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Evaluation of Combining Ability and Heterosis for Yield and Its Components Traits of Rice under Normal Irrigation and Drought Stress Conditions

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ABSTRACT

During 2010 and 2011seasons, two field experiments of rice experimental farm of Sakha, Kafr El-Sheïkh, Egypt, were performed through a 6 x 6 diallel system analysis to investigation the combining ability and heterosis and their component features of rice under normal irrigation and drought stress conditions.A broad range of genetic variation among research genotypes was indicated by the routine analysis of variance. As for all the features of normal irrigation and drought stress conditionsThe significance of non-additive genetic variation in the heritage of grain yield / plant has been established by GCA / SCA ratios. While the selection based on the accumulation of the additive effect will boost yield and assign it successfully. According to drought susceptibility index (DSI), four parents and six crosses were the lowest genotypes affected by drought.GCA shows all parental lines are intrinsically performing with a strong index of their overall ability to blend. The combinations of IR7887-176-B-2-B X IR80508-B-194-1-B to boost the output of grain per plant was the best possible cross, as reported by SCA.Under drought, the highest values significant for heterosis from better parent, five crosses for panicle length and seven crosses for number of branches / panicles and grain yield characters. In the general sense, higher heritability levels emerged in normal irrigation; genotypic variances played a major part in phonotypical yield variances and their components.Lower and moderate heritage tests for all yields and their components showed that selection for these characteristics would be successful in late generations.

Keywords: Rice, drought stress, drought susceptibility index, grain yield, combining ability, heterosis and heritability.

INTRODUCTION

Rice is part of the family of grasses that is semi-aquatic and poorly adapted to dry environments, and is prone more than other essential cereals in this family to water deficits. Rice has to resolve its tolerance to flooding to increase productivity in aerobic or water environments (Mohankumar *et al*. 2011).

Rice is one of Egypt 's largest cultivated fields. While rice is cultivated in an area of approximately 1,600 million feddan, which produced an average 3,938 tonnes / food paddy rice of approximately 6,300 million tons in 2016 (FAO, 2018). It is the largest cereal cultivation in Egypt during the summer.

Drought has an detrimental effect on crop production, like many other environmental stresses. The availability of low water is one of the main factors for declines in crop yields affecting most of the world's farmed regions. The construction of drought tolerant lines becomes more and more important as water supplies for agricultural uses become more limited..

Drought is a major abiotic stress restricting global rice production, with some 30 percent of the rice producing regions worldwide experiencing moisture and water shortages. Approximately 18 million tons of rice worth US$ 650 million annually in rainfed and irrigated areas was lost due to the drought (Pandey *et al*. 2005). This is why drought tolerance breeding in rice breeding is becoming highly important, in Egypt, in particular, because of the low irrigation from the River Nile water requirement, the total water requirements of rice crops are serious issues. Some rice-plants have, especially at the end of the terminal irrigation canals, been considered one of the most important constraints on rice production during different stages of development. (Abd Allah *et al*., 2009).

Even a detailed knowledge of the genetic properties of the rice varieties that are rich in yield and qualitatively stronger. The producers thus seek to combine the desired properties of different varieties, using suitable quantitative genetic methods. Griffing (1956) introduced the diallel-cross technique. In addition to its high agronomic efficiency, many commercial cultivars in the F1 generation perform poorly due to genetic barriers in various cross-combinations. As a result, the single common, efficient technique to calculate, classify and pick superior genotypes is diallel crossing (Mohammad, 2003). Assessment of combination capacity, diallel analysis and other related parameters is the first step in most plant breeding programs (Pickett, 1993).

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Diallel analysis of grain yield and its associated characteristics that provide useful information about gene action, helping to understand what gene action is involved in the expression of a trait in particular situations. We may distinguish genotypes with the most dominant and recessive allles for the presentation of those characteristics. It helps breeders to effectively pick in the isolation generations, resulting in the increase in conditions of water stress in certain breeding populations. (Griffing 1956).

The purpose of this investigation therefore was to analyze, in addition to determining the most drought tolerant genotypes of rice under analysis, the general and specific combining capacity, nature of the gene, heterosis, and heritability of cereal yield and its elements under normal irrigation and dry stress conditions.

MATERIALS AND METHODS

Materials

The current study was performed in two seasons, in two successive rice growing seasons, from 2010 and 2011, at the Rice Research and Training Center Experimental Farm (RRTC), the Faculty of Agriculture and Farming, Mansoura University, Sakha Gaza District, the Governorate of Kafrelsheikh Field Crops Research Institute, FCRI and the Rice Research and Training Center (RRTC). There were six genotypes namely: IR81025-B-2-7-3a and IR80508-B-194-1-B; Giza-177, Sakha101, Azucena; IR78875–176-B-2-B. Such genotypes are prone to different degrees and drought resistant. These genotypes have been obtained in the Sakha, Kafrelshiekh, rice research and education center.

Methods

Six varieties of rice used in the study in 2010 were cultivated with 10 days intervals in three seed dates to address the disparity in the heading date between these varieties. In three rows (each row was five maters) and 20 x 200 cm between plants, each genotype was transplanted individually in three rows in the experimental field three days after sowing. The six parents flowered to create 15 F1 hybrids were carried out a half diallel cross (without reciprocal). The bulk method of emasculation was used by Jodon's (1938) and Butany's (1961) technique of hot water.

In the 2011 rice crop season a total of 15 F1 cross-breeds have been produced with the hybrid seeds being grown with F1 plants, and plants are transplanted individually after 30 days of sowing with three réplications in a randomized complete block pattern (RCBD). There were 25 individual plants in each row, which was five meters long. In the 2011 rice growing season, the evaluation of six rice parental genotypes and 15 f1 crosses took place.

All 21 genotypes (six parents and 15 F1 crosses) were planted under regular irrigation (irrigation every four days) and under drought (dried irrigation enforced every 12 days without water after irrigation). All the suggested farming practices for the specific rice field were implemented as normal. Weeds have been chemically tested. For parents and their 15 F1 crosses, the data was reported on an individual plant basis.

For parents and their F1 crosses, the following characteristics were assessed. Such traits were: weight of the bubble (g); length of panicle (cm); number of primary panicle-1 branches; weight of 1000 grain (g) and yield of the grain / planter (g). The weights of grain yield / pot (g) of each individual plant were reported and the humidity content was modified to 14%.

In order to determine drought tolerances of all genotypes, the drought susceptibility index (DSI) was also used. It should be emphasized that SI offers a dryness tolerance metric based on the minimisation of stress yield loss in comparison with moist conditions rather than on yield level in dry conditions per se. This index has been determined using the generalized formula using genotype grain yield (SI) means reported by Fisher and Maurer (1978) in which:

$$\mathbf{DSI = (1 - Y_d / Y_p) / D,}$$

Where:

Y_d = Performance of a genotype under drought stress,

Y_p= Performance of a genotype under normal irrigation,

D = Drought stress intensity = 1 - (mean Y_d of all genotypes under stress / mean Y_p of all genotypes under normal irrigation)

Statistical analysis

The study of the combined capacity followed Model 1, Method 2, which included parents, and a collection of F1, in order to estimate the general (GCA) and specific(SCA) effects of combining capacity with variance components under water stress conditions. The output of the effects and the relative significance of additive gene or non-additive gene effects were assessed in order to determine the GCA / SCA relation (Singh and Chaudhary, 1979). Falconer and Mackay (1996) estimated heterosis. In order to check the importance of heterotic effects in the model suggested by Wynne *et al*. (1970), sufficient L.S.D. values were further determined.

RESULTS AND DISCUSSION

Analysis of variance and mean performance

In normal irrigation and drought stress conditions, the normal variance tests showed highly significant differences in the levels and their related characteristics between genotypes, which suggest a broad range of genetic variation among genotypes Table 1.For all the features of standard irrigation and dry tension, both general and particular combining variances of ability were found to be highly significant . This shows the significance for the success of these characteristics of additives and non-additive genetic variances. These results were similar to those reported by Ramesh *et al*. (2018), who revealed that significant GCA and SCA showed the significance for the expression of the yield traits in rice genotypes of additive and non-additive gene behavior.

For this study, the GCA / SCA ratios were used to explain genetic effects of yielding component expression. Many GCA/ SCA ratios for all yields and components, with the exception of plant grain yields in normal irrigation, were found to be larger than unit. This shows the value for the heritage of grain per plant of non-additive genetic variation. Additive and additive forms of genetic operation were also of great importance for the inheritance of yield characteristics. However, choosing the additive effect on the basis of accumulation will effectively boost these attributed characteristics. Ramesh et coll. (18), who found that the bulk of GCA and SCA ratios are found to be larger than unity for most of the rice genotype yield component traits, identified major general and unique combining ability variances for these features.

Table 1. The analysis of variance and the combination of yield capacities in natural irrigation and drought stress conditions with its rice genotype components.

Treatment S.O.V	d.f	Panicle weight (g)		Panicle length (cm)		No. of branches/ panicle	
		Normal	Drought	Normal	Drought	Normal	Drought
Replications	2	0.09	0.03	67.79**	0.30	2.56	1.16
Genotypes	20	1.40**	1.37**	14.24**	7.20*	4.77**	6.47**
Error	40	0.24	0.03	2.91	0.19	1.30	0.62
GCA	5	1.18**	1.19**	7.46**	5.06**	4.12**	4.79**
SCA	15	0.23**	0.21**	3.85**	1.51**	0.75	0.52
Error	40	0.08	0.01	0.97	0.06	0.43	0.70
GCA/SCA	-	5.16	5.63	1.94	3.34	5.52	9.21

Table 1. Continued

Treatment S.O.V	d.f	1000-grain weight (g)		Grain yield/ plant (g)	
		Normal	Drought	Normal	Drought
Replications	2	1.82**	4.94**	1.80**	3.83**
Genotypes	20	18.75**	7.97**	89.53**	66.70**
Error	40	0.34	2.53	0.03	0.25
GCA	5	14.21**	5.68**	9.26**	31.22**
SCA	15	3.60**	1.65*	36.71**	19.24**
Error	40	0.11	0.84	0.01	0.08
GCA/SCA	-	3.95	3.45	0.25	1.62

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

Means of grain yield and its related traits in both treatments are shown in Table 2. The best genotypes were the parents IR7887-176-B-2-B and IR 81025-B-347-3 and the two crosses; Azucena X IR 80508-B-194-1-B and Sakha101 X Azucena produced the highest mean values of 4.11, 3.33, 5.71 and 3.89g) of panicle weight under both normal irrigation and drought stress conditions, respectively. For panicle length, the parents IR 81025-B-347-3 and IR 80508-B-194-1-B and the two crosses; Sakha101 X IR 81025-B-347-3 and IR 7887-176-B-2-B X IR 80508-B-194-1-B recorded the highest mean values of 24.93,20.57,26.07and 22.57cm under normal irrigation and water deficit conditions, respectively. Concerning number of primary branches/panicle, the two parents; Sakha101 and Azucena, and the two crosses; AZUCENA X IR 7887-176-B-2-B and AZUCENA X IR80508-B-194-1-B produced the highest mean values of 22.27, 11.73, 25.47 and 13.60 under normal irrigation and drought stress condition, respectively. For 1000-grain weight (g), the two parents IR80508-B-194-1-B and IR81025-B-347-3, and the two crosses IR 80508-B-194-1-B X IR 81025-B-347-3B and Giza177 X IR 81025-B-347-3 showed the heaviest grains values of 29.72, 26.16, 31, 07 and 22.99 g under normal irrigation and drought stress condition, respectively. With respect to grain yield / plant, the two parents; Sakha101 and AZUCENA, and the two crosses IR 7887-176-B-2-B X IR 80508-B-194-1-B and IR 7887-176-B-2-B X IR 81025-B-347-3 produced the highest mean values of grain yield/plant of 47.31 ,35.02 ,55.57 and 38.42 g under normal irrigation and water deficit conditions, respectively. These variations among rice genotypes performance, are due to the genetic variances of these genotypes under both conditions. These findings agree with Zaman *et al* . (2018), who observed substantial variations in grain yield and components of the rice genotype, both under standard irrigation conditions and under drought stress conditions.

Drought susceptibility index

The dry-susceptibility index (DSI) provides a stress resistance to the optimum condition based on reducing drought-stress yield loss. The relative drought tolerance of the wheat genotypes was characterized (Fisher and Maurer (1978). This index was used for estimating relative stress injuries because the variability in yield potential and stress intensity was expressed. The low DSI is a highe stress resistance, while the high DSI is a higher stress response (higher DSI > 1).

At the level of parents, P_3 (Azucena), P_4 (IR 7887-176-B-2-B), P_5 (IR 80508-B-194-1-B) and P_6 (IR 81025-B-347-3) possessed DSI less than one. This indicated the lowest water stress (more drought tolerant) caused by these kin. At the other hand, more than one DSI was held by the other two parents (P1 and P2). This indicated that these parents were sensitive to water stress.

Six crosses counted in F1 crosses; DSI less than one showed 2,3, 10, 11 , 12, 14 showed that these crosses had the lowest water-pressure affected (more drought-tolerant). Both crosses were tolerant to higher water stress. This could also be used in rice breeding programs for dryness tolerance. these hybrid genotypes. In other crosses, the high drought susceptibility index (DSI>1) indicates that these genotypes are susceptible to water stress.

These results agreed with Kumar *et al.* (2018), who evaluated some rice genotypes under normal irrigation and drought stress conditions based on susceptibility index (DSI) for grain yield/plant, and found that some genotypes were more tolerant to drought and others were more sensitive to drought.

Table 2. Means of parents and F1 hybrids in natural irrigation and drought stress conditions for yield and its components

Traits and treatment	Panicle weight (g)		Panicle length (cm)		No. of branches/ panicle	
	Normal	Drought	Normal	Drought	Normal	Drought
Parents						
1-Giza177	3.79	2.33	18.50	16.20	17.33	9.47
2-Sakha101	3.84	2.68	20.57	18.70	22.27	8.60
3-Azucena	3.06	2.50	23.80	20.55	18.13	11.73
4-IR 7887-176-B-2-B	4.11	2.60	21.30	18.33	16.00	9.80
5-IR 80508-B-194-1-B	3.64	2.29	24.03	20.57	18.00	11.67
6-IR 81025-B-347-3	3.80	3.33	24.93	19.40	14.60	10.07
F_1 Crosses						
1-Giza 177 X Sakha101	4.49	2.35	18.89	16.33	15.47	11.60
2-Giza 177 X Azucena	4.47	2.35	23.30	19.43	15.07	13.13
3-Giza 177 X IR 7887-176-B-2-B	3.46	2.01	24.19	17.37	15.60	10.53
4-Giza 177 X IR 80508-B-194-1-B	3.55	2.01	25.10	19.33	16.60	10.93
5-Giza 177 X IR 81025-B-347-3	3.27	1.71	25.71	21.43	15.80	11.67
6-Sakha101 X azucena	4.62	3.89	24.80	19.57	18.53	13.07
7-Sakha101 X IR 7887-176-B-2-B	4.30	2.32	25.27	19.47	17.13	11.27
8-Sakha101 X IR 80508-B-194-1-B	4.43	3.26	25.90	19.13	16.47	9.27
9-Sakha101 X IR 81025-B-347-3	4.45	2.84	26.07	20.53	16.33	10.47
10-Azucena X IR 7887-176-B-2-B	5.19	3.14	24.00	20.54	25.47	12.87
11-Azucena X IR 80508-B-194-1-B	5.71	3.43	25.70	20.53	18.60	13.60
12-Azucena X IR 81025-B-347-3	4.90	3.49	25.17	20.70	16.20	10.93
13-IR 7887-176-B-2-B X IR 80508-B-194-1-B	4.72	2.34	24.50	22.57	16.67	10.53
14-IR 7887-176-B-2-B X IR 81025-B-347-3	3.97	2.38	24.27	20.07	16.53	9.67
15-IR 80508-B-194-1-B X IR 81025-B-347-3	3.97	2.46	23.60	19.50	16.53	8.47
$LSD_{0.05}$	0.68	0.22	2.34	0.60	1.57	1.08
$LSD_{0.01}$	0.97	0.32	3.37	0.86	2.25	1.56

Table 2.Continued

Traits and treatment	1000-grain weight (g)		Grain yield/plant (g)		DSI
	Normal	Drought	Normal	Drought	
Parents					
P1-Giza177	28.76	23.55	44.14	31.16	1.03
P2-Sakha101	27.38	22.23	47.31	33.53	1.02
P3-Azucena	26.78	22.52	40.00	35.02	0.44
P4-IR 7887-176-B-2-B	29.06	24.95	41.00	31.02	0.86
P5-IR 80508-B-194-1-B	29.72	25.27	40.79	31.81	0.77
P6-IR 81025-B-347-3	29.39	26.16	42.02	34.04	0.67
F_1 Crosses					
1-Giza177 X Sakha101	26.61	18.87	46.92	23.93	1.72
2-Giza177 X Azucena	25.95	18.45	48.92	35.27	0.98
3-Giza177 X IR 7887-176-B-2-B	30.71	25.85	47.55	34.57	0.96
4-Giza177 X IR 80508-B-194-1-B	28.24	19.72	38.46	25.87	1.15
5-Giza177 X IR 81025-B-347-3	28.46	22.99	31.34	22.35	1.01
6-Sakha101 X Azucena	24.65	18.23	44.50	30.86	1.08
7-Sakha101 X IR 7887-176-B-2-B	26.67	19.01	36.77	23.79	1.24
8-Sakha101 X IR 80508-B-194-1-B	26.81	18.55	37.11	24.13	1.23
9-Sakha101 X IR 81025-B-347-3	27.59	18.71	44.92	31.91	1.02
10-Azucena X IR 7887-176-B-2-B	30.08	21.25	46.83	33.84	0.97
11-Azucena X IR 80508-B-194-1-B	28.85	20.08	48.01	35.03	0.95
12-Azucena X IR 81025-B-347-3	28.92	20.76	50.40	37.43	0.90
13-IR 7887-176-B-2-B X IR 80508-B-194-1-B	29.00	19.57	55.57	32.59	1.45
14-IR 7887-176-B-2-B X IR 81025-B-347-3	27.85	19.70	41.41	38.42	0.25
15-IR 80508-B-194-1-B X IR 81025-B-347-3	31.07	21.56	41.24	28.26	1.11
LSD 0.05	0.80	2.19	0.23	0.68	-
LSD 0.01	1.15	3.15	0.33	0.98	-

General combining ability

For certain cases, the general composite effects measured herein varied significantly from zero. GCA values are highly important and constructive in terms of yield. Low negative values will be useful for the breeder for days to heading and plant height. General combining ability of each parent for all yield traits would be useful for drought tolerance (Table 3). These effects may be used to compare the average output of each genotype and the other to make it possible for parents to be selected to enhance their dry resistance.

The best general combiners which showed significance for yield and its components, were: Azucena under both conditions and IR81025-B-347-3 under drought stress for panicle weight; IR80508-B-194-1-B and IR81025-B-347-3 under normal irrigation , and the three parents Azucena, IR80508-B-194-1-B and IR81025-B-347-3 under drought stress for panicle length; Azucena under both conditions for number of primary branches/panicle; the three parental genotypes IR7887-176-B-2-B, IR80508-B-194-1-B and IR81025-B-347-3 at normal irrigation, the two parents IR7887-176-B-2-B and IR81025-B-347-3 under drought stress for 1000-grain weight; two parents Azucena and IR7887-176-B-2-B under both normal irrigation and drought stress conditions for grain yield/ plant.

Based on these tests, the intrinsic performance of these parental lines could be concluded to provide a good indicator of their overall ability. Thus selection may be performed on the basis of mean output or GCA effects on similar productivity in order to boost economic characteristics in rice. Many investigators found significant GCA effects in positive direction for these traits in many rice genotypes under both conditions, As for Ramesh *et al* . (2018) who found that substantial additive and non-additive gene effects for the expression of yield features in the genotypes of rice were described as important as GCA and SCA.

Table 3. Combining the potential for yield with parental genotypes components under natural irrigation conditions and drought stress.

Traits and treatment	Panicle weight (g)		Panicle length (cm)		No. of branches/ panicle	
	Normal	Drought	Normal	Drought	Normal	Drought
Giza177	-0.46**	-0.46**	-1.54**	-1.31**	-0.99**	0.04
Sakha101	-0.24*	-0.09**	-0.56	-0.54**	-0.46*	-0.45**
Azucena	0.67**	0.69**	0.51	0.64**	1.00**	1.33**
IR7887-176-B-2-B	-0.08	-0.17**	-0.21	-0.01	0.41	-0.25
IR80508-B-194-1-B	0.15	-0.08**	0.79*	0.68**	0.34	-0.04
IR81025-B-347-3	-0.04	0.10**	1.02**	0.53**	-0.31	-0.64**
LSD $_{0.05}$	0.19	0.07	0.64	0.16	0.43	0.55
LSD $_{0.01}$	0.25	0.09	0.86	0.22	0.58	0.73

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

Table 3. Continued

Traits and treatment	1000-grain weight (g)		Grain yield /plant (g)	
	Normal	Drought	Normal	Drought
Giza177	-1.80**	-1.04**	-0.45**	-1.75**
Sakha101	-1.34**	-1.06**	-0.03	-2.08**
Azucena	-0.23*	0.19	1.70**	3.02**
IR7887-176-B-2-B	1.07**	0.62*	0.63**	0.87**
IR80508-B-194-1-B	1.19**	0.46	-0.39**	-1.10**
IR81025-B-347-3	1.10**	0.84**	-1.47**	1.02**
LSD $_{0.05}$	0.22	0.60	0.06	0.19
LSD $_{0.01}$	0.29	0.80	0.09	0.25

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

Specific combining ability

Estimates of unique combining capacity (SCA) for normal irrigation and drought stress combinations are given in Table 4.

The best cross combinations for improving yield and its components, which exhibited significant and positive SCA effects, were: the two crosses Giza177 X Sakha101 and Azucena X IR80508-B-194-1-B under normal irrigation and the three crosses Giza177 X Sakha101, Sakha101 X Azucena and Sakha101 X IR80508-B-194-1-B under drought stress for panicle weight.

The six cross combinations Giza177 X IR7887-176-B-2-B, Giza177 X IR80508-B-194-1-B, Giza177 X IR81025-B-347-3, Sakha101 X IR 7887-176-B-2-B, Sakha101 X IR80508-B-194-1-B and Sakha101 X IR81025-B-347-3 under normal irrigation and the five cross combinations Giza177 X Azucena, Giza177 X IR 81025-B-347-3, Sakha101 X IR 7887-176-B-2-B, Sakha101 X IR81025-B-347-3 and IR7887-176-B-2-B X IR80508-B-194-1-B under drought stress for panicle length; two crosses Sakha101 X Azucena and AZUCENA X IR7887-176-B-2-B under normal irrigation .

The seven crosses Giza177 X Sakha101, Giza177 X Azucena, Giza177 X IR81025-B-347-3, Sakha101 X Azucena, Sakha101 X IR7887-176-B-2-B, Azucena X IR7887-176-B-2-B and AZUCENA X IR80508-B-194-1-B) under drought stress recorded the desirable value of SCA for number of branches/panicle; six crosses (Giza177 X Sakha101, Giza177 X IR7887-176-B-2-B, Giza177 X IR80508-B-194-1-B, Giza177 X IR81025-B-347-3, Azucena X IR7887-176-B-2-B and IR80508-B-194-1-B X IR81025-B-347-3 under normal irrigation

one cross Giza177 X IR 7887-176-B-2-B under drought recorded the desirable value of SCA for 1000-grain weight; and eight crosses Giza177 X Sakha101, Giza177 X Azucena, Giza177 X IR 7887-176-B-2-B, Sakha101 X IR81025-B-347-3, Azucena X IR7887-176-B-2-B, Azucena X IR80508-B-194-1-B, Azucena X IR81025-B-347-3, and IR7887-176-B-2-B X IR80508-B-194-1-B) under normal irrigation .

Seven crosses (Giza177 X Azucena, Giza177 X IR7887-176-B-2-B, Sakha101 X IR81025-B-347-3, Azucena X IR80508-B-194-1-B, AZUCENA X IR81025-B-347-3, IR7887-176-B-2-B X IR80508-B-194-1-B and IR7887-176-B-2-B X IR81025-B-347-3) under drought stress recorded the desirable value of SCA for grain yield/plant.

The best crosses under both normal irrigation and drought stress conditions were the six crosses, Giza177 X Azucena, Giza177 X IR 7887-176-B-2-B, Sakha101 X IR81025-B-347-3, Azucena X IR 80508-B-194-1-B, AZUCENA X IR81025-B-347-3 and IR7887-176-B-2-B X IR80508-B-194-1-B for improving grain yield/plant. Manickavelu *et al* . (2006), who found that the non-additive gene effects played an important part in heritage of these characteristics, had previously obtained similar findings under water stress and irrigation, on the other hand Shehata (2004) and Sedeek (2006), identified additive genetic effects as an important part of the inheritance of such trait.

Table 4. 15 F1 crosses common combination potential for all yield components under standard irrigation and conditions of dry stress Components.

Traits	Panicle weight (g)		Panicle length (cm)		No. of branches/ panicle	
Crosses	Normal	Drought	Normal	Drought	Normal	Drought
Giza177 X Sakha101	0.84**	0.22**	-2.80**	-1.36**	0.32	1.08*
Giza177 X Azucena	-0.09	-0.56**	0.55	0.56*	-0.53	0.84*
Giza177 X IR 7887-176-B-2-B	-0.36	-0.04	2.15*	-0.85**	-0.41	-0.18
Giza177 X IR 80508-B-194-1-B	-0.49	-0.13	2.06*	0.42	-0.34	0.01
Giza177 X IR 81025-B-347-3	-0.59*	-0.61**	2.44**	2.67**	-0.48	1.34*
Sakha101 X Azucena	-0.16	0.60**	1.06	-0.07	1.40*	1.27*
Sakha101 X IR 7887-176-B-2-B	0.26	-0.10	2.25*	0.48*	0.59	1.04*
Sakha101 X IR 80508-B-194-1-B	0.16	0.75**	1.88*	-0.54*	-0.01	-1.17*
Sakha101 X IR 81025-B-347-3	0.37	0.15	1.82*	1.00**	0.52	0.63
Azucena X IR 7887-176-B-2-B	0.25	-0.07	-0.08	0.37	1.47*	0.87*
Azucena X IR 80508-B-194-1-B	0.54*	0.14	0.61	-0.33	-0.33	1.39*
Azucena X IR 81025-B-347-3	-0.08	0.02	-0.15	-0.01	-1.08	-0.68
IR 7887-176-B-2-B X IR 80508-B-194-1-B	0.29	-0.09	0.13	2.36**	-0.68	-0.10
IR 7887-176-B-2-B X IR 81025-B-347-3	-0.27	-0.23**	-0.33	0.01	-0.15	-0.37
IR 80508-B-194-1-B X IR 81025-B-347-3	-0.49	-0.23**	-2.00*	-1.25**	-0.08	-1.77*
$LSD_{0.05}$	0.510	0.166	1.764	0.448	1.179	1.501
$LSD_{0.01}$	0.682	0.222	2.360	0.599	1.577	2.008

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

Table 4. Continued

Traits	1000-grain weight (g)		Grain yield/ plant (g)	
Crosses	Normal	Drought	Normal	Drought
Giza177 X Sakha101	2.06**	1.50	3.82**	-3.43**
Giza177 X Azucena	0.28	-0.17	4.09**	2.81**
Giza177 X IR 7887-176-B-2-B	3.74**	2.80**	3.79**	4.26**
Giza177 X IR 80508-B-194-1-B	1.15**	0.82	-4.28**	-2.47**
Giza177 X IR 81025-B-347-3	1.46**	0.72	-10.33**	-8.11**
Sakha101 X Azucena	-1.47**	-0.37	-0.75**	-1.28**
Sakha101 X IR 7887-176-B-2-B	-0.75*	-0.02	-7.41**	-6.19**
Sakha101 X IR 80508-B-194-1-B	-0.73*	-0.32	-6.06**	-3.88**
Sakha101 X IR 81025-B-347-3	0.14	-0.54	2.83**	1.78**
Azucena X IR 7887-176-B-2-B	1.54**	0.97	0.91**	-1.24**
Azucena X IR 80508-B-194-1-B	0.19	-0.04	3.12**	1.92**
Azucena X IR 81025-B-347-3	0.35	0.26	6.58**	2.20**
IR 7887-176-B-2-B X IR 80508-B-194-1-B	-0.96**	-0.98	11.74**	1.63**
IR 7887-176-B-2-B X IR 81025-B-347-3	-2.02**	-1.23	-1.34**	5.35**
IR 80508-B-194-1-B X IR 81025-B-347-3	1.08**	0.78	-0.49**	-2.84**
$LSD_{0.05}$	0.600	1.646	0.174	0.514
$LSD_{0.01}$	0.803	2.202	0.233	0.688

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

Heterosis

The "hybrid vigor" or heterosis is analogous to the condition of inbreeding depression. Their progeny, as inbred lines are crossed, exhibits an improvement in the characteristics that had been inbreeding before. Conversely, health lost by inbreeding depression may be recovered by crossing in general terms. The disparity between the interbred and inbred implies is the sum of heterosis Falconer *et al.* (1996).

As hybridization occurs between parental varieties, rice displays hybrid vigor. Table 5 indicates heterosis as the F1 variance percentage mean values from better parent.

The highest significant heterosis over the better parent (heterobeltiosis, $H_{B.P}$ %) in the desirable direction were recorded by five crosses (from 17.94 % for Giza177 X Azucena to 56.87 % for Azucena X IR80508-B-194-1-B) under normal irrigation and four crosses (from 20.77 % for the cross Azucena X IR7887-176-B-2-B to 45.15 % for the cross Sakha101 X Azucena) under drought stress for panicle weight.

The two crosses, Giza177 X IR7887-176-B-2-B (13.57 %) and Sakha101 X IR7887-176-B-2-B (18.64 %) under normal irrigation and five crosses (ranged from 3.45 % for IR7887-176-B-2-B X IR81025-B-347-3 to 10.46 % for Giza177 X IR81025-B-347-3.) under drought stress for panicle length.

The e cross Azucena X IR7887-176-B-2-B (40.49 %) under normal irrigation and seven crosses (ranged from 3.97 % for Sakha101 X IR81025-B-347-3 to 22.49 % for Giza177 X Sakha101) under drought stress for number of primary branches/panicle.

Three crosses i.e., Azucena X IR7887-176-B-2-B (3.51 %), IR80508-B-194-1-B X IR81025-B-347-3 (4.54 %) and Giza177 X IR7887-176-B-2-B (5.68 %)] under normal irrigation for 1000-grain weight;

Eight crosses (ranged from 7.73 % for Giza177 X IR7887-176-B-2-B to 68.39 % for IR7887-176-B-2-B X IR80508-B-194-1-B under normal irrigation and seven crosses (ranged from 2.45 % for IR7887-176-B-2-B X IR80508-B-194-1-B to 13.19 % for Giza177 X Azucena) under drought stress for grain yield/plant. Consequently, one or more of these crosses might be used in any breeding program for drought stress conditions. These findings revealed that over dominance played a remarkable role in the inheritance of these traits in these crosses. Similar results were obtained previously by Bagheri (2010), Muthuramu *et al.*, (2010), Tiwari *et al.*, (2011) and El-Gamal (2013), who found positive significant heterosis over better parent for some of crosses for the same yield traits under both normal irrigation and drought stress conditions.

Table 5. Heterosis over better parent (HB.P %) of the 15 F1 hybrids of rice for yield and its components under normal irrigation and drought stress conditions.

Traits / treatment	Panicle weight (g)		Panicle length (cm)		No. of branches/ panicle	
	Normal	Drought	Normal	Drought	Normal	Drought
Giza177 X Sakha101	16.93	-12.31*	-8.17	-12.67**	-30.53**	22.49**
Giza177 X Azucena	17.94*	-6.00	-2.10	-5.54**	-16.88**	11.94**
Giza177 X IR 7887-176-B-2-B	-15.82	-22.69**	13.57*	-5.24**	-9.98**	7.45**
Giza177 X IR 80508-B-194-1-B	-6.33	-13.73*	4.45	-6.03**	-7.78	-6.34**
Giza177 X IR 81025-B-347-3	-13.95	-48.65**	3.13	10.46**	-8.83	15.89**
Sakha101 X Azucena	20.31*	45.15**	4.20	-4.86**	-16.79**	11.42**
Sakha101 X IR 7887-176-B-2-B	4.62	-13.43**	18.64**	4.12*	-23.08**	15.00*
Sakha101 X IR 80508-B-194-1-B	15.36	21.64**	7.78	-7.00**	-26.04**	-20.57**
Sakha101 X IR 81025-B-347-3	15.89	-14.71**	4.57	5.82**	-26.67**	3.97**
Azucena X IR 7887-176-B-2-B	26.28**	20.77**	0.84	-0.15	40.49**	9.72
Azucena X IR 80508-B-194-1-B	56.87**	37.20**	6.95	-0.19	2.59	15.94
Azucena X IR 81025-B-347-3	28.95**	4.80	0.96	0.63	-10.65*	-6.82
IR 7887-176-B-2-B X IR 80508-B-194-1-B	14.84	-10.00*	1.96	9.72**	-7.39	-9.77**
IR 7887-176-B-2-B X IR 81025-B-347-3	-3.41	-28.53**	-2.65	3.45**	3.31	-3.97**
IR 80508-B-194-1-B X IR 81025-B-347-3	4.47	-26.13**	-5.33	-5.20**	-8.17	-27.42**
$LSD_{0.05}$	0.67	0.24	2.35	0.60	1.57	1.08
$LSD_{0.01}$	0.97	0.34	3.37	0.86	2.26	1.56

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

Table 5. Continued.

Traits and treatment Crosses Cross	1000-grain weight (g)		Grain yield /plant (g)	
	Normal	Drought	Normal	Drought
Giza177 X Sakha101	-7.48**	-19.87**	-0.82**	-28.63**
Giza177 X Azucena	-9.77**	-21.66**	10.83**	13.19**
Giza177 X IR 7887-176-B-2-B	5.68**	3.61	7.73**	10.94**
Giza177 X IR 80508-B-194-1-B	-4.98**	-21.96**	-12.87**	-18.67**
Giza177 X IR 81025-B-347-3	-3.16**	-12.12**	-29.00**	-34.34**
Sakha101 X Azucena	-9.97*	-19.05**	-5.94**	-7.96**
Sakha101 X IR 7887-176-B-2-B	-8.22**	-23.81**	-22.28**	-29.05**
Sakha101 X IR 80508-B-194-1-B	-9.79**	-26.59**	-21.56**	-28.03**
Sakha101 X IR 81025-B-347-3	-6.12**	-28.48**	-5.05**	-6.26**
Azucena X IR 7887-176-B-2-B	3.51*	-14.83**	41.91**	9.09**
Azucena X IR 80508-B-194-1-B	-2.93*	-20.54**	50.03**	10.12**
Azucena X IR 81025-B-347-3	-1.60	-20.64**	57.40**	9.96**
IR 7887-176-B-2-B X IR 80508-B-194-1-B	-2.42	-22.56**	68.39**	2.45**
IR 7887-176-B-2-B X IR 81025-B-347-3	-5.24**	-24.69**	25.48**	12.87**
IR 80508-B-194-1-B X IR 81025-B-347-3	4.54**	-17.58**	28.79**	-16.98**
$LSD_{0.05}$	0.80	2.19	0.24	0.69
$LSD_{0.01}$	1.15	3.15	0.34	0.99

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

Heritability estimates

Heritabilité estimates for the studied yield and its components under normal irrigation and drought conditions in broad (hB.S percent) and narrow (hN.S percent) senses are shown in Table 6. The inheritance should be relatively large in selecting to achieve hereditary improvements (Calhoun *et al.* 1994).

Higher heritability estimates in broad sense ($h_{B.S}$ %) were detected for; panicle weight (77.95 and 97.60%), panicle length (79.19 and 97.08%), number of branches/ panicle (64.81 and 89.85%), 1000-grain weight (97.91 and 62.57%) and grain yield per plant (99.98 and 99.64%) under normal irrigation and drought stress conditions, respectively. Such data shows that the key role of phenotypic variation in yields and their components has been genotypic variances.

Of all yields and compounds, the lower and moderate heritability figures of grain yields in the narrow-scale (hN.S percent) ranged from 3.06 percent in the usual irrigation cycle to 41.13 percent in the drought-stressed panicle mass. These findings showed that late generations of selection for these characteristics in the studied crosses would be successful. These results agreed with Abd El-Lattef *et al.* (2012).

Table 6. Heritability estimates for the studied yields and their components under normal irrigation and drought stress conditions in broad (hB.S percent) and narrow (hN.S percent) senses.

Traits and treatment	$h_{B.S}$ %		$h_{N.S}$ %	
	Normal	Drought	Normal	Drought
Panicle weight (g)	77.95	97.60	37.54	41.13
Panicle length (g)	79.19	97.08	17.42	29.22
Number of branches/ panicle	64.81	89.85	38.17	22.63
1000-grain weight (g)	79.91	62.57	32.87	26.84
Grain yield /plant (g)	99.98	99.64	3.06	16.83

CONCLUSION

Sakha 101 , Azucena as parents and AZUCENA X IR 7887-176-B-2-B , AZUCENA X IR 80508-B-194-1-B,IR80508-B-194-1-B X IR81025-B-347-3 , IR 7887-176-B-2-B X IR 80508-B-194-1-B and IR 7887-176-B-2-B X IR 80508-B-194-1-B X IR81025-B-347-3 were the best genotypes under normal and water stress condition.

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تقييم القدرة على التآلف وقوة الهجين للمحصول ومكوناته في الأرز تحت ظروف الري الطبيعي والجفاف

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أجريت تجربتان حقليتان فى المزرعة البحثية لمركز البحوث والتدريب فى الأرز – سخا – كفر الشيخ - مصر خلال موسمى 2010 – 2011 م على محصول الأرز باستخدام نظام الهجن التبادلية (نصف دائرى) بين ستة تراكيب وراثية مختلفة وذلك بدون الهجن العكسية لدراسة القدرة على التآلف وقوة الهجين لبعض صفات المحصول ومكوناته تحت ظروف الري الطبيعي والجفاف. اشار تحليل التباين ان هناك مدى اختلافات وراثية بين التراكيب الوراثية لكلا من القدرة العامة والخاصة كانت عالية المعنوية للصفات المدروسة تحت ظروف الرى الطبيعى والإجهاد المائى . النسبة بين تباين القدرة العامة والخاصة تدل على اهمية التباعد الوراثى الغير مضيف فى وراثة محصول الحبوب الفردى وعلى اساس الإنتخاب على تجميع التأثير المضيف يكون افضل لتحسين المحصول والصفات المتعلقة به . طبقا لدليل حساسية الجفاف يوجد اربعة اباء وستة هجن كانت اقل التراكيب الوراثية وكانت اقل تأثيرا للإجهاد المائى . طبق للقدرة العامة على الأئتلاف: اشارت الى حقيقة سلوك السلالات الأبوية كانت جيدة للقدرة العامة على الإئتلاف. طبقا للقدرة الخاصة على الإئتلاف : سجلت افضل الهجن تحت ظروف الرى العادى والاجهاد المائى كان الهجين IR7887-176-B-2-BXIR80508-B-194-1-B افضل لتحسين محصول الحبوب / نباتز فى حالة تحمل الجفاف : كانت اعلى القيم معنوية لقدرة الهجين على اساس افضل الأباء حيث يوجد خمسة هجن لطول السنبلة وسبعة هجن لصفة عدد الفروع / السنبلة وسبعة هجن لمحصول الحبوب . أشارت النتائج ايضا الى ان السيادة الفائقة تلعب دورا واضحا فى وراثة بعض الصفات فى الأرز. أظهرت قيم درجة التوريث بالمعنى الواسع واضحة تحت ظروف الرى العادى والتباين الوراثى يلعب دورا كبيرا فى التباين المظهرى للمحصول ومكوناته . قيم درجة التوريث بالمعنى الضيق منخفض الى متوسط للمحصول ومكوناته حيث اشارت الى ان الإنتخاب للصفات فى الأجيال المتأخره يكون افضل .