J. of Plant Production, Mansoura Univ., Vol. 13 (8):629 - 634, 2022

Journal of Plant Production

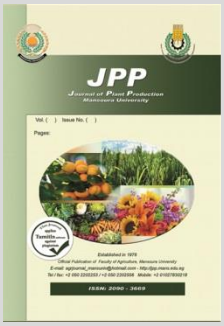
Journal homepage & Available online at: www.jpp.journals.ekb.eg

Estimation of Heterosis and Combing Ability for some Grain Traits of Rice under Saline Sodic Soil Conditions

El-Gamaal, A. A.[1]; B. A. Zayed[2]; H. M. Ashry[1] and A. E. M. M. Bakr[2*]

[1]Agronomy Department, Faculty of Agriculture, Tanta University, Egypt
[2]Rice Research Department, Field Crops Research Institute, Agriculture Research Center, Egypt

Cross Mark



ABSTRACT

During 2020 and 2021 growing seasons, a randomized complete block design with three replications was used to examine sixteen F_1 hybrids produced from Line x Tester and their eight parents under saline sodic conditions. This study's main objective was to examine the links between eight different rice genotypes and their offspring from the first generation (F_1) by examining heterosis and combing ability. The best combinations were Giza 178 x GZ1368, Giza 178 x GZ9399, GZ10365 X G179, and Sakha 104 x GZ1368 regarding to grain yield^{-1}, number of panicles plant^{-1}, panicle weight, and sterility percentages. These paternal lineages might be used in further breeding initiatives. Positively, there is a strong positive heterosis for the number of panicles per plant, grain yield plant $^{-1}$, and the number of field grains per panicle and 1000-grain weight. The crosses Giza 177 x GZ9399, Giza 178 x GZ13684, and Giza 178 x GZ9399 were among the finest. These lines can be used in breeding programs under saline soil conditions.

Keywords: rice, combining ability, salinity, yield and line x tester design

INTRODUCTION

Rice is one of the most important cereal crops, which is a very popular staple food in many developing countries such as Egypt. Grain yield is one of the most breeding objectives. Considerable efforts have been made by breeders to study the genetic expression for numerous traits contributing to yield potential including chlorophyll content (SPAD), number of panicles plant^{-1}, panicle weight (g), Na^+/K^+, grain yield plant^{-1} (g), number of filled grains panicle^{-1}, sterility (%), and harvest index (%). With a salinity threshold of 3 dS/m and a yield drop of 12% per dsm^{-1} over this threshold, rice is regarded as a salt-sensitive crop species. Consequently, when cultivated under moderate (6 dSm^{-1}) salt conditions, rice yields might be decreased by as much as 50% (Zeng *et al.*, 2002). In general, rice plants are somewhat resistant to salinity stress throughout later vegetative stages but become vulnerable once again during reproduction (Flowers and Yeo 1981 and Lutts *et al*., 1995). An integrated strategy incorporating reclamation and management tactics, as well as improved genetic tolerance, may be used to address the declining rice yield in salt-affected regions. (Zayed *et al*., 2017) However, there are certain situations where management approaches are not long-term viable, such as coastal regions, where salt stress is seasonal or interior places where reclamation expenses are exorbitant. In both situations, it would appear more practical to produce salt-tolerant cultivars to increase the yield of these marginal soils. Because it can thrive in flooded circumstances, which might aid in draining harmful salts, rice is suggested as the crop most suited for soils damaged by salt (Zayed *et al*., 2017) The selection of appropriate parents for hybridization and the genetic action of various economic features are key factors in plant breeding programs' success. Such details are provided by combining ability analysis in order to successfully frame the breeding program. The line x tester analysis provides accurate details on the kind, scope, and interaction effects of the genes that make up the genetic material. In terms of the projected performance of the hybrids and their offspring. Dhillon, (1975) noted that the combining ability provides important information on the choice of parents. In order to breed self-pollinated and cross-pollinated plants, as well as to determine the favorable parents and crosses, as well as their general and specialized combining skills, the line x tester analysis technique is applied (Kempthorne, 1957). It may not always be clear from a parent's performance whether it is a good or bad combiner. In order to understand the nature of gene effects and how they manifest in terms of combinatorial ability, information collection is required. In addition, it clarifies the kind of gene activity involved in the transmission of traits. It is theoretically possible to fix general combining ability (GCA), which is linked to additive gene effects and additive x additive epistasis. On the other hand, the unique combining ability caused by non-additive gene activity may be unfixable and may result from epistasis, dominance, or both. The major basis for beginning the hybrid program is the existence of non-additive genetic diversity (Pradhan *et al.* 2006). The main objectives of the present investigation are to study the general and specific combining abilities and genetic parameters for yield and its components traits under saline conditions.

MATERIALS AND METHODS

The most current research was done at El-Sirw Farm Agriculture Research Station, Dammietta Governorate, Egypt, during the seasons of 2020 and 2021. Through a line X tester mating design, eight rice entries with varying

[*] Corresponding author.
E-mail address: bakr23213@gmail.com
DOI: 10.21608/jpp.2022.149492.1141

sensitivities to salinity stress tolerance was employed. The cultivars GZ1368, Giza 179, GZ9399, and IIR45427 were used as tests, whereas the cultivars Giza178, Sakha 104, Giza 177, and GZ10365 were utilized as lines. The parents were chosen based on their genetic and geographical backgrounds. The testers used for this study were selected according to their subcontinent origin and adaption to Egyptian locality and their yield potential was up to the mark (The lines were originated from RRTC, Egypt). The reprehensive soil samples were taken from experimental site into the depth of (0.0- 30 cm). The chemical and physical soil properties were analyses and listed in Table 1.

Table 1. Some physical and chemical properties for the soil at the experimental site.

PH	EC	Soluble cautions meg $^{-1}$				Soluble anions meg $^{-1}$			
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Co3⁻	Hco_3^-	Cl^-	So4⁻
8.65	8.13	8.2	6.42	1.20	75.25	1.50	10.65	74.30	6.25

In order to overcome the variations in blooming times between parents, the four lines and four testers were cultivated at RRTC farm in 2021 across three sequential planting dates spaced ten days apart. Following the method suggested by Jodon (1938) to create their F_1 employing line x tester mating design, 30- day old seedlings of each parent were separately transplanted in the permanent field in five rows at the time of blooming. The line x tester F_1 hybrids and their parents' seeds were sowed in a dry seedbed during the 2021 growing season. Seedlings of each F_1 hybrid and their parents were transplanted in a lysimeter with saline soil conditions in a randomized complete block design (RCBD) experiment with three replications after thirty days after sowing. For each F_1 cross, there were five rows in each duplicate, with a spacing of 20 × 20 cm between the rows and the seedlings. The prescribed dates for planting, fertilizer use, and weed management were used in all agricultural operations. Data were collected for yield and its components traits; chlorophyll content (SPAD), number of panicles plant^{-1}, panicle weight (g) Na^+/K^+, 1000-grain weight (g), grain yield plant^{-1} (g), number of filled grains panicle^{-1}, sterility (%) and harvest index (%) according to the standard evaluation system of IRRI (1996). Line x tester was used to analyze combining capabilities. The variances for general and particular combining abilities were compared to their respective error variances generated from ANOVA at the mean level. The T-test was used to determine the significance of GCA and SCA effects. The following variance components were computed using Kempthorne's mean squares expectations (1957).

RESULTS AND DISCUSSION

Yield and its attributed traits:

Analysis of variance and mean performance

In the present research, the mean square across genotypes was shown to be very significant for all of the studied attributes (Tables, 2 and 3), indicating that rice genotypes varied in their genetic potential for such features. All qualities were determined to be extremely important when comparing parents to crosses. Chlorophyll content (SPAD), number of panicles plant^{-1}, panicle weight (g) Na^+/K^+, 100-grain weight (g), grain yield plant^{-1} (g), number of filled grains panicle^{-1}, spikelet sterility (%) and harvest index (%); line variance was extremely significant, for all of the qualities investigated, the interaction of line × tester was likewise extremely significant. For all the genotypes. Moreover, the crosses Giza 178 x GZ1368, Giza 178 x G179 and Giza 178 x GZ9399, were high yielding combinations (25.72, 23.63, 22.72 g/plant) respectively.

Table 2. Mean squares for chlorophyll content, no. of panicles/ plant, panicle weight (g) Na^+/K^+ Ratio and 1000-grain weight (g) under salinity stress conditions

S.O.V.	D.F.	Chlorophyll content (SPAD)	No. of panicles/ plant	Panicle weight (g)	Na^+/K^+ Ratio	1000- grain weight (g)
		Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Genotypes	23	44.991**	26.925**	0.118**	0.235**	0.135**
Parents (P)	7	19.15**	26.65**	0.114**	0.299**	0.164**
Crosses (C)	15	55.34**	26.826**	0.102**	0.219**	0.102**
P *vs* C	1	70.644**	30.333**	0.381**	0.031	0.419**
Lines	3	64.964**	24.964**	0.061**	0.005	0.061**
Testers	3	43.079**	8.906**	0.105**	0.149**	0.105**
Line x Tester	9	56.219**	33.42**	0.114**	0.314**	0.114**
Error	46	0.058	2.087	0.006	0.009	0.003
δ2GCA		1.25	2.3	0.008	0.02	0.01
δ2 SCA		12.72	10.4	0.036	0.11	0.03

*and ** Significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

Table 3. Mean squares for grain yield / plant (g), no. of filled grains panicle^{-1}, spikelet sterility (%) and harvest index (%) under salinity stress conditions.

S.O.V.	D.F.	Grain yield / plant (g)	No. of. filled grains panicle^{-1}	Spikelets sterility (%)	Harvest index (%)
		Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Genotypes	23	63.373**	531.643**	108.629**	113.799**
Parents (P)	7	56.979**	614.467**	149.553**	142.694**
Crosses (C)	15	68.758**	524.892**	71.005**	107.896**
P *vs* C	1	27.353**	53.132**	386.516**	0.068
Lines	3	279.243**	151.279**	6.375**	74.111**
Testers	3	9.263**	296.987**	93.403**	64.092**
Line x Tester	9	18.428**	725.398**	85.082**	133.76**
Error	46	0.114	1.244	0.058	0.07
δ2GCA		1.76	13.3	16.6	27.2
δ2 SCA		6.15	25.2	28.3	40.2

* Significant at level of 0.05 and ** highly significant at level of 0.01

For the characteristics under consideration, there were extremely significant variations between genotypes (Tables, 4 and 5). The agronomic qualities of sixteen hybrid combinations, four lines, and four testers were evaluated.

Table 4. Mean performances of all genotypes for chlorophyll content, no. of panicles/ plant, panicle weight (g) Na^+/K^+ ratio and 1000-grain weight (g) under salinity stress conditions.

Genotypes	Chlorophyll content (SPAD)	No. of panicles / plant	Panicle weight (g)	Na+ /K+ Ratio	1000-grain weight (g)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza178	34.8	12	2.38	1.761	2.42
Sakha 104	39.83	10.33	2.24	1.37	2.56
Giza 177	35.63	8.00	2.11	1.99	2.56
GZ10365	36.60	10.67	2.22	1.58	2.43
GZ1368	41.93	17.33	2.25	1.08	2.07
Giza 179	37.60	15.33	1.95	1.18	2.13
GZ9399	38.73	12.33	2.43	1.50	2.61
IIR45427	40.80	14.00	1.87	1.18	2.05
Giza 178 x GZ1368	36.97	13.67	2.55	1.35	2.73
Giza 178 x G179	33.87	15.67	2.57	1.58	2.75
Giza 178 x GZ9399	36.70	16.00	2.26	1.42	2.44
Giza 178 x IR45427	47.20	15.33	2.14	1.24	2.32
Sakha 104 x GZ1368	46.20	14.33	2.38	1.29	2.56
Sakha 104 x G179	40.70	15.00	2.31	1.75	2.49
Sakha 104 x GZ9399	43.53	13.33	2.37	1.09	2.55
Sakha 104 x IR45427	39.77	11.33	2.03	1.51	2.21
G177 X GZ1368	35.20	11.67	2.50	1.67	2.68
G177 X G179	40.90	17.67	2.10	0.87	2.28
G177 X GZ9399	39.10	18.33	2.03	1.21	2.21
G177 X IR45427	36.83	11.67	2.48	1.83	2.66
GZ10365 X GZ1368	38.40	15.67	2.32	1.43	2.50
GZ10365 X G179	37.83	5.67	2.59	1.82	2.77
GZ10365 X GZ9399	46.63	12.67	2.34	1.28	2.52
GZ10365 X IR45427	45.63	14.00	2.40	1.23	2.58
L.S.D 0.05	1.26	1.38	0.87	0.75	0.23
L.S.D 0.01	1.68	1.56	1.17	0.82	0.31

Table 5. Mean performances of all genotypes for grain yield / plant (g), no. of. filled grains $panicle^{-1}$, spikeletsterility (%) and harvest index (%) under salinity stress conditions.

Genotypes	Grain yield / plant (g)	No. of. filled grains $panicle^{-1}$	Spikelets sterility (%)	Harvest index (%)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza178	16.89	55.82	32.87	41.89
Sakha 104	12.01	59.82	28.11	21.67
Giza 177	10.22	54.78	35.59	23.86
GZ10365	15.45	52.98	34.32	21.90
GZ1368	22.88	85.61	17.18	22.93
Giza 179	20.98	84.06	20.33	30.64
GZ9399	14.92	56.22	31.97	23.45
IIR45427	12.90	79.78	21.97	29.14
Giza 178 x GZ1368	25.72	65.42	28.10	19.27
Giza 178 x G179	23.63	48.94	36.51	22.51
Giza 178 x GZ9399	22.72	52.60	36.86	23.61
Giza 178 x IR45427	20.50	73.60	29.44	30.24
Sakha 104 x GZ1368	21.01	77.78	25.30	28.65
Sakha 104 x G179	19.51	56.56	40.46	22.93
Sakha 104 x GZ9399	18.00	77.53	27.88	33.97
Sakha 104 x IR45427	16.00	50.26	33.61	18.51
G177 X GZ1368	12.96	48.82	35.05	15.98
G177 X G179	14.02	83.18	27.53	35.64
G177 X GZ9399	13.24	81.46	30.37	30.54
G177 X IR45427	9.00	60.50	41.44	29.14
GZ10365 X GZ1368	12.00	78.94	27.50	33.86
GZ10365 X G179	13.00	43.62	34.15	23.95
GZ10365 X GZ9399	14.00	63.83	33.50	31.84
GZ10365 X IR45427	18.11	66.01	35.62	29.22
L.S.D 0.05	1.26	0.81	0.87	0.75
L.S.D 0.01	1.68	1.09	1.17	1.01

Parental lines and crosses exhibited extremely significant differences in all of the characteristics studied. The average heterosis in all crosses was extremely significant when the parents *vs*. crosses mean square was shown. Furthermore, male testers showed extremely significant disparities in all agronomic parameters.

Estimates of general and specific combining ability effects

Combining ability effects:

The estimations of general combining ability impacts are a significant measure of parental lines' capability for producing better breeding populations (Tables, 6 and 7).

Table 6. Estimates of GCA effects (gi) of parent lines and testers for chlorophyll content, no. of panicles/ plant, panicle weight (g) Na^+/K^+ ratio and 1000-grain weight (g) under salinity stress conditions.

Genotypes	Chlorophyll content (SPAD)	No. of panicles/ plant	Panicle weight (g)	Na^+/K^+ Ratio	1000-grain weight (g)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Lines :					
Giza178	-1.66**	1.29**	0.04	-0.01	0.04*
Sakha 104	2.21**	-0.38	-0.06**	0.00	-0.06**
Giza 177	-2.33**	0.96*	-0.06*	-0.03	-0.06**
GZ10365	1.78**	-1.87**	0.08**	0.04**	0.08**
LSD 5%	0.13	0.83	0.04	0.03	0.08
LSD 1%	0.18	1.12	0.06	0.07	0.04
Testers :					
GZ1368	-1.15**	-0.04	0.10**	0.02	0.10**
Giza 179	-2.02**	-0.37	0.06*	0.09**	0.06**
GZ9399	1.15**	1.21**	-0.09**	-0.16**	-0.09**
IIR45427	2.02**	-0.79	-0.07**	0.04	-0.07**
L.S.D 5%	0.13	0.83	0.04	0.07	0.08
L.S.D 1%	0.18	1.12	0.06	0.07	0.04

* Significant at level of 0.05 and ** highly significant at level of 0.01

Table 7. Estimates of GCA effects (gi) of parent lines and testers for grain yield / plant (g), no. of. filled grains $panicle^{-1}$, spikelets sterility (%) and harvest index (%) under salinity stress conditions.

Genotypes	Grain yield / plant (g)	No. of. filled grains $panicle^{-1}$	Spikelet sterility (%)	Harvest index (%)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Lines :				
Giza178	6.05**	-4.18**	0.02	-2.96**
Sakha 104	1.54**	1.22**	-0.90**	-0.85**
Giza 177	-4.78**	4.17**	0.89**	0.96**
GZ10365	-2.81**	-1.22**	-0.02	2.85**
LSD 5%	0.19	0.86	0.18	0.23
LSD 1%	0.27	0.91	0.19	0.25
Testers :				
GZ1368	0.83**	3.42**	-3.72**	-2.43**
Giza 179	0.45**	-6.24**	1.96**	-0.61**
GZ9399	-0.10	4.54**	-0.56**	3.12**
IIR45427	-1.19**	-1.72**	2.32**	-0.09
L.S.D 5%	0.25	0.88	0.19	0.26
L.S.D 1%	0.27	0.96	0.22	0.28

* Significant at level of 0.05 and ** highly significant at level of 0.01

A minimal or negative combining ability impact suggests that the species has a weak capacity to impart its genetic superiority to hybrids. The parent, GZ10365, achieved the most desired significant and positive GCA effects for (panicle weight (g), Na^+/K^+ Ratio, 1000-grain weight (g), and harvest index, on the other hand GZ9399 was the greatest general combiner for chlorophyll content (SPAD) No. of panicles/plant, in addition to plant height, the number of filled grains panicle^{-1}, and the percentage of sterility. Furthermore, the Giza 177 rice line was an excellent general combiner for No. of panicles plant^{-1}, grain yield plant^{-1}, and Giza178 for filled grains panicle^{-1} and Spikelet sterility percent, . The findings showed that Giza 178, followed by Giza 177 and GZ 1368 were the best general combiners for grain yield plant^{-1} among the examined parents. Some parents with high mean values, on the other hand, had minimal GCA impacts. As a result, for parental selection, both performance and GCA impacts should be considered. Similar results were obtained previously by Verma and Srivastava (2004), Shehata, (2004), Soroush and Moumeni (2006). El Abd *et al.* (2007), Viswanathan and Muthuramu, *et al*. (2010) and El-Naem (2010).

Specific combining ability effect (SCA)

Estimates of the 16F1 crosses' SCA impacts for all of the examined characteristics under salinity stress and combined analyses are shown in Tables 8 and 9.

Under stress salinity circumstances, four crosses revealed significant and beneficial SCA effects for chlorophyll content, science the crosses Giza 178 x IR45427 exhibiting the most desirable SCA benefits.

Results exhibited crosses GZ10365 X GZ1368 had positive and significant SCA effects for no. of panicles plant-1 under salinity condition as reported earlier by El Abd, *et al*. (2007), Verma and Srivastava (2004), El-Naem (2010) and Negm (2012).

Table 8. Estimates of SCA effects (Sij) of cross combinations for chlorophyll content, no. of panicles/ plant, panicle weight (g) Na^+/K^+ ratio and 1000-grain weight (g) under salinity stress conditions.

Cross combinations	Chlorophyll content (SPAD)	No. of panicles plant^{-1}	Panicle weight (g)	Na^+/K^+ Ratio	1000-grain weight(g)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza 178 x GZ1368	-0.57**	-1.46	0.07	-0.07	0.07
Giza 178 x G179	-2.80**	0.88	0.13**	0.09	0.13**
Giza 178 x GZ9399	-3.13**	-0.37	-0.03	0.18**	-0.03
Giza 178 x IR45427	6.50**	0.96	-0.17**	-0.20**	-0.17**
Sakha 104 x GZ1368	4.80**	0.87	0.01	-0.15*	0.01
Sakha 104 x G179	0.17	1.88*	-0.02	0.24**	-0.02
Sakha 104 x GZ9399	-0.17	-1.37	0.18**	-0.16**	0.18**
Sakha 104 x IR45427	-4.80**	-1.37	-0.17**	0.06	-0.17**
G177 X GZ1368	-1.66**	-3.12**	0.12*	0.25**	0.12**
G177 X G179	4.91**	3.21**	-0.23**	-0.62**	-0.23**
G177 X GZ9399	-0.06	2.29**	-0.16**	-0.02	-0.16**
G177 X IR45427	-3.19**	-2.37**	0.28**	0.39**	0.28**
GZ10365 X GZ1368	-2.57**	3.71**	-0.19**	-0.03	-0.19**
GZ10365 X G179	-2.28**	-5.96**	0.12*	0.27**	0.12**
GZ10365 X GZ9399	3.36**	-0.54	0.01	0.01	0.01
GZ10365 X IR45427	1.49**	2.79**	0.06	-0.26**	0.06
LSD S_{ij} 0.05	0.89	0.91	0.17	0.58	0.07
LSD S_{ij} 0.01	1.19	1.21	0.1	0.77	0.06
LSD sij-skl 0.05	0.37	2.37	0.14	1.46	0.08
LSD sij-skl 0.01	0.39	2.24	0.12	1.95	0.09

* Significant at level of 0.05 and ** highly significant at level of 0.01

Table 9. Estimates of SCA effects (Sij) of cross combinations for grain yield / plant (g), no. of. filled grains panicle$^{-1,}$ spikelets sterility (%) and harvest index (%) under salinity stress conditions.

Cross combinations	Grain yield / plant (g)	No. of. filled grains panicle^{-1}	Spikelets sterility (%)	Harvest index (%)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza 178 x GZ1368	1.74**	1.86**	-0.91**	-2.21**
Giza 178 x G179	0.04	-4.96**	1.83**	-0.79**
Giza 178 x GZ9399	-0.32	-12.08**	4.69**	-3.42**
Giza 178 x IR45427	-1.46**	15.18**	-5.61**	6.42**
Sakha 104 x GZ1368	1.55**	8.82**	-2.79**	5.06**
Sakha 104 x G179	0.43*	-2.73**	6.69**	-2.48**
Sakha 104 x GZ9399	-0.53**	7.46**	-3.38**	4.83**
Sakha 104 x IR45427	-1.44**	-13.55**	-0.52**	-7.42**
G177 X GZ1368	-0.18	-23.09**	5.17**	-9.42**
G177 X G179	1.26**	20.93**	-8.02**	8.42**
G177 X GZ9399	1.03**	8.43**	-2.67**	-0.41*
G177 X IR45427	-2.12**	-6.27**	5.52**	1.40**
GZ10365 X GZ1368	-3.11**	12.42**	-1.47**	6.57**
GZ10365 X G179	-1.73**	-13.24**	-0.50**	-5.16**
GZ10365 X GZ9399	-0.18	-3.81**	1.36**	-1.00**
GZ10365 X IR45427	5.02**	4.63**	0.61**	-0.41*
LSD S_{ij} 0.05	0.35	1.15	0.28	0.32
LSD S_{ij} 0.01	0.39	1.29	0.35	0.41
LSD sij-skl 0.05	0.54	1.73	0.38	0.43
LSD sij-skl 0.01	0.55	1.85	0.39	0.45

* Significant at level of 0.05 and ** highly significant at level of 0.01

Regarding panicle weight, the crosses Giza 177 X IR45427 was the best since it had the highest significant and positive effects under saline condition.

Results showed that the crosses Giza177 X IR45427 positive and significant SCA effects for Na+/K+ under salinity condition.

For 1000-grain weight, two crosses exhibited significant and positive SCA effects under stress salinity conditions, the most desirable SCA effects were detected for the crosses Giza 178 x Giza179.

Regarding grain yield plant-1, one crosses gave significant and positive SCA effects under salinity conditions, the cross Giza 178 x GZ1368 showed the most desirable SCA for grain yield plant-1under salinity conditions.

As for Spikelets sterility (%, seven hybrids had desirable SCA effects under normal, stress and combined data, respectively the cross Sakha 104 x G179 was the best since it had the highest significant and positive effects in all environments.

Regarding grain Harvest Index, ten cross gave significant and positive SCA effects under salinity conditions, the cross G177 X G179 showed the most desirable SCA under salinity conditions, as obtained by El Abd, *et al.* (2007), Verma and Srivastava (2004), El-Naem (2010) and Negm (2012).

Heterosis

Heterosis relative to mid-parent and better-parent for chlorophyll content (SPAD), No. of panicles plant^{-1}, panicle weight (g), Na^+/K^+, 1000- grain weight (g), grain yield plant^{-1} (g), No. of. filled grains panicle^{-1}, Spikelet sterility (%) and Harvest index (%) under salinity stress and are presented in Tables 10, 11, 12 and 13.

The cross Giza 178 x IR45427 (24.87) exhibited the highest positive and significant mid-parent heterosis under salinity. However, the cross, Sakha GZ10365 X GZ9399 (20.40) gave the highest positive and significant better-parent heterosis under salinity condition.

Under salinity conditions, the cross Giza 177 X GZ9399 displayed the strongest positive and substantial heterotic effects in terms of the number of panicles per plant when compared to the mid-parent and better-parent.

Concerning panicle weight, the cross Giza177 X IR45427 expressed the most desirable mid-parent heterosis under normal irrigation and the cross Giza177 X IR45427 under stress, recording (24.62%). This particular cross exhibited the most desirable better-parent heterosis under salinity stress (17.54%)

Table 10. Heterosis relative to mid -parents for chlorophyll content, no. of panicles/ plant, panicle weight (g) Na^+/K^+ ratio and 1000-grain weight (g) under salinity stress conditions.

Cross combinations	Chlorophyll content (SPAD)	No. of panicles / plant	Panicle weight (g)	Na^+/K^+ Ratio	1000-grain weight (g)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza 178 x GZ1368	-3.64**	-6.78**	10.15**	-4.94**	21.60**
Giza 178 x G179	-6.44**	14.67**	18.71**	7.54**	20.88**
Giza 178 x GZ9399	-0.18	31.51**	-6.03**	-13.08**	-2.98**
Giza 178 x IR45427	24.87**	17.92**	0.71**	-15.33**	3.80**
Sakha 104 x GZ1368	13.01**	3.62**	6.01**	5.19**	10.58**
Sakha 104 x G179	5.13**	16.91**	10.26**	36.75**	6.18**
Sakha 104 x GZ9399	10.82**	17.64**	1.50**	-24.13**	-1.35**
Sakha 104 x IR45427	-1.35**	-6.86**	-1.22**	18.81**	-4.12**
G177 X GZ1368	-9.23**	-7.86**	14.68**	9.01**	15.77**
G177 X G179	11.70**	51.48**	3.45**	-44.98**	-2.77**
G177 X GZ9399	5.16**	80.30**	-10.57**	-30.68**	-14.51**
G177 X IR45427	-3.62**	6.09**	24.62**	15.81**	15.40**
GZ10365 X GZ1368	-2.20**	11.94**	3.80**	8.07**	11.11**
GZ10365 X G179	1.97**	-56.38**	24.22**	31.74**	21.49**
GZ10365 X GZ9399	23.80**	10.17**	0.65**	-16.98**	0.75
GZ10365 X IR45427	17.91**	13.51**	17.36**	-10.90**	15.18**

* Significant at level of 0.05 and ** highly significant at level of 0.01

Table 11. Heterosis relative to mid -parents for grain yield / plant (g), no. of. filled grains panicle^{-1}, spikelets sterility (%) and harvest index (%) under salinity stress conditions.

Cross combinations	Grain yield / plant (g)	No. of. filled grains panicle^{-1}	Spikelets sterility (%)	Harvest index (%)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza 178 x GZ1368	29.34**	-7.48**	12.29**	-40.53**
Giza 178 x G179	24.80**	-30.02**	37.26**	-37.92**
Giza 178 x GZ9399	42.85**	-6.10**	13.70**	-27.72**
Giza 178 x IR45427	37.63**	8.56**	7.37**	-14.84**
Sakha 104 x GZ1368	20.44**	6.96**	11.72**	28.49**
Sakha 104 x G179	18.28**	-21.39**	67.05**	-12.32**
Sakha 104 x GZ9399	33.68**	33.61**	-7.19**	50.59**
Sakha 104 x IR45427	28.46**	-28.00**	34.23**	-27.13**
G177 X GZ1368	-21.69**	-30.46**	32.84**	-31.68**
G177 X G179	-10.13**	19.81**	-1.54**	30.80**
G177 X GZ9399	5.33**	46.76**	-10.09**	29.12**
G177 X IR45427	-22.15**	-10.09**	43.99**	9.97**
GZ10365 X GZ1368	-37.39**	13.91**	6.80**	51.07**
GZ10365 X G179	-28.63**	-36.35**	24.98**	-8.82**
GZ10365 X GZ9399	-7.80**	16.89**	1.07**	40.43**
GZ10365 X IR45427	27.76**	-0.57	26.56**	14.51**

* Significant at level of 0.05 and ** highly significant at level of 0.01

Table 12. Heterosis relative to better -parents for chlorophyll content, no. of panicles plant^{-1}, panicle weight (g) Na^+/K^+ ratio and 100-grain weight (g) under salinity stress conditions.

Cross combinations	Chlorophyll content (SPAD)	No. of panicles plant^{-1}	Panicle weight (g)	Na+ /K+ Ratio	1000-grain weight (g)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza 178 x GZ1368	-11.83**	-21.12**	7.14**	-23.45**	12.81**
Giza 178 x G179	-9.92**	2.22	7.98**	-10.11**	13.64**
Giza 178 x GZ9399	-5.24**	29.73**	-7.00**	-19.42**	-6.51**
Giza 178 x IR45427	15.69**	9.50**	-10.08**	-29.42**	-4.13**
Sakha 104 x GZ1368	10.18**	-17.31**	5.78**	-6.20**	0.63
Sakha 104 x G179	2.18**	-2.15	3.12**	27.33**	-2.73**
Sakha 104 x GZ9399	9.29**	8.08**	-2.47**	-27.46**	-2.30**
Sakha 104 x IR45427	-2.52**	-19.07**	-9.38**	10.28**	-13.67**
G177 X GZ1368	-16.05**	-32.66**	11.11**	-16.00**	4.69**
G177 X G179	8.78**	15.26**	-0.47**	-56.11**	-10.94**
G177 X GZ9399	0.96**	48.63**	-16.46**	-39.10**	-15.33**
G177 X IR45427	-9.73**	-16.64**	17.54**	-7.85**	3.91**
GZ10365 X GZ1368	-8.42**	-9.58**	3.11**	-9.13**	2.88**
GZ10365 X G179	0.61**	-63.01**	16.67**	15.28**	13.99**
GZ10365 X GZ9399	20.40**	2.73*	-3.70**	-18.90**	-3.45**
GZ10365 X IR45427	11.84**	1.02	8.11**	-22.26**	6.17**

* Significant at level of 0.05 and ** highly significant at level of 0.01

Table 13. Heterosis relative to better -parents for grain yield / plant (g), no. of. filled grains panicle^{-1}, spikelets sterility (%) and harvest index (%) under salinity stress conditions.

Cross combinations	Grain yield / plant (g)	No. of. filled grains panicle^{-1}	Spikelets sterility (%)	Harvest index (%)
	Salinity Stress	Salinity Stress	Salinity Stress	Salinity Stress
Giza 178 x GZ1368	12.41**	-23.59**	-14.51**	-53.99**
Giza 178 x G179	12.63**	-41.79**	11.07**	-46.26**
Giza 178 x GZ9399	34.52**	-6.45**	12.14**	-43.63**
Giza 178 x IR45427	21.37**	-7.75**	-10.44**	-27.80**
Sakha 104 x GZ1368	-8.17**	-9.15**	-10.00**	24.96**
Sakha 104 x G179	-7.01**	-32.72**	43.93**	-25.15**
Sakha 104 x GZ9399	20.64**	29.59**	-12.79**	44.88**
Sakha 104 x IR45427	24.03**	-37.01**	19.57**	-36.47**
G177 X GZ1368	-43.36**	-42.98**	-1.52**	-33.01**
G177 X G179	-33.17**	-1.05	-22.65**	16.33**
G177 X GZ9399	-11.26**	44.88**	-14.67**	28.01**
G177 X IR45427	-30.23**	-24.17**	16.44**	0.01
GZ10365 X GZ1368	-47.55**	-7.80**	-19.87**	47.68**
GZ10365 X G179	-38.04**	-48.11**	-0.50*	-21.82**
GZ10365 X GZ9399	-9.39**	13.52**	-2.39**	35.79**
GZ10365 X IR45427	17.22**	-17.27**	3.79**	0.29

* Significant at level of 0.05 and ** highly significant at level of 0.01

The cross Sakha 104 x GZ1368 (-6.20%) exhibited the lowest negative and significant mid-parent heterosis under salinity. However, the cross, Sakha Giza 178 x GZ1368 (-4.94%) gave the lowest negative and significant better-parent heterosis under salinity condition.

Concerning 1000-grain weight, the cross Giza 178 x G179 exhibited the highest positive and significant heterotic effects relative to mid-parent under stress conditions, the cross Giza 178 x GZ1368 showed the highest positive and significant heterotic effects relative to better-parent under normal condition,

For grain yield plant^{-1}, the crosses Giza 178 x GZ9399 expressed positive and significant mid-parent and better parent heterosis recorded, (42.85 and 34.52%).

Concerning No. of. filled grains panicle^{-1} weight, the cross Giza177 X GZ9399 exhibited the highest positive and significant heterotic effects relative to mid-parent and better-parent heterotic under salinity condition.

As for sterility %, the hybrid, Giza177 X Giza179 had the lowest and significant heterotic effects relative to mid-parent under normal conditions. While the cross, GZ10365 X Giza179 showed lowest and significant heterotic effects relative to better-parent heterotic under salinity condition,

Regarding harvest index, the cross G177 X GZ9399 exhibited the highest positive and significant heterotic effects relative to mid-parent and better- parent under salinity condition.

REFERENCES

Dhillon, B.S. (1975). The application of partial diallel crosses in plant breeding -A Review. Crop Improve. 2: 1-7.

El Abd, A. B., A. A. Abd Allah, S. M. Shehata, A. S. M. Abd El-Lateef and B. A. Zayed. (2007). Heterosis and combining ability for yield and its components and some root characters in rice under water stress conditions. Proc. Fifth Plant Breeding Conference, May 27. Egypt. J. Plant Breeding, Special Issue, Vol. 11 (2): 593-609.

El-Naem, S, M, A. (2010) . Breeding studies on rice (*Oryza sativa* L.) under water stress conditions. M.Sc. Crops, Fac. of Agric; Mansoura Univ. Egypt.

Flowers, T. J. and A. R. Yeo (1981). Variability in the resistance of sodium chloride salinity within rice varieties. New Phytol. 88, 363—373.

IRRI (1996). International Rice Research Descriptors for Rice. Los Banos, Laguna, Philippines. 52p.

Jodon, N. E. (1938). Experiments on artificial hybridization of rice. J. Amer. Soc. Agron., 30: 249 – 305.

Kempthorne, O. (1957). An introduction to genetic statistics. John Wiley & Sons.

Lutts, S.; J. M. Kinet and J. Bouharmont (1995). Changes in plant response to NaCl during development of rice (*Oryza sativus* L.) varieties differing in salinity resistance. J. Exp. Bot. 46, 1843—1852.

Muthuramu, S., S. Jebaraj, R. Ushakumari and M. Gnanasekaran. (2010). Estimationof combining ability and heterosis for drought tolerance in different locations in rice (*Oryza sativa* L.). Electronic Journal of Plant Breeding. 1: 5, 1279-1285.

Pradhan, S. K., L.K. Boss and J. Meher. (2006). Studies on gene action and combining ability analysis in Basmati rice. Journal of Centeral European Agriculture, Vol. 7 (2): 267-272.

Shehata, S. M. (2004). Lines x testers analysis of combining ability under salinity and drought conditions in rice. (*Oryza sativa*). Egyptian J. of Agric. Res. 82(1): 119-138.

Soroush, H. R. and A. Moumeni . (2006). Genetic dissection of some important agronomic characters in rice using line x tester analysis. Journal of Science and Technology of Agriculture and Natural Resources. 10(1): 177-187.

Verma, O. P. and H. K. Srivastava. (2004). Genetic component and combining ability analyses in relation to heterosis for yield and associated traits using three diverse rice-growing ecosystems. Field Crops Research. 88(2/3): 91- 102.

Zayed, B., Abdelaal, M., & Deweedar, G. (2017). Response of rice yield and soil to sulfur application under water and salinity stresses. Egyptian Journal of Agronomy, 39(3), 239-249.

Zayed, B. A.; W.H. El-Kellawy, Amira, M. Okasha and M.M. AbdEl-Hamed (2017) Improvement of Salinity Soil Properties and Raising Rice Productivity Under Different Irrigation Intervals Along With Gypsum Rates. Mansoura Univ., 3 (8):361-368

Viswanathan S. and K. Thiyagarajan. (2008). Combining ability studies for yield and yield components in rice (*Oryza sativa* L.). International J. of Plant Sciences (Muzaffarnagar). 3: 1, 61-68.

Zeng, L.m M. C. Shannon and C. M. Grieve. (2002). Evaluation of salt tolerance in rice genotypes by multiple agronomic parameters. Euphytica 127, 235— 245.

تقدير قوة الهجين والقدرة على الائتلاف لبعض صفات محصول الحبوب للأرز تحت ظروف الأراضي الملحية

أمجد عبد الغفار الجمال [١]، بسيوني عبد الرازق زايد[٢]، هناء محمد عشرى[١] و أحمد اليمنى محمد مصطفى بكر[٢]
[١]قسم المحاصيل – كلية الزراعة – جامعة طنطا
[٢]مركز البحوث والتدريب في الأرز – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية.

الملخص

تم زراعة ستة عشرة هجين من تجربة السلالة x الكشاف مع ثمانية آباء في تجربة تصميم قطاعات كاملة العشوائية في ثلاث مكررات خلال موسمي ٢٠٢٠/ ٢٠٢١م، وكان الهدف الأساسي من الدراسة هو تحليل القدرة العامة والخاصة وقوة الهجين والعلاقة بين ثمانية تراكيب وراثية والجيل الأول بتحليل قوة الهجين والقدرة على الائتلاف تحت ظروف الأراضي الملحية.كانت أفضل التوليفات لمحصول الحبوب وعدد السنابل ووزن السنبلة ونسبة العقم كانت جيزة ١٧٨ x جى زد ١٣٦٨ ، جيزة ١٧٨ x جى زد ٩٣٩٩ وجى زد ١٠٣٦٥ x جيزة ١٧٩ وسخا ١٠٤ x جى زد ١٣٦٨ وسجلت السلالات الأبوية جى زد ١٣٦٨ ، جى زد ٩٣٩٩ أفضل السلالات وأعطت قدرة عامة على الائتلاف للصفات المدروسة لاستخدامها في برامج التربية .كذلك يوجد قوة هجين عالية وموجبة لصفات عدد السنابل ووزن ١٠٠٠ حبه وعدد الحبوب الكلية ومحصول الحبوب / نبات ومن بين هذه الهجن جيزة ١٧٧ x جى زد ٩٣٩٩ ، جيزة ١٧٨ x جى زد ١٣٦٨ ، جيزة ١٧٨ x جى زد ٩٣٩٩ . هذه السلالات يمكن استخدامها في برامج التربية تحت ظروف الأراضي الملحية.