	18.51	14.04	40.03	26.87	124.33	93.33	14.33	11.67	26.00	22.33
Sakha 108/ A 69-1	114.67	129.33	19.43	11.42	35.80	27.23	140.33	129.33	14.00	9.33	25.33	18.33
Sakha 108/ MTU1010	110.33	116.67	16.33	11.67	49.90	29.68	121.67	111.33	16.33	9.00	29.00	22.67
Sakha 108/ CSR 28	121.33	128.33	19.81	12.89	48.57	35.92	135.33	120.33	13.67	10.67	31.33	20.67
Sakha 108/ SAL 010	114.00	111.67	16.45	11.91	38.53	30.55	130.33	103.33	14.67	10.67	26.33	20.00
Sakha 108/ IRRI 123	117.67	105.67	15.60	13.73	44.00	26.25	121.00	106.00	13.67	8.33	27.33	21.67
LSD 0.05	1.51	2.21	1.81	0.98	1.01	1.28	1.71	1.84	0.90	1.01	1.27	1.38
LSD 0.01	1.99	2.93	2.39	1.29	1.34	1.69	2.26	2.44	1.19	1.34	1.68	1.82

* and ** significant at P=0.05 and 0.01 respectively

Table 2. Continued

Genotype	Panicle weight (g)		100-grain weight (g)		Spikelets fertility (%)		Grain yield plant⁻¹g)(		Harvest index (%)	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Lines										
Giza 177	3.55	1.40	2.77	1.69	94.98	32.34	25.51	6.33	43.32	25.09
Giza 178	4.00	1.84	2.83	1.95	91.78	76.50	29.74	8.54	46.35	35.18
Giza 179	4.40	2.10	2.70	2.05	93.68	78.51	35.70	9.81	45.41	39.42
Giza 182	4.05	2.60	3.10	2.15	94.75	80.05	30.43	13.82	49.29	44.71
Sakha 104	4.12	2.21	2.85	2.10	92.11	73.13	25.59	12.88	49.90	40.31
Sakha 107	3.74	1.99	2.73	1.81	94.98	84.57	22.52	10.71	40.33	42.60
Sakha 108	3.89	2.12	3.09	2.02	94.45	82.41	27.72	7.27	47.58	30.97
Testers										
A 69-1	4.02	2.61	3.18	2.60	93.61	70.66	31.34	12.90	39.49	49.66
MTU 1010	4.04	2.52	2.39	1.83	92.23	78.86	33.38	13.21	37.32	43.99
CSR 28	4.65	2.78	2.75	2.33	94.37	83.89	38.63	17.05	27.55	46.70
SAL 010	4.14	2.31	2.95	2.37	91.23	80.49	30.38	11.60	46.60	44.66
IRRI 123	3.14	2.71	2.64	2.28	95.33	80.33	33.65	11.11	42.29	34.54
Giza 177/ A 69-1	3.17	2.03	2.83	2.03	93.59	65.55	33.24	7.68	37.50	29.80
Giza 177/ MTU 1010	3.63	1.07	2.62	2.02	92.76	78.41	33.53	9.30	36.39	45.09
Giza 177/ CSR 28	3.96	2.17	2.81	2.40	92.99	70.23	39.49	13.74	45.56	43.57
Giza 177/ SAL 010	3.85	2.53	2.86	2.00	93.57	68.38	34.59	14.52	37.27	41.24
Giza 177/ IRRI 123	3.61	2.10	2.98	1.87	89.18	65.22	36.57	7.50	36.09	33.82
Giza 178/ A 69-1	3.15	2.82	2.91	2.50	91.35	80.60	27.61	9.47	32.56	37.78
Giza 178/ MTU 1010	3.11	2.63	3.01	2.64	89.67	75.63	31.51	11.48	35.63	47.73
Giza 178/ CSR 28	3.39	3.64	2.89	2.41	92.33	80.33	34.44	12.57	33.42	41.35
Giza 178/ SAL 010	3.74	1.88	2.97	2.12	83.11	72.67	32.40	10.88	35.66	38.17
Giza 178/ IRRI 123	3.96	2.98	2.77	1.45	88.55	75.44	26.64	9.77	44.01	35.72
Giza 179/ A 69-1	3.47	1.71	2.79	2.40	93.05	84.57	35.49	14.21	36.92	44.49
Giza 179/ MTU 1010	2.85	2.64	2.90	2.27	92.16	81.44	35.81	16.46	44.91	37.43
Giza 179/ CSR 28	3.02	2.04	3.35	2.40	88.49	89.41	36.56	15.54	45.71	44.45
Giza 179/ SAL 010	2.63	1.68	2.83	2.50	86.60	80.36	33.51	12.48	36.74	29.39
Giza 179/ IRRI 123	2.44	1.72	2.68	2.31	85.51	76.02	31.55	9.63	31.26	24.37
Giza 182/ A 69-1	4.36	2.00	3.02	2.65	88.71	82.51	35.65	11.56	32.44	31.17
Giza 182/ MTU 1010	2.57	1.82	2.63	2.29	86.15	80.44	38.47	15.73	37.88	39.58
Giza 182/ CSR 28	3.11	2.01	2.99	2.60	85.78	80.24	32.33	17.71	30.73	45.48
Giza.182/ SAL 010	2.57	1.53	2.83	2.40	88.36	80.25	31.36	19.44	31.44	38.47
Giza 182/ IRRI 123	2.94	2.23	2.82	2.36	87.12	79.84	31.33	12.30	34.74	30.62
Sakha 104/ A 69-1	3.08	2.25	2.65	2.29	89.87	81.34	27.43	13.21	33.91	40.80
Sakha 104/ MTU 1010	2.70	2.03	2.45	2.20	91.00	79.39	25.78	15.30	34.36	33.37
Sakha 104/ CSR 28	3.19	3.01	2.84	2.42	92.06	82.51	32.33	16.79	48.57	40.66
Sakha 104/ SAL 010	3.37	2.77	2.45	2.11	86.69	80.38	26.65	20.71	38.53	39.82
Sakha 104/ IRRI 123	1.97	1.78	2.16	1.98	88.23	80.15	30.23	13.46	42.25	39.05
Sakha 107/ A 69-1	4.14	2.52	2.84	2.50	89.68	80.46	32.36	14.54	40.17	40.49
Sakha 107/ MTU 1010	3.91	2.59	3.06	2.41	90.94	83.46	34.65	18.34	40.84	42.51
Sakha 107/ CSR 28	5.00	2.81	2.90	2.68	88.84	80.67	39.40	23.68	41.33	46.57
Sakha 107/ SAL 010	3.60	2.11	2.87	2.70	86.70	82.63	41.51	25.94	44.44	43.43
Sakha 107/ IRRI 123	3.16	1.98	2.79	2.40	92.25	77.87	43.75	17.71	50.00	39.39
Sakha 108/ A 69-1	2.91	2.37	2.24	1.99	93.07	84.59	31.51	10.35	36.80	38.56
Sakha 108/ MTU1010	3.59	2.12	2.21	2.00	91.41	79.85	40.40	8.63	41.51	44.70
Sakha 108/ CSR 28	4.54	2.57	2.77	2.25	90.67	84.54	38.52	12.58	48.04	50.12
Sakha 108/ SAL 010	3.20	2.17	2.72	1.96	90.64	85.57	39.72	10.44	39.22	44.52
Sakha 108/ IRRI 123	2.68	1.38	2.81	2.40	88.44	75.79	34.60	11.40	47.56	48.78
LSD 0.05	0.31	0.10	0.12	0.11	0.64	1.72	0.96	1.36	2.12	1.53
LSD 0.01	0.40	0.13	0.16	0.14	0.85	2.27	1.27	1.80	2.80	2.03

* and ** significant at P=0.05 and 0.01 respectively

Table 3. General combining ability effects for the related traits.

Parents	Days to 50% flowering (day)		Total chlorophyll (mg/g)		Flag leaf area (cm^2)		Plant height(cm)		Panicles plant^{-1}		Panicles length(cm)	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Lines												
Giza 177	-7.09**	-19.84**	-2.32**	-3.35**	-2.35**	1.81**	-7.38**	-5.19**	-1.89**	-2.01**	-1.13**	-5.12**
Giza 178	4.51**	-0.17	-3.04**	-2.30**	-3.16**	-1.07**	-10.18**	-1.32*	-0.82**	0.06	-0.13	0.41
Giza 179	5.71**	4.03**	-0.69*	0.88**	-3.20**	0.33	1.22*	-2.26**	1.11**	0.26	1.53**	-0.06
Giza 182	3.51**	0.30	1.07**	1.57**	0.17	0.010	-2.71**	-2.66**	2.58**	1.66**	-0.07	1.41**
Sakha 104	-7.22**	6.43**	-0.63*	-0.36*	3.05**	-1.30**	8.22**	-4.66**	-1.02**	-0.28	0.20	1.61**
Sakha 107	-5.29**	2.43**	2.68**	2.41**	3.77**	-1.02*	8.55**	1.21*	0.78**	-0.01	-1.07**	1.54**
Sakha 108	5.85**	6.83**	2.93**	1.15**	1.72**	1.24**	2.29**	14.88**	-0.75**	0.31	0.67*	0.21
LSDgi 0.05	0.48	0.70	0.57	0.31	0.32	0.40	0.54	0.58	0.28	0.32	0.40	0.43
LSD gi0.01	1.25	1.83	1.50	0.81	0.84	1.06	1.41	1.53	0.74	0.84	1.05	1.14
LSD g-gj0.05	0.67	0.99	0.81	0.44	0.45	0.57	0.76	0.82	0.40	0.45	0.57	0.61
LSDgi-gj0.01	1.77	2.59	2.12	1.15	1.18	1.50	2.01	2.16	1.05	1.19	1.49	1.61
Testers												
A 69-1	3.96**	4.35**	-0.78*	-0.90**	0.88**	0.95**	8.50**	6.00**	-0.27*	-0.13	-0.49*	-1.22**
MTU 1010	-4.47**	-7.79**	-1.48**	-0.49**	0.63*	-0.94**	-2.26**	-0.14	-0.17	-0.28*	-0.72*	-0.27
CSR 28	6.10**	12.78**	1.12*	0.31*	7.21**	4.92**	9.08**	8.19**	2.21**	1.58**	2.37**	2.02**
SAL 010	-3.23**	-2.17**	1.12*	0.28*	-4.49**	-2.64**	-8.40**	-6.76**	-1.27**	-1.04**	-1.30**	-1.98**
IRRI 123	-2.37**	-7.17**	0.02	0.80**	-4.22**	-2.29**	-6.92**	-7.29**	-0.50*	-0.128	0.131	1.45**
LSD gi0.05	0.40	0.59	0.48	0.26	0.27	0.34	0.45	0.46	0.24	0.27	0.34	0.37
LSD gi0.01	1.06	1.55	1.27	0.69	0.71	0.90	1.20	1.29	0.63	0.71	0.89	0.96
LSD g- gj 0.05	0.57	0.83	0.68	0.37	0.38	0.48	0.64	0.70	0.34	0.38	0.48	0.52
LSD gi-gj0.01	1.50	2.19	1.79	0.97	1.00	1.27	1.69	1.83	0.89	1.01	1.26	1.36

Table 3. Continued

Parents	Panicles weight (g)		100-grain weight (g)		Spikelets fertility (%)		Grain yield plant^{-1} (g)		Harvest index (%)	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Lines										
Giza 177	0.31**	-0.24**	0.041*	-0.22**	2.72**	-9.49**	1.46**	-3.31**	-0.42	-1.08*
Giza 178	0.14*	0.57**	0.13**	-0.06*	-0.70**	-2.11**	-3.51**	-3.02**	-2.72**	0.37
Giza 179	-0.45**	-0.26**	0.13**	0.09**	-0.54**	3.31**	0.56*	-0.19	0.13	-3.76**
Giza 182	-0.22*	-0.30**	0.08*	0.18**	-2.48**	1.61**	-0.20	1.49**	-5.54**	-2.72**
Sakha 104	-0.47**	0.15**	-0.27**	-0.08*	-0.13	1.70**	-5.54**	2.04**	0.54	-1.05*
Sakha 107	0.63**	0.18**	0.11**	0.26**	-0.02	1.97**	4.31**	6.19**	4.37**	2.69**
Sakha 108	0.05	-0.10**	-0.23**	-0.16**	1.15**	3.02**	2.92**	-3.18**	3.64**	5.55**
LSD gi0.05	0.10	0.03	0.04	0.03	0.20	0.54	0.30	0.43	0.67	0.48
LSD gi0.01	0.25	0.08	0.10	0.09	0.53	1.42	0.80	1.13	1.75	1.27
LSD g- gj 0.05	0.14	0.04	0.05	0.05	0.29	0.77	0.43	0.61	0.94	0.68
LSD gi-gj0.01	0.36	0.12	0.14	0.12	0.75	2.01	1.13	1.60	2.48	1.80
Testers										
A 69-1	0.14*	0.02	-0.02	0.05*	1.63**	0.90*	-2.13**	-2.29**	-3.23**	-2.20**
MTU 1010	-0.14*	-0.09**	-0.08**	-0.02	0.89**	0.75*	0.28*	-0.25	-0.19	1.70**
CSR 28	0.41**	0.39**	0.16**	0.17**	0.46**	2.08**	2.13**	2.23**	2.92**	4.81**
SAL 010	-0.05	-0.13**	0.01	-0.03*	-1.75**	-0.44	0.22	2.49**	-1.37*	-0.50*
IRRI 123	-0.36**	-0.20**	-0.06*	-0.17**	-1.23**	-3.29**	-0.50*	-2.18**	1.86**	-3.82**
LSD gi0.05	0.08	0.03	0.03	0.03	0.17	0.46	0.26	0.36	0.56	0.41
LSD gi0.01	0.21	0.07	0.08	0.07	0.45	1.20	0.67	0.95	1.48	1.07
LSD g- gj 0.05	0.12	0.04	0.05	0.04	0.24	0.65	0.36	0.51	0.80	0.58
LSD gi-gj0.01	0.30	0.10	0.12	0.10	0.63	1.70	0.95	1.35	2.10	1.52

Table 4. Specific combining ability (sca) effects of crosses for different traits.

Crosses	Days to 50% flowering (day)		Total Chlorophyll (mg/g)		Flag leaf area (cm²)		Plant height (cm)		Panicles plant-1		Panicle length (cm)	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	1.37*	1.31	-1.65*	-0.32	0.56	-1.15*	12.10**	-1.67*	-0.73*	1.53*	-2.91**	-2.78**
Giza 177/ MTU 1010	2.13*	7.12**	-0.50	-1.17*	-2.66**	-1.07*	13.19**	10.48**	-0.83*	-1.32*	-0.01	-2.40*
Giza 177/ CSR 28	1.23*	-4.45**	1.54*	1.31*	3.30**	4.12**	-18.48**	-0.86	0.12	-2.18**	-0.10	2.98**
Giza 177/ SAL 010	-4.77**	-1.50	2.79*	0.99*	1.50*	-2.17*	-9.00**	-7.24**	-0.73*	-0.56	0.89	-1.69*
Giza 177/ IRRI 123	0.04	-2.50*	-2.18*	-0.81*	-2.70**	0.28	2.19*	-0.71	2.17**	2.53**	2.13*	3.89**
Giza 178/ A 69-1	2.44*	-4.69**	-1.39*	-0.02	0.88*	1.95*	-7.10**	-2.20*	0.20	-0.53	-0.25	0.69
Giza 178/ MTU 1010	-0.80	-3.54*	-1.64*	-0.53	-0.31	2.15*	-14.68**	-8.06**	-2.56**	0.61	0.66	1.73*
Giza 178/ CSR 28	9.63**	11.55**	-1.04	0.54	0.54	-1.96*	14.66**	14.94**	0.06	0.75*	1.23*	1.78*
Giza 178/ SAL 010	-8.37**	1.84*	4.33**	2.26**	-0.96*	0.41	2.80*	-1.10	1.53*	1.04*	-0.10	-1.22*
Giza 178/ IRRI 123	-2.90**	-5.16**	-0.25	-2.25**	-0.16	-2.55**	4.32**	-3.58**	0.77*	-1.87**	-1.53*	-2.98**
Giza 179/ A 69-1	14.90**	-3.89*	0.01	1.41*	-1.68*	1.43*	1.50*	-2.93*	0.60	0.93*	2.75**	-0.85
Giza 179/ MTU 1010	-18.67**	-25.74**	2.34*	1.34*	1.19*	4.04**	-1.41*	-1.79*	-0.50	1.08*	-0.34	0.87
Giza 179/ CSR 28	-3.57**	-2.31*	-5.13**	-4.28**	-2.35**	-4.22**	-0.08	-2.12*	2.79**	1.55*	-3.10**	-0.09
Giza 179/ SAL 010	8.10**	16.30**	1.29*	0.36	-0.08	0.12	-0.93	8.50**	-1.07*	-1.83*	1.90*	-1.09*
Giza 179/ IRRI 123	-0.76	15.64**	1.50*	1.18*	2.92**	-1.37*	0.92	-1.65*	-1.83**	-1.73*	-1.20*	1.15*
Giza 182/ A 69-1	-7.90**	4.85**	0.07	-1.34*	2.42**	0.73	1.43*	-2.53*	0.13	-0.80*	-1.65*	0.35
Giza 182/ MTU 1010	9.87**	4.32**	2.03*	1.49*	0.13	-0.47	2.52*	7.61**	0.04	0.01	0.26	0.070
Giza 182/ CSR 28	2.96**	6.09**	1.56*	2.28**	-0.85*	-0.85	-0.14	-4.72**	0.32	0.15	2.50**	1.11*
Giza.182/ SAL 010	-0.37	-2.30**	-4.60**	-3.27**	1.78*	-0.58	-4.67**	-1.10	0.13	-0.90*	-2.17*	-1.22*
Giza 182/ IRRI 123	-4.56**	-12.96**	0.93	0.85*	-3.48**	1.18*	0.86	0.75	-0.62	1.53*	1.07*	-0.31
Sakha 104/ A 69-1	-5.83**	-1.95*	1.33*	0.16	3.50**	-0.92*	-2.84*	-2.53*	-0.27	0.47	3.09**	1.49**
Sakha 104/ MTU 1010	1.60*	6.86**	-1.89**	-0.21	-0.85*	0.04	-1.08	-2.39*	-0.03	0.61	-2.34*	-0.47
Sakha 104/ CSR 28	-3.30**	-8.05**	0.35	-0.56	-1.66*	-1.94*	3.92**	-2.72*	0.26	1.09*	-0.44	-3.09**
Sakha 104/ SAL 010	2.36*	2.57*	-0.52	-0.16	-0.70	0.47	1.73*	1.90*	-0.93*	-0.30	-0.77	2.25*
Sakha 104/ IRRI 123	5.17**	0.57	0.73	0.77*	-0.30	2.34*	-1.74*	5.75**	0.97*	-1.87*	0.47	-0.18
Sakha 107/ A 69-1	-0.10\	-2.29*	-1.05	0.11	2.75**	1.60*	-7.17**	2.60*	0.27	-1.47*	1.02*	2.22*
Sakha 107/ MTU 1010	6.67**	4.86**	-0.63	-0.75*	-3.41**	-5.38**	7.26**	-3.26*	1.84**	-0.66	-0.08	-2.07*
Sakha 107/ CSR 28	-6.57**	-0.05	1.55*	0.46	3.02**	3.78**	3.59**	-2.59*	-0.54	-0.85*	-1.17*	-0.69
Sakha 107/ SAL 010	1.43**	-12.43**	-1.09	0.52	-1.22*	-1.51*	1.07	3.03*	-0.40	0.44	0.50	1.65*
Sakha 107/ IRRI 123	-1.43**	9.90**	1.22	-0.34	-1.15*	1.50*	-4.74**	0.22	-1.16*	2.53**	-0.27	-1.12*
Sakha 108/ A 69-1	-4.90**	6.65**	2.69*	0.02	-8.44**	-3.65**	2.10*	9.27**	-0.20	-0.13	-2.05*	-1.11*
Sakha 108/ MTU1010	-0.80	6.12**	0.29	-0.17	5.91**	0.69	-5.81**	-2.59*	2.04**	-0.32	1.86*	2.27*
Sakha 108/ CSR 28	-0.37	-2.78**	1.16	0.26	-2.00**	1.07*	-3.48**	-1.92*	-3.01**	-0.51	1.10*	-2.02*
Sakha 108/ SAL 010	1.63*	-4.50**	-2.19*	-0.70*	-0.34	3.26**	9.00**	-3.97**	1.47*	2.10**	-0.24	1.31*
Sakha 108/ IRRI 123	4.44**	-5.50**	-1.94*	0.61	4.86**	-1.38*	-1.81*	-0.78	-0.30	-1.13*	-0.67	-0.45
LSD Sij0.05	1.06	1.56	1.27	0.69	0.71	0.90	1.20	1.30	0.63	0.72	0.90	0.97
LSDSij0.01	2.80	4.10	3.35	1.81	1.87	2.37	3.16	3.42	1.66	1.88	2.36	2.55
LSD Sij-SKI0.05	1.51	2.21	1.80	0.98	1.01	1.28	1.70	1.84	0.89	1.01	1.27	1.37
LSD Sij-SKI0.01	3.96	5.80	4.74	2.57	2.65	3.35	4.47	4.84	2.35	2.66	3.33	3.61

* and ** significant at P=0.05 and 0.01 respectively.

Table 4. Continued

Crosses	Panicle weight (g)		100-grain weight(g)		Spikelets fertility (%)		Grain yield plant^{-1} (g)		Harvest index (%)	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	-0.62**	0.03	0.03	-0.08*	-0.46*	-4.90**	-0.12	-0.58	2.16*	-6.70**
Giza 177/ MTU 1010	0.13	-0.82**	-0.12*	-0.03	-0.54*	8.10**	-2.24**	-1.00*	-1.99*	4.68**
Giza 177/ CSR 28	-0.10	-0.20**	-0.17*	0.17*	0.11	-1.41*	1.88**	0.97*	4.07**	0.05
Giza 177/ SAL 010	0.25*	0.67**	0.03	-0.04	2.90**	-0.74	-1.12*	1.49*	0.07	3.03**
Giza 177/ IRRI 123	0.33*	0.32**	0.23**	-0.02	-2.01**	-1.05	1.59*	-0.87	-4.33**	-1.06
Giza 178/ A 69-1	-0.46*	0.01	0.03	0.22**	0.72*	2.77*	-0.78*	0.92	-0.47	-0.17
Giza 178/ MTU 1010	-0.21	-0.06	0.18*	0.44**	-0.22	-2.06*	0.71*	0.90	-0.43	5.88**
Giza 178/ CSR 28	-0.49*	0.46**	-0.18*	0.02	2.86**	1.32*	1.79**	-0.49	-5.76**	-3.62*
Giza 178/ SAL 010	0.32*	-0.79**	0.05	-0.08*	-4.14**	-3.82**	1.66*	-2.44*	0.77	-1.49*
Giza 178/ IRRI 123	0.85**	0.39**	-0.08*	-0.60**	0.78*	1.80*	-3.38**	1.11*	5.89**	-0.61
Giza 179/ A 69-1	0.45*	-0.27**	-0.10*	-0.03	2.26**	1.31*	3.03**	2.83*	1.04	10.67**
Giza 179/ MTU 1010	0.10	0.77**	0.07	-0.08*	2.11**	-1.67*	0.94*	3.05**	6.00**	-0.30
Giza 179/ CSR 28	-0.27*	-0.30**	0.28**	-0.14*	-1.14*	4.97**	-0.15	-0.35	3.67*	3.61**
Giza 179/ SAL 010	-0.20	-0.15*	-0.09*	0.15*	-0.81*	-1.56*	-1.29*	-3.67**	-1.00	-6.14**
Giza 179/ IRRI 123	-0.08	-0.04	-0.17*	0.10*	-2.42**	-3.05*	-2.54**	-1.86*	-9.71**	-7.84**
Giza 182/ A 69-1	1.11**	0.06	0.19*	0.14*	-0.15	0.96	3.96**	-1.50*	2.22*	-3.70**
Giza 182/ MTU 1010	-0.41*	0.010	-0.14*	-0.15*	-1.96**	-0.97	4.36**	0.63	4.63**	0.81
Giza 182/ CSR 28	-0.41*	-0.30**	-0.03	-0.03	-1.90**	-2.50*	-3.63**	0.13	-5.64**	3.60**
Giza.182/ SAL 010	-0.49*	-0.27**	-0.04	-0.03	2.88**	0.04	-2.69**	1.61*	-0.64	1.91*
Giza 182/ IRRI 123	0.20	0.51**	0.02	0.07*	1.12*	2.47*	-2.00**	-0.87	-0.57	-2.62**
Sakha 104/ A 69-1	0.08	-0.15*	0.17*	0.04	-1.33**	-0.31	1.07*	-0.40	-2.39*	4.26**
Sakha 104/ MTU 1010	-0.02	-0.24**	0.02	0.02	0.54*	-2.12*	-2.98**	-0.34	-4.97**	-7.07**
Sakha 104/ CSR 28	-0.09	0.25**	0.17*	0.05	2.03**	-0.33	1.72*	-1.34*	6.12**	-2.90**
Sakha 104/ SAL 010	0.56*	0.53**	-0.07	-0.06	-1.14*	0.07	-2.06**	2.33*	0.38	1.57*
Sakha 104/ IRRI 123	-0.53*	-0.39**	-0.29**	-0.04	-0.11	2.69*	2.25**	-0.26	0.86	4.13**
Sakha 107/ A 69-1	0.040	0.10*	-0.03	-0.09*	-1.63**	-1.45*	-3.85**	-3.22**	0.04	0.21
Sakha 107/ MTU 1010	0.080	0.28**	0.25**	-0.11*	0.37	1.69*	-3.97**	-1.45*	-2.33*	-1.67*
Sakha 107/ CSR 28	0.63**	0.02	-0.15*	-0.03	-1.31**	-2.43*	-1.06*	1.41*	-4.95**	-0.72
Sakha 107/ SAL 010	-0.31*	-0.17*	-0.03	0.19*	-1.23**	2.05*	2.96**	3.41**	2.46*	1.44*
Sakha 107/ IRRI 123	-0.44*	-0.23**	-0.04	0.04	3.80**	0.14	5.92**	-0.15	4.78**	0.73
Sakha 108/ A 69-1	-0.61**	0.23**	-0.28**	-0.18*	0.59*	1.62*	-3.31**	1.95**	-2.60*	-4.57**
Sakha 108/ MTU1010	0.34*	0.09*	-0.26**	-0.10*	-0.32	-2.97*	3.17**	-1.79**	-0.93	-2.34*
Sakha 108/ CSR 28	0.74**	0.06	0.06	-0.03	-0.64*	0.39	-0.55	-0.33	2.49*	-0.03
Sakha 108/ SAL 010	-0.14	0.17*	0.16*	-0.14*	1.54**	3.95**	2.54**	-2.73**	-2.04*	-0.32
Sakha 108/ IRRI 123	-0.34*	-0.55**	0.33**	0.45**	-1.17*	-2.99*	-1.85*	2.90**	3.08*	7.26**
LSD Sij 0.05	0.22	0.07	0.08	0.07	0.45	1.21	0.68	0.96	1.49	1.08
LSD Sij0.01	0.57	0.18	0.22	0.20	1.19	3.18	1.78	2.52	3.92	2.84
LSD Sij-SKI 0.05	0.31	0.10	0.12	0.10	0.64	1.71	0.96	1.36	2.11	1.53
LSD Sij-SKI 0.01	0.80	0.26	0.31	0.28	1.68	4.50	2.52	3.57	5.55	4.02

* and ** significant at P=0.05 and 0.01 respectively.

Table 5. Estimation of heterosis over Mid (Mp) and better (Bp) parent for the investigated traits.

Crosses	Days to 50% flowering (day)				Total chlorophyll (mg/g)			
	MP %		BP %		MP %		BP %	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	-4.284*	-11.111**	14.085**	20.661**	-36.88**	-33.32**	-41.11**	-42.24**
Giza 177/ MTU 1010	0.838	-7.770**	5.986**	12.810**	-31.57**	-40.01**	-34.02**	-49.37**
Giza 177/ CSR 28	0.002	-6.687*	16.197**	23.967**	-1.07	-16.32**	-5.04**	-33.43**
Giza 177/ SAL 010	-5.175*	-14.976**	0.002	9.091**	1.19	-8.94**	-7.63**	-21.57**
Giza 177/ IRRI 123	-3.215	-21.905**	5.986**	1.653	-34.98**	-21.60**	-39.21**	-32.36**
Giza 178/ A 69-1	2.550	-3.478	15.655**	21.091**	-40.56	-22.37**	-43.82**	-30.56**
Giza 178/ MTU 1010	4.473*	-4.000	4.473**	9.091**	-44.60**	-26.03**	-45.87**	-35.61**
Giza 178/ CSR 28	13.208**	20.414**	24.601**	48.00**	-23.94**	-16.27**	-26.02**	-31.48**
Giza 178/ SAL 010	-1.911	1.835	-1.597*	21.091**	5.01*	10.63**	-2.93**	-1.64**
Giza 178/ IRRI 123	0.461	-10.407**	4.473**	8.000**	-28.11**	-27.88**	-31.91**	-35.77**
Giza 179/ A 69-1	18.529**	5.136	40.418**	40.891**	-21.07**	14.87**	-21.37	9.82**
Giza 179/ MTU 1010	-7.667**	-17.588**	-3.484**	-0.405	-8.22**	14.13**	-10.96**	5.94**
Giza 179/ CSR 28	6.787**	16.667**	23.345**	53.036**	-38.75**	-34.35**	-40.32**	-43.02**
Giza 179/ SAL 010	19.934**	24.281**	25.784**	57.490**	-4.37	15.21**	-6.94**	9.42**
Giza 179/ IRRI 123	7.840**	17.165**	17.422	50.607**	-7.09**	27.64**	-7.24**	21.46**
Giza 182/ A 69-1	-3.529	8.846**	14.286**	44.048**	-11.94**	-4.40**	-13.38**	-8.27**
Giza 182/ MTU 1010	18.667**	7.973**	24.042**	28.968**	-1.32	21.04**	-6.12**	12.75**
Giza 182/ CSR 28	10.709**	20.061**	27.875**	55.556**	11.22**	24.09**	6.27**	8.06**
Giza.182/ SAL 010	9.302**	2.060	14.634**	27.778**	-29.92**	-11.78**	-30.42**	-15.91**
Giza 182/ IRRI 123	2.080	-14.063**	11.150**	9.127**	-1.98	30.35**	-3.78**	24.49**
Sakha 104/ A 69-1	-14.083**	4.185	-2.581**	29.856**	-15.72**	-5.22**	-18.19**	-11.91**
Sakha 104/ MTU 1010	-4.013*	11.783	-3.548**	26.259	-36.43**	-8.12**	-40.30**	-17.01**
Sakha 104/ CSR 28	-7.872**	8.395**	1.935*	32.374**	-7.77**	-11.97**	-13.00**	-25.48**
Sakha 104/ SAL 010	-2.400	8.067**	-1.613*	27.698**	-17.36**	2.07	-17.88**	-5.75**
Sakha 104/ IRRI 123	-2.469	0.300	1.935*	20.144**	-14.37**	15.82**	-17.06**	7.15**
Sakha 107/ A 69-1	-5.120**	3.571	11.301**	35.409**	-1.99	17.88**	-7.56**	11.77**
Sakha 107/ MTU 1010	5.785**	9.720**	9.589**	29.572**	-0.23	10.00**	-2.74**	1.29**
Sakha 107/ CSR 28	-6.587**	15.502**	6.849**	47.860**	30.66**	17.42**	26.81**	1.18*
Sakha 107/ SAL 010	1.483	-6.289*	5.479**	15.953**	7.02**	31.56**	-1.27	23.93**
Sakha 107/ IRRI 123	-4.127**	8.527**	3.425**	36.187**	17.75**	28.70**	11.28**	21.46**
Sakha 108/ A 69-1	-3.099	14.623**	8.517**	48.092**	10.09**	12.52**	4.50**	-0.23
Sakha 108/ MTU1010	5.079*	14.379**	5.751**	33.588**	-4.46	10.92**	-12.18**	-4.27**
Sakha 108/ CSR 28	5.051*	16.139**	14.826**	46.947**	15.42**	11.91**	6.54**	-9.12**
Sakha 108/ SAL 010	8.228**	4.524	8.571**	27.863**	-8.89**	16.46**	-11.51**	2.64**
Sakha 108/ IRRI 123	7.786**	-2.462	11.356**	20.992**	-11.43**	34.56**	-16.10**	18.81**

* and ** significant at P=0.05 and 0.01 respectively.

Table 5. Continued

Crosses	Flag leaf area (cm²)				Plant height (cm)			
	MP %		BP %		MP %		BP %	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	25.205**	42.992**	8.816**	17.139**	29.647**	27.155**	29.647**	27.155**
Giza 177/ MTU 1010	17.995**	50.502**	4.878**	33.500**	23.005**	39.732**	23.005**	39.732**
Giza 177/ CSR 28	43.378**	75.663**	19.044**	38.734**	-1.920	30.472**	-1.920	30.472**
Giza 177/ SAL 010	36.466**	46.701**	31.363**	38.836**	7.692**	13.475**	7.692**	13.475**
Giza 177/ IRRI 123	12.907**	56.523**	8.979**	43.291**	12.338**	18.894**	12.338**	18.894**
Giza 178/ A 69-1	19.623**	36.687**	7.480**	17.990**	5.170*	12.339**	5.170*	12.339**
Giza 178/ MTU 1010	18.715**	43.707**	9.193**	35.141**	-9.474**	2.087	-9.474**	2.087
Giza 178/ CSR 28	29.023**	29.334**	10.518**	7.312**	20.341**	33.211**	20.341**	33.211**
Giza 178/ SAL 010	19.254**	36.170**	10.726**	35.107**	12.040**	7.570**	12.040**	7.570**
Giza 178/ IRRI 123	14.558**	17.803**	14.302**	14.592**	7.165**	1.754	7.165**	1.754
Giza 179/ A 69-1	17.973**	37.877**	0.534**	21.353**	28.395**	21.457**	28.395**	21.457**
Giza 179/ MTU 1010	30.102**	56.634**	13.321**	50.516**	17.925**	19.247**	17.925**	19.247**
Giza 179/ CSR 28	26.979**	23.380**	3.506**	4.270**	22.552**	24.597**	22.552**	24.597**
Giza 179/ SAL 010	30.424**	38.842**	28.445**	34.712**	25.835**	30.684**	25.835**	30.684**
Giza 179/ IRRI 123	32.461**	28.225**	25.028**	27.558**	20.065**	13.793**	20.065**	13.793**
Giza 182/ A 69-1	36.391**	33.036**	20.481**	17.436**	22.610**	9.290**	22.610**	9.290**
Giza 182/ MTU 1010	32.538**	32.658**	19.794**	27.891**	15.920**	17.073**	15.920**	17.073**
Giza 182/ CSR 28	36.578**	35.685**	15.139**	14.986**	17.080**	8.893**	17.080**	8.893**
Giza.182/ SAL 010	44.103**	33.049**	36.237**	28.670**	15.517**	4.724	15.517**	4.724
Giza 182/ IRRI 123	16.781**	39.019**	14.815**	38.762**	14.103**	4.046	14.103**	4.046
Sakha 104/ A 69-1	57.940**	15.487**	31.077**	5.992**	23.977**	5.946**	23.977**	5.946**
Sakha 104/ MTU 1010	47.648**	23.347**	25.141**	22.548**	18.155**	2.412	18.155**	2.412
Sakha 104/ CSR 28	51.002**	21.208**	20.080**	6.575**	25.634**	7.72**	25.634**	7.72**
Sakha 104/ SAL 010	57.162**	25.721**	54.498**	16.656**	27.934**	4.669	27.934**	4.669
Sakha 104/ IRRI 123	47.672**	32.219**	35.241**	26.897**	17.411**	6.286*	17.411**	6.286*
Sakha 107/ A 69-1	52.990**	35.708**	30.988**	16.830**	24.284**\	20.887**	24.284**\	20.887**
Sakha 107/ MTU 1010	37.085**	6.741**	19.981**	0.078	29.954**	10.857**	29.954**	10.857**
Sakha 107/ CSR 28	62.433**	54.202**	32.988**	27.620**	29.463**	17.127**	29.463**	17.127**
Sakha 107/ SAL 010	52.010**	26.529**	48.875	25.942**	32.192**	16.00**	32.192**	16.00**
Sakha 107/ IRRI 123	42.046**	39.445**	34.792**	35.223**	18.790**	9.589**	18.790**	9.589**
Sakha 108/ A 69-1	14.682**	24.408**	-4.363**	5.258**	30.139**	46.692**	30.139**	46.692**
Sakha 108/ MTU1010	64.868**	51.270**	40.432**	39.109**	14.961**	30.214**	14.961**	30.214**
Sakha 108/ CSR 28	45.337**	54.839**	16.096**	26.065**	20.654**	35.970**	20.654**	35.970**
Sakha 108/ SAL 010	52.406**	67.857**	50.717**	65.165**	37.676**	27.049**	37.676**	27.049**
Sakha 108/ IRRI 123	60.878**	38.975**	48.148**	32.087**	18.627**	27.455**	18.627**	27.455**

* and ** significant at P=0.05 and 0.01 respectively.

Table 5. Continued

Crosses	Panicles plant^{-1}				Panicle length (cm)			
	MP %		BP %		MP %		BP %	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	5.714**	62.500**	2.778**	36.842**	-9.333**	-31.313**	-18.07**	-50.00**
Giza 177/ MTU 1010	4.225**	-2.857*	0.010	-22.727**	2.013	-21.649**	-7.317**	-42.42**
Giza 177/ CSR 28	17.500**	11.111**	2.174**	-13.043**	8.974**	23.232**	-4.494**	-10.29**
Giza 177/ SAL 010	3.030*	6.250**	0.003	-10.526**	3.356*	-26.316**	-6.098**	-45.31**
Giza 177/ IRRI 123	25.000**	81.250**	18.421**	52.632**	14.094**	25.253**	3.659**	-8.824**
Giza 178/ A 69-1	26.471**	57.576**	19.444**	36.842**	2.597	16.190**	-4.819**	-10.29**
Giza 178/ MTU 1010	1.449	61.111**	-5.405**	31.818**	5.882**	30.097**	-1.221	1.515**
Giza 178/ CSR 28	28.205**	89.189**	8.696**	52.174**	15.000**	40.952**	3.371**	8.824**
Giza 178/ SAL 010	37.500**	69.697**	37.500**	47.368**	0.653	4.950**	-6.098**	-17.19**
Giza 178/ IRRI 123	25.714**	33.333**	15.789**	15.789**	0.656	10.476**	-6.098**	-14.71**
Giza 179/ A 69-1	47.059**	63.158**	38.889**	63.158**	17.722**	-2.655	12.048**	-19.12**
Giza 179/ MTU 1010	36.232**	51.220**	27.027**	40.909**	5.732**	13.514**	1.222	-4.545**
Giza 179/ CSR 28	64.103**	80.952**	39.130**	65.217**	2.439	18.584**	-5.618**	-1.471*
Giza 179/ SAL 010	31.250**	5.263**	31.250**	5.263**	12.102**	-4.587**	7.317**	-18.75**
Giza 179/ IRRI 123	20.000**	21.053**	10.526**	21.053**	5.732**	22.124**	1.220	1.481*
Giza 182/ A 69-1	41.333**	46.341**	35.897**	36.364**	1.351	2.439	-9.639**	-7.353**
Giza 182/ MTU 1010	39.474**	45.455**	35.897**	45.455**	8.844**	7.438**	-2.439**	-1.515*
Giza 182/ CSR 28	43.529**	68.889**	32.609**	65.217**	24.675**	21.951**	7.865**	10.294**
Giza.182/ SAL 010	40.845**	31.707**	28.205**	22.727**	-3.401*	-5.882**	-13.42**	-12.50**
Giza 182/ IRRI 123	29.870**	80.488**	28.205**	68.182**	15.646**	12.195**	3.659**	1.491*
Sakha 104/ A 69-1	17.143**	60.000**	13.889**	47.368**	20.000**	11.667**	8.434**	-1.470**
Sakha 104/ MTU 1010	18.310**	47.368**	13.514**	27.273**	-2.013	8.475**	-10.98**	-3.030**
Sakha 104/ CSR 28	25.000**	79.487**	8.696**	52.174**	12.821**	5.000**	-1.124	-7.353**
Sakha 104/ SAL 010	9.091**	31.429**	5.882**	21.053**	2.013	15.517**	-7.317**	4.688**
Sakha 104/ IRRI 123	22.222**	20.000**	15.789**	10.526**	12.752**	16.667**	2.439**	2.941**
Sakha 107/ A 69-1	29.730**	27.778**	26.316**	21.053**	4.575**	15.000**	-3.614**	1.471*
Sakha 107/ MTU 1010	41.333**	28.205**	39.474**	13.636**	0.011	0.010	-7.317	-10.61**
Sakha 107/ CSR 28	26.190**	50.000**	15.217**	30.435**	3.145	16.667**	-7.865**	2.941**
Sakha 107/ SAL 010	22.857**	44.444**	13.158**	36.842**	0.010	12.069**	-7.317**	1.563*
Sakha 107/ IRRI 123	13.158**	94.444**	13.158**	84.211**	2.632	11.667**	-4.878**	-1.471*
Sakha 108/ A 69-1	31.250**	60.000**	16.667**	47.368**	-3.185	-0.901	-8.434**	-19.12**
Sakha 108/ MTU1010	50.769**	42.105**	32.432**	22.727**	11.538**	24.771**	6.098**	3.030**
Sakha 108/ CSR 28	10.811**	64.103**	-10.870**	39.130**	15.337**	11.712**	5.618**	-8.824**
Sakha 108/ SAL 010	46.667**	82.857**	37.500**	68.421**	1.282	12.150**	-3.659**	-6.250**
Sakha 108/ IRRI 123	24.242**	42.857**	7.895**	31.579**	5.128**	17.117**	0.011	-4.412**

* and ** significant at P=0.05 and 0.01 respectively.

Table 5. Continued

Crosses	Panicle weight(g)				100-grain weight (g)			
	MP %		BP %		MP %		BP %	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	-16.336**	1.249**	-21.292**	-22.251**	-4.821**	-5.280**	-11.01**	-21.80**
Giza 177/ MTU 1010	-4.260**	-45.532**	-10.140**	-57.672**	1.487**	14.367**	-5.422**	10.00**
Giza 177/ CSR 28	-3.415**	3.828**	-14.900**	-22.036**	1.994**	19.205**	1.687**	2.857**
Giza 177/ SAL 010	0.130	36.208**	-7.080**	9.222**	0.117	-1.723**	-2.941**	-15.75**
Giza 177/ IRRI 123	8.076**	2.273**	1.880**	-22.509**	10.426**	-5.626**	7.831**	-17.72**
Giza 178/ A 69-1	-21.45**	26.932**	-21.707**	8.184**	-3.050**	9.890**	-8.39**	-3.846**
Giza 178/ MTU 1010	-22.720**	20.581**	-23.166**	4.233**	15.326**	39.559**	6.360**	35.385**
Giza 178/ CSR 28	-21.618**	57.431**	-27.149**	30.659**	3.584**	12.374**	2.120**	3.143**
Giza 178/ SAL 010	-8.108**	-9.558**	-9.735**	-18.876**	2.827**	-2.006**	0.792**	-10.69**
Giza 178/ IRRI 123	10.883**	31.085**	-1.001**	9.963**	1.341**	-31.230**	-2.120**	-36.16**
Giza 179/ A 69-1	-17.610**	-27.286**	-21.136**	-34.399**	-5.215**	3.300**	-12.37**	-7.692**
Giza 179/ MTU 1010	-32.570**	14.513**	-35.303**	4.894**	14.080**	17.182**	7.531**	11.075**
Giza 179/ CSR 28	-33.211**	-16.257**	-35.029**	-26.587**	22.936**	9.741**	21.82**	3.00**
Giza 179/ SAL 010	-38.353**	-23.810**	-40.152**	-27.378**	0.354*	13.208**	-3.846**	5.485**
Giza 179/ IRRI 123	-35.367**	-28.433**	-44.621**	-36.531**	0.301	6.708**	-0.864**	1.318**
Giza 182/ A 69-1	8.137**	-23.175**	7.825**	-23.274**	-3.715**	11.719**	-4.927**	2.051**
Giza 182/ MTU 1010	-36.547**	-28.776**	-36.573**	-29.872**	-4.068**	15.146**	-15.05**	6.667**
Giza 182/ CSR 28	-28.429**	-25.449**	-33.095**	-27.904**	2.222**	15.985**	-3.548**	11.429**
Giza.182/ SAL 010	-37.241**	-37.856**	-37.973**	-41.282**	-6.505**	6.342**	-8.817**	1.406**
Giza 182/ IRRI 123	-18.089**	-16.008**	-27.265**	-17.712**	-1.801**	6.627**	-9.140**	3.66**
Sakha 104/ A 69-1	-24.324**	-6.777**	-25.182**	-13.811**	-12.044**	-2.622**	-16.56**	-11.92**
Sakha 104/ MTU 1010	-33.824**	-14.085**	-34.413**	-19.312**	-6.548**	11.770**	-14.14**	4.596**
Sakha 104/ CSR 28	-27.328**	20.480**	-31.519**	8.144**	1.487**	8.941**	-0.350**	3.571**
Sakha 104/ SAL 010	-18.321**	22.533**	-18.584**	19.885**	-15.632**	-5.514**	-16.97**	-10.83**
Sakha 104/ IRRI 123	-45.80**	-27.691**	-52.227**	-34.317**	-21.311**	-9.437**	-24.30**	-12.88**
Sakha 107/ A 69-1	6.569**	9.869**	2.817**	-3.197**	-3.837**	13.293**	-10.69**	-3.846**
Sakha 107/ MTU 1010	0.385	14.941**	-3.380**	2.778**	19.609**	32.358**	12.225**	31.636**
Sakha 107/ CSR 28	19.222**	17.959**	7.521**	1.078*	5.782**	29.260**	5.333**	14.86**
Sakha 107/ SAL 010	-8.584**	-2.016**	-13.033**	-8.934**	1.058**	29.243**	-2.715**	14.06**
Sakha 107/ IRRI 123	-8.140**	-15.685**	-15.508**	-26.937**	4.040**	17.522**	2.323**	5.564**
Sakha 108/ A 69-1	-26.369**	0.423**	-27.589**	-8.951**	-28.442**	-13.791**	-29.455	-23.46**
Sakha 108/ MTU1010	-9.496**	-8.621**	-11.212**	-15.873**	-19.343**	3.896**	-28.48**	-0.826**
Sakha 108/ CSR 28	6.204**	4.827**	-2.507**	-7.665**	-5.023**	3.602**	-10.25**	-3.429**
Sakha 108/ SAL 010	-20.415**	-2.105**	-22.848**	-6.196**	-9.994**	-10.790**	-12.08**	-17.44**
Sakha 108/ IRRI 123	-23.661**	-42.857**	-31.020**	-49.077**	-1.746**	11.801**	-8.954**	5.417**

* and ** significant at P=0.05 and 0.01 respectively.

Table5. Continued

Crosses	Spikelets fertility (%)				Grain yield plant^{-1}(g)			
	MP %		BP %		MP %		BP %	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	-0.755	27.292**	-1.470**	-7.223**	16.921**	-20.159**	6.041**	-40.476**
Giza 177/ MTU 1010	-0.899	41.035**	-2.337**	-0.562	13.880**	-4.845**	0.459	-29.606**
Giza 177/ CSR 28	-1.783**	20.843**	-2.102**	-16.287**	23.147**	17.536**	2.235**	-19.398**
Giza 177/ SAL 010	0.492	21.207**	-1.491**	-15.046**	23.760**	61.866**	13.834**	25.108**
Giza 177/ IRRI 123	-6.286**	15.769**	-6.458**	-18.811**	23.635**	-14.007**	8.677**	-32.493**
Giza 178/ A 69-1	-1.458	9.546**	-2.421**	5.364**	-9.604**	-11.602**	-11.91**	-26.544**
Giza 178/ MTU 1010	-2.538**	-2.639	-2.772**	-4.096**	-0.158	5.626**	-5.593**	-13.049**
Giza 178/ CSR 28	-0.804	0.172	-2.162**	-4.243**	0.751	-1.733	-10.84**	-26.261**
Giza 178/ SAL 010	-9.178**	-7.417**	-9.450**	-9.712**	7.772**	8.011**	6.637**	-6.263**
Giza 178/ IRRI 123	-5.350**	-3.786	-7.112**	-6.079**	-15.96**	-0.577	-20.84**	-12.09**
Giza 179/ A 69-1	-0.641	13.383**	-0.676*	7.710**	5.867**	25.114**	-0.588	10.158**
Giza 179/ MTU 1010	-0.857	3.501	-1.626**	3.276**	3.687**	43.035**	0.317	24.659**
Giza 179/ CSR 28	-5.889**	10.102**	-6.231**	6.572**	-1.614	15.736**	-5.350**	-8.819**
Giza 179/ SAL 010	-6.331**	1.078	-7.554**	-0.162	1.433	16.545**	-6.116**	7.555**
Giza 179/ IRRI 123	-9.516**	-4.281	-10.301**	-5.361**	-9.022**	-7.982**	-11.63**	-13.351**
Giza 182/ A 69-1	-5.813**	9.502**	-6.378**	3.077**	15.439**	-13.451**	13.751**	-16.333**
Giza 182/ MTU 1010	-7.846**	1.246	-9.073**	0.491	20.579**	16.418**	15.25**	13.848**
Giza 182/ CSR 28	-9.280**	-2.108	-9.464**	-4.351**	-6.367**	14.764**	-16.31**	3.891**
Giza.182/ SAL 010	-4.984**	-0.019	-6.748**	-0.290	3.141*	52.95**	3.067**	40.700**
Giza 182/ IRRI 123	-8.338**	-0.439	-8.619**	-0.610	-2.226	-1.311	-6.914**	-10.98**
Sakha 104/ A 69-1	-3.222**	13.135**	-3.999**	11.222**	-3.653**	2.470	-12.49**	2.404**
Sakha 104/ MTU 1010	-1.268	4.474*	-1.330**	0.681	-12.561**	17.327**	-22.76**	15.876**
Sakha 104/ CSR 28	-1.260	5.093*	-2.441**	-1.649*	0.675	12.185**	-16.32**	-1.525*
Sakha 104/ SAL 010	-5.438**	4.650*	-5.888**	-0.133	-4.788**	69.176**	-12.30**	60.792**
Sakha 104/ IRRI 123	-5.856**	4.459	-7.448**	-0.220	2.054	12.213**	-10.17**	4.503**
Sakha 107/ A 69-1	-4.894**	3.666	-5.577**	-4.864**	20.136**	23.168**	3.233**	12.742**
Sakha 107/ MTU 1010	-2.844**	2.140	-4.250**	-1.312*	23.971**	53.344**	3.815**	38.869**
Sakha 107/ CSR 28	-6.163**	-4.230	-6.465**	-4.615**	28.856**	70.605**	1.993**	38.913**
Sakha 107/ SAL 010	-6.876**	0.117	-8.711**	-2.302**	56.930**	132.502**	36.632**	123.585**
Sakha 107/ IRRI 123	-3.056**	-5.559*	-3.238**	-7.930**	55.770**	62.334**	30.012**	59.436**
Sakha 108/ A 69-1	-1.024	10.520**	-1.461**	2.637**	6.694**	2.595	0.521	-19.77**
Sakha 108/ MTU1010	-2.061**	-0.974	-3.212**	-3.110**	32.268**	-15.69**	21.053**	-34.63**
Sakha 108/ CSR 28	-3.962**	1.664	-4.002**	0.767	16.127**	3.454	-0.276	-26.21**
Sakha 108/ SAL 010	-2.366**	5.058**	-4.027**	3.830**	36.718**	10.577**	30.719**	-10.05**
Sakha 108/ IRRI 123	-6.794**	-6.862**	-7.227**	-8.041**	12.759**	23.989**	2.813**	2.580**

* and ** significant at P=0.05 and 0.01 respectively.

Table 5. Continued

Crosses	Harvest index (%)			
	MP %		BP %	
	Normal	Stress	Normal	Stress
Giza 177/ A 69-1	-9.446**	-20.267**	-13.445**	-39.99**
Giza 177/ MTU 1010	-9.759**	30.533**	-16.005**	2.494**
Giza 177/ CSR 28	28.565**	21.379**	5.169**	-6.701**
Giza 177/ SAL 010	-17.115**	18.241**	-20.034**	-7.662**
Giza 177/ IRRI 123	-15.688**	13.429**	-16.688**	-2.082**
Giza 178/ A 69-1	-24.133**	-10.924**	-29.744**	-23.913**
Giza 178/ MTU 1010	-14.826**	20.581**	-23.119**	8.501**
Giza 178/ CSR 28	-9.558**	1.001	-27.897**	-11.460**
Giza 178/ SAL 010	-23.277**	-4.377*	-23.485**	-14.529**
Giza 178/ IRRI 123	-0.700	2.483	-5.045**	1.554*
Giza 179/ A 69-1	-13.033**	-0.103	-18.699**	-10.402**
Giza 179/ MTU 1010	8.575**	-10.255**	-1.092	-14.918**
Giza 179/ CSR 28	25.287**	3.236	0.653	-4.811**
Giza 179/ SAL 010	-20.143**	-30.099**	-21.164**	-34.200**
Giza 179/ IRRI 123	-28.718**	-34.103**	-31.165**	-38.183**
Giza 182/ A 69-1	-26.933**	-33.947**	-34.196**	-37.242**
Giza 182/ MTU 1010	-12.531**	-10.755**	-23.151**	-11.467**
Giza 182/ CSR 28	-20.029**	-0.495	-37.664**	-2.620**
Giza.182/ SAL 010	-34.433**	-13.899**	-36.222**	-13.942
Giza 182/ IRRI 123	-24.145**	-22.727**	-29.531**	-31.513**
Sakha 104/ A 69-1	-24.130**	-9.308**	-32.040**	-17.842**
Sakha 104/ MTU 1010	-21.213**	-20.825**	-31.141**	-24.135**
Sakha 104/ CSR 28	25.407**	-6.548**	-2.673*	-12.938**
Sakha 104/ SAL 010	-20.140**	-6.284**	-22.778**	-10.845**
Sakha 104/ IRRI 123	-8.353**	4.342*	-15.338**	-3.131**
Sakha 107/ A 69-1	0.640	-12.223**	-0.407	-18.462**
Sakha 107/ MTU 1010	5.172	-1.812	1.250	-3.365**
Sakha 107/ CSR 28	21.759**	4.291*	2.469*	-0.287
Sakha 107/ SAL 010	2.247	-0.471	-4.631**	-2.766**
Sakha 107/ IRRI 123	21.030**	2.115	18.225**	-7.546**
Sakha 108/ A 69-1	-15.472**	-4.341*	-22.651**	-22.34**
Sakha 108/ MTU1010	-2.222	19.262**	-12.757**	1.610*
Sakha 108/ CSR 28	27.888**	29.058**	0.976	7.321**
Sakha 108/ SAL 010	-16.71**	17.730**	-17.562**	-0.315
Sakha 108/ IRRI 123	5.852*	48.912**	-0.025	41.217**
LSD 0.05	5.496	3.982	2.116	1.533
LSD 0.01	7.264	5.262	2.796	2.026

* and ** significant at P=0.05 and 0.01 respectively.

Table 6. Estimates of Gene action, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability in broad sense (h2b) and narrow sense (h2n) for the studied traits.

Characters	Gene Action				Coefficient of variation (%)				Heritability (%)			
	δ2A		δ2D		σ2 Ph		σ2 G		h2b		h2n	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Days to 50% flowering (day)	2.146	6.323	52.459	93.903	55.468	102.082	54.605	100.226	98.445	98.182	3.868	6.194
Total chlorophyll (mg/g)	0.245	0.210	5.287	2.500	6.769	3.073	5.532	2.710	81.730	88.197	3.620	6.831
Flag leaf area (cm^2)	1.369	0.413	10.344	6.981	12.100	8.013	11.714	7.394	96.805	92.276	11.317	5.157
Plant height (cm)	4.909	4.282	66.189	35.199	72.201	40.770	71.097	39.481	98.472	96.839	6.799	10.503
Panicles plant^{-1}	0.169	0.064	2.071	2.259	2.545	2.713	2.240	2.323	88.023	85.617	6.631	2.358
Panicle length (cm)	0.083	0.352	3.276	4.232	3.972	5.302	3.359	4.584	84.568	86.457	2.090	6.634
Panicle weight (g)	0.008	0.004	0.262	0.191	0.305	0.199	0.270	0.195	88.375	98.141	2.610	2.252
100-grain weight (g)	0.001	0.002	0.035	0.044	0.042	0.050	0.036	0.046	87.036	91.565	3.243	3.259
Spikelets fertility (%)	0.157	1.096	4.381	9.753	4.694	11.966	4.539	10.849	96.700	90.665	3.355	9.160
Grain yield plant^{-1}(g)	0.570	0.821	9.761	4.406	10.680	5.929	10.330	5.227	96.728	88.151	5.334	13.848
Harvest index (%)	0.566	0.675	19.129	23.559	21.390	25.124	19.695	24.234	92.074	96.459	2.647	2.688

Genotypic varianceδ2A: Additive genetic variance δ2D: dominance genetic variance σ2Ph: Phenotypic variance σ2 G:

Table 7. Contribution of lines, testers and their interaction to the total variance in rice genotypes.

Characters	Contribution of					
	Lines		Testers		L x T Interaction	
	Normal	Stress	Normal	Stress	Normal	Stress
Days to 50% flowering(day)	37.829	36.603	20.499	30.430	41.672	32.967
Total chlorophyll (mg/g)	48.183	63.977	11.096	6.191	40.721	29.832
Flag leaf area (cm^2)	22.684	9.083	55.466	55.281	21.850	35.636
Plant height (cm)	30.617	38.607	38.124	38.251	31.259	23.142
Paniclesplant^{-1}	41.755	29.726	27.882	21.822	30.363	48.452
Panicle length (cm)	15.857	46.944	33.968	22.913	50.175	30.143
Panicle weight (g)	35.493	33.187	17.346	16.322	47.161	50.491
100-grain weight (g)	44.148	38.656	12.488	17.503	43.364	43.841
Spikelets fertility (%)	32.269	63.252	23.775	11.951	43.956	24.797
Grain yield plant^{-1}(g)	54.497	59.057	9.922	23.378	35.581	17.565
Harvest index (%)	35.568	25.769	17.069	26.633	47.363	47.599

DISCUSSION

The significant mean square of lines and testers indicated a prevalence of additive variance for the yield and its components (Jayasudha and Sharma, 2006). This reveals high variability among the genotypes providing abundant scope of selection for different quantitative traits. A significant variation for various quantitative traits was also reported (Bekele *et al.,* 2013; Sandhya *et al.,* 2014; Ghidan and Khedr 2021). Ghidan *et al.,* 2019 suggested that parents with high GCA would produce transgressive segregants in later generations and may be utilized in hybridization programs. Selecting parents is a crucial step in breeding programs to enhance drought tolerance. Parents with higher average performance and general combining ability potential for yield contributing characters are ideal for obtaining desirable segregants. In the present study, none of the cross combinations exhibited high specific combining ability effects for all studied traits under salinity. Vanave *et al.,* 2018, and Ghidan and khedr 2021 also reported that no specific cross-combination was desirable for all the traits in their studies.

Usually, it is expected that a combination of two good general combiners should throw some useful transgressive segregants, but this is not normally the case. Such behavior has been attributed to over-dominance or epistasis (Devi *et al.,* 2017). The superiority of average/average combinations might be due to the concentration or interaction between favorable genes contributed by parents. Abo-Yousef *et al.,* 2020 also reported the interaction between positive alleles for good combiners and negative alleles for poor combiners that suggested the exploitation of heterosis in F_1 generation as their potential would be unfixable in the succeeding generation. Therefore, dominance plays an important role in the inheritance of this trait. Similar findings were also suggested by Borah *et al.,* (2017).

These results are in corroborating the findings of Bhati *et al.,* 2015. It was observed that the parents of all the crosses were of one good and one poor combiner indicating the presence of dominance gene action. Therefore, these crosses are recommended for heterosis breeding, because the usefulness of a particular cross in the exploitation of heterosis is judged by the specific combining ability effect (Ghidan and Khedr 2021).Estimates of heritability help in estimating expected progress through selection (Devi *et al.,* 2017). Prasad *et al.,* 2017; Ghidan *et al.,* 2019 also observed close estimates of GCV and PCV for different traits in rice, and values of PCV were slightly higher than GCV.

The high estimates of direct selection parameters observed for the above characters are broadly in agreement with earlier reports on rice (Sumanth *et al.,* 2017). The low to high estimates of direct selection parameters for the above-mentioned traits indicated that ideal traits with high estimates are ideal for improvement through selection in the context of materials evaluated due to the existence of high genetic variability represented by high coefficients of variation and high transmissibility denoted by high heritability for them. Traits with low estimates of selection parameters indicated that improving through selection in the context of present material would be difficult due to a lack of genetic variability for these traits. The highest estimates of direct selection parameters observed for the above characters are broadly in agreement with Basavaraja *et al.,* (2013).

CONCLUSION

Based on these findings, it is possible to reach the following conclusion, for grain yield plant^{-1}, among lines and testers, the parental lines Giza 182 and CSR 28 recorded the highest mean value of 13.82 and 17.05 g, receptively. While the highest mean values were observed in the two cross combinations Sakha 107/CSR 28 and Sakha 107/SAL 010 of 23.68 and 25.94 g, respectively under salinity stress condition. The variety Sakha 107 was identified as a good general combiner among testers for the grain yield plant^{-1} under normal and salinity conditions. The cross combinations Giza 178/MTU 1010 and Sakha 108/IRRI 123 had highly significant SCA effects for 100-grain weight under both conditions. All traits showed highly significant non-additive gene effects due to lines and testers interactions, explaining the significance of specific combining ability and non-additive gene action.

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إختلاف القدرة علي الائتلاف وبعض المقاييس الوراثية للمحصول ومكوناتة في الأرز تحت ظروف الليزوميتر

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تعتبر الملوحة هي أحد المعوقات الرئيسية الرئيسية التي يواجهها المزارعون في معظم مناطق زراعة الأرز في العالم ، ويعد تحسين محصول الحبوب في الأرز من أهم أهداف التربية. تم تقييم خمسة وثلاثين هجينًا في تصميم تزاوج السلاله x الكشاف من خلال تهجين سبعة سلالات مع خمسة كشافات في تصميم قطاعات كاملة العشوائية في صوبة الليزوميتر السلكية بقسم بحوث الأرز ، سخا ، كفر الشيخ ، مصر خلال موسمي زراعة الأرز في شهر مايو 2021 و 2022. أظهر تحليل التباين وجود فروق عالية المعنوية بين السلالات المستخدمه والكشافات لجميع الصفات تحت الدراسة. وكانت الفروق في قيم القدرة الخاصة على الائتلاف أعلى من القدرة العامة على الائتلاف. واظهرت الاصناف سخا 107 ، سخا 104 ، وجيزة 182 بما في ذلك الكشافات سال 010 وسى إس أر 28 المانحة لصفة محصول الحبوب تحت ظروف الملوحة كأفضل الأباء. بينما اظهر الصنف جيزه 179 يليه الصنف سخا107 افضل التراكيب الوراثية لصفة وزن 100 حبة تحت الظروف العادية والملحية. كما أظهرت التراكيب الوراثية جيزة 179× إم تي يو و سخا 107× سال 010 قيم عالية المعنوية ومرغوبة لصفة محصول الحبوب للنبات الفردي. كانت قيم درجة التوريث بالمعنى الضيق منخفضة لجميع الصفات المدروسة مما يدل على تحكم الجين غير المضيف في توريث هذه الصفات. من خلال اختيار التراكيب الوراثية والأنماط الظاهرية المناسبة ، ستكون النتائج مفيدة في تربية الأصناف المتحملة للملوحة.

الكلمات المفتاحية: الأرز ، القدرة على الائتلاف ، قوه الهجين ، المقاييس الوراثية ، الفعل الجيني ، الملوحة.