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ESTIMATES OF COMBINING ABILITY FOR YIELD AND ITS COMPONENTS AND SOME ROOT CHARACTERS UNDER WATER STRESS CONDETIONS IN RICE (*Oryza sativa* L.).

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ABSTRACT

The present investigation was carried out at the Farm of El-Gemiza Agricultural Research Station, during 2011 and 2012 summer seasons. Combining ability analysis was estimated in rice through a 6 x 6 diallel set analysis involving 6 diverse parents for root, grain yield and its related characters. Mean square values of parents and crosses were found to be highly significant for all characters except parents for panicle length and root fresh weight of parents were significant. Parents Vs crosses mean squares were highly significant for all yield and its related and root characters. Both general and specific combining ability variance were found to be highly significant for all characters, indicating the importance of both additive and non-additive genetic variance in determining the performance of these twelve characters. GCA/SCA ratios were found to be greater than unity for all characters studied except for panicle length, number of filled grains/panicle and 100-grain weight as well as root/shoot% indicating that the additive and additive x additive types of gene action were great importance in the inheritance of all the studied characters except for these four mentioned traits which has been controlled by non-additive genetic variance. The genotypes Sakha 104, Sakha106, Giza178 and Cica 4 were good general combiners for most of all studied characters. Cross combinations involving for such parents were superior for most of all studied characters. The promising combinations for grain yield along with at least two of yield component characters were Sakha 104 X BG-357-4, Sakha 104 X Hixe 5, Sakha 106 X Hixe 5 and Giza178 X BG-357-4. Eight crosses Sakha106 X Hixe 5, Sakha104 X Giza178, Sakha106 X BG-357-4, Sakha104 X Cica 4, Giza178 X BG-357-4, Sakha104 X BG-357-4, Sakha106 X Giza178 and BG-357-4 X Hixe 5 showed highly significant and positive SCA for root length. While three crosses Sakha 104 X Sakha106, Sakha 104 X Hixe 5 and BG-53-2 X Hixe 5 showed highly significant or significant and positive for root volume. Also 7 crosses, Sakha106 X Hixe 5, Sakha104 X Giza178, Sakha106 X Cica4, Giza178 X Hixe 5, Giza178 X BG-357-4, Sakha106 X Giza178 and BG-357-4 showed highly significant and positive for root fresh weight. The best positive SCA for root/shoot % was recorded for Cica4 X Hixe 5, BG-357-4 X Hixe 5, Sakha104 X Giza178, Sakha104 X BG-357-4 and Sakha104 X Hixe 5. A greater magnitude of heterosis ranged between 3.83 and 13.08% was observed in fife crosses for grain yield /plant. The availability of sufficient hybrid vigor in several crosses in respect of grain yield suggests that a hybrid breeding program could profitably be undertaken in rice under water stress conditions. Highest crop water use efficiency 0.55 (kg / m^3) was recorded from one m^3 water irrigation in the parent of Sakha 106 and crosses Sakha104 X Sakha106, (0.56 (kg/m^3), Sakha104 X Hixe 5 (0.55 kg/m^3) and Sakha104 X Cica4 (0.55 kg/m^3).
From the foregoing results, the parents Sakha106, Sakha104, Giza178, and Cica4, crosses Sakha 104 X Sakha106, Sakha 104 X Giza178, Sakha104 X Hixe 5 and Sakha 104 X Cica4 could be recommended for growing under drought conditions to obtain the highest rice grain yield and the highest value of saving water at the same time.

INTRODUCTION

Water deficit is fundamental big problem for rice growing in Egypt. Approximately one-third of rice area is affected by water shortage, this area is located in North Nile Delta or in the terminal of irrigation canals. One of the pertinent avenues for over come this problem is screening of some rice genotypes under water deficit to make new crosses with desirable characters related to drought tolerance to cover more than one-third of rice growing area in Egypt.

Rice is a semi aquatic crop plant that requires high amount of water in the field for proper growth and development. Its impact on economy lies within the fact that it occupies about 22% of the planted area in Egypt during the summer season. Moreover, rice is an important export crop. The amount exported was 500.000 tons. The rice area is increased during the last five years to about one and half million feddans. In Egypt, the success in releasing new rice varieties suitable for drought conditions will not only increase the rice production but also, maximum the farmer's income. Recently, water of the river Nile is not sufficient for irrigation of both old and reclaimed areas. Therefore, water saving becomes argent demand to face this problem through either prolonging irrigation intervals without any drastic effect on the grain yield, or growing drought tolerant varieties, which have a capability to grow under shortage of water (Nour, 1989 and Mady,2004). Therefore, efforts are needed to develop improved rice cultivars with early maturity and higher grain yield potential. Saving rice food in Egypt is challenged by increasing rice demand and threatened by declining water availability. More than 6 million tons of paddy rice were produced from 1.5 million feddans (0.63) million hectares of irrigated area which largely depends largely on the irrigated system of rice production. However, the water use efficiency of rice is low, and growing rice requires large amounts of water. Rice transplanting usually requires a large amount of labor usually at critical time for labor availability, which often results in shortage and increasing labor costs. Alternate methods of establishing crops, especially rice crop that require less labor and water without sacrificing productivity are needed. A fundamental approach to reduce water inputs in rice is to grow the crop like an irrigated upland crop such as wheat or maize. GCA (general combining ability) and SCA (specific combining ability) values would be need for good combiners and proper choice of male and female parent in hybridization programs and rice selection. 4 Root and 8 yield and its related characters were estimated.

The objectives of this study are: (1) screening some of rice genotypes under water stress conditions using water deficit induced by flashing water irrigation every 12 days in the field, (2) making new crosses with desirable characters related to drought tolerance in rice and (3) over coming the water shortage area cultivated by rice.

MATERIALS AND METHODS

The present investigation was carried out at El-Gemiza Agricultural Research Station, during 2011 and 2012 summer seasons. Six Egyptian rice cultivars, namely, Sakha 104, Sakha 106, Giza 178, Cica 4, BG-357-4 and Hixe 5 crossed in half diallel to estimate the general (GCA) and specific (SCA) combining ability and type of heterossis as a better parent for root, and grain yield and its related characters in rice. Parentage and Type of Planting Group of these rice cultivars are given in Table 1.

Table 1: Parentage and Type of Planting Group of rice cultivars

No	Cultivars	Parentage	Type	Drought tolerance
1	**Sakha 104**	GZ4096-8-1 / GZ4100-9-1	Japonica	Moderate
2	**Sakha 106**	Giza177 // Hexi30	Japonica	Sensitive
3	**Giza 178**	Giza 175 / Milyaing 49	Japonica	Tolerant
4	**Cica 4**	Colombia	India	Tolerant
5	**BG-357-4**	Srilanka	India	susceptible
6	**Hexi 5**	Todorokiwase / yaengeng / 35irbn 98-63	India	Moderate

Six rice cultivars chosen based on their considerable level of variability in yield and its related characters were raised thrice at an interval of 10 days to overcome the differences in flowering time for the purpose of hybridization during 2011 summer season at Sakha Agricultural Research Station and 15 half diallel crosses were carried out. Thirty days old seedlings from fifteen cross combinations along with the six parents were transplanted in randomized complete block design with three replications during 2012 summer season at El-Gemiza Farm Station. In each replication the size of the plot consisted of 5 rows with a length of 5 meters. Using A spacing of 20 x 20 cm. Each hybrid was raised in 5m length plot size. The three central rows were used for data collection and observation. Flashing water irrigations were added each twelve days and the agronomic practices was used as recommended. Twenty plants were randomly taken from each parent and each F_1 cross, from each replicate. Data were collected on eight rice characters, yield and its components viz; plant height (cm), days to 50% heading, panicle length (cm), number of panicles / plant, number of filled grains / panicle, sterility%, 100-grain weight and grain yield /plant (g). and four root characters viz; root length, root volume, root fresh weight and root/shoot%.

A- Statistical analysis:

The combining ability analysis was done following (Griffings, 1956) Model 1 Method 2. The data for each measurement were tabulated and analyzed by Fisher's analysis of variance (Steel and Torrie, 1980). The diallel analysis was used to evaluate traits that show significant variation among the parents. Significant differences in phenotypes assumed to imply that genetic differences were present. Simple additive – dominance model approach of Hayman (1954) and Singh and Chaudhary (1979) as modified by Mather and Jinks (1982) was followed for genetic analysis and for the estimation of components of genetic variation. The significance of components of variation in F_1 generation was tested by Mather and Jink (1971). When the value of a parameter divided by its standard error, exceeds 1.96 then it was significant.

Estimation of heterosis:

Useful heterosis for each trait of individual crosses was calculated as the percentage increase in F_1, performance above the better parent performance. Heterosis over better-parent % was estimated as follows:

$$H (\%) = \frac{F_1 - BP \times 100}{BP}$$

Where, F_1 = Mean value of the first generation and BP= Mean value of the better-parent. Appropriate LSD value was calculated to test the significance of the heterotic effects, according to the following formula, suggested by **Wynne et al. (1970).**

$$\text{LSD for better parent heterosis} = \frac{t (\sqrt{2Mse})}{r}$$

Where: t = tabulated "t" value at the specified level of probability for the experimental error degrees of freedom. MSE = the experimental error mean squares of the analysis of variance, and r = number of replications.

B- Water relations

1- Monitoring soil moisture

Soil samples were collected before two days after each irrigation from three successive layers (20 cm each) to determine soil moisture content (Table 2).

Table 2. Soil moisture contents of the experimental site.

Soil depth, (cm)	Field capacity (F.C) %	Permanent wilting point (PWP) %	Available water (AW) (cm)	Bulk density, (g/cm^3)
0-20	41.00	21.18	20.54	1.10
20-40	40.22	19.20	16.12	1.25
40-60	39.11	17.52	14.25	1.66

2- Climatologic elements

Values of the climatological elements were obtained from The Meteorological Station at El-Gemiza, Gharbia Governorate (Table 3), situated at 30 to 47 N latitude and 31 longitude and 15 m altitude. It represents the circumstances and conditions of the North Delta. Average values of temperature, air relative humidity (RH%) and wind speed were recorded daily during two studying seasons.

Table 3. Average meteorological data two seasons

Month	Temperature (%)	RH (%)	wind velocity, (Km/day)
June	23.45	54.36	110.24
July	25.42	60.45	101.58
August	28.41	65.41	81.62
Sept.	23.62	82.64	94.73

3- Estimation of crop coefficient (KC)

Crop coefficient was estimated, according to FAO (1990) as follows:
ETc = Actual evapotranspiration (mm/day).
ETp = Potential evapotranspiration calculated by the modified penman equation (mm/day), and **Kc** = Crop coefficient, dimensionless.
The amount of water needed for land preparation for nursery or permanent field was recorded, beside the amount of water needed for raising the nursery or through the first nine days after transplanting (seedling establishment period), as well as the amount of water used for replenish the plots. Water depth at every irrigation was kept at 3 cm height.

4- Water consumptive use

Total of water applied; i.e., the amount of water delivered each plot plus amount of water applied in both nursery and permanent field for applying three water treatments was measured for each cultivar.

Soil moisture content was determined before and after each irrigation to calculate water consumptive use, according to Iseraelson and Hansen (1962), as follows:

$$Cu = \sum_{i=I}^{n=1} \frac{\theta_2-\theta_1}{100} \times Bd \times D \times 4200\ m^2$$

Where:
Cu = Water consumptive use in each irrigation (cm^3), θ_2 = Soil moisture percent after irrigation (%, d.b), θ_1 = Soil moisture percent before irrigation (%, d.b), **Bd** = Soil bulk density in (g/cm^3), **n** = Number of irrigation, I = Number of soil layer, **D** = Depth of soil layer of the soil (cm) and **4200 m^2** = Area of fed.

5- Crop water use efficiency (CWUE)

It was calculated, according to Hansen *et al.* (1980) by the following equation:

$$CWUE\ (kg/m^3) = \frac{\text{Yield (kg/fed)}}{\text{Water consumptive use } (m^3/fed)}$$

6- Field water use efficiency (FWUE)

It was calculated according to Michael (1978) by the following equation:

$$FWUE\ (kg/m^3) = \frac{\text{Yield (kg/fed)}}{\text{Water applied } (m^3/fed)}$$

RESULTS AND DISCUSSION

Analysis of variance

Analyses of variance for the studied traits under investigation are presented in Tables 4 and 5. The genotype mean squares ware highly significant for all the studied traits indicating wide range of genetic variability among the studied genotypes and this is a primary requirement for further computation. Mean square values of parents and crosses were found to be highly significant for all characters except for parents for panicle length and root fresh weight which wear significant. Parents Vs crosses mean squares were highly significant for all root, yield and its related characters. Both general and specific combining ability variance wares found to be highly significant for all characters, indicating the importance of both additive and non-additive genetic variance in determining the performance of these twelve characters. General combining ability/specific combining ability ratio was used to clarify the nature of the genetic variance involved. With the exception of four traits under investigation, GCA/SCA ratios were found to be greater than unity for all characters under study except for panicle length, number of filled grains/panicle, 100-grain weight and root/shoot% indicating that the additive and additive x additive types of gene action were great importance in the inheritance of all the studied characters except for these four mentioned traits which has been controlled by non-additive genetic variance. Therefore, it could be concluded that the presence of large amounts of additive effects suggests the potentiality for obtaining further to improvement in these characters studied.

Table 4: Mean square estimates of ordinary and combining ability analysis for some, yield and its component characters.

S.O.V.	d.f	Plant height (cm)	Days to heading (days)	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight(g)	Grain yield/plant
Replications	3	14.62	9.31	1.79	0.92	80.63	1.62	0.97	25.62
Genotypes	20	200.63**	299.52**	24.23**	15.99**	1521.32**	13.41**	19.62**	400.25**
Parents (P)	5	2245.26**	280.48**	3.21*	51.34**	869.42**	444.63**	17.41**	611.54**
Crosses (Cr)	14	197.32**	274.32**	22.62**	4.03**	130.25**	5.84**	22.63**	182.41**
P. vs Cr.	1	181.36**	302.54**	95.41**	40.52**	4520.36**	93.62**	18.34**	2377.12**
Error	60	10.47	5.41	0.97	0.95	75.42	1.84	1.99	18.72
G.C.A	5	136.45**	203.51**	3.97**	9.15**	129.45**	8.54**	3.58**	199.74**
S.C.A	15	30.27**	36.56**	5.81**	4.72**	397.42**	3.06**	5.39**	60.27**
Error	60	3.21	0.99	0.31	0.39	16.84	0.27	0.68	6.29
GCA / SCA		4.01	5.13	0.59	4.92	0.59	3.12	0.94	5.12

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

Table 5: Mean square estimates of ordinary and combining ability analysis for some root characters.

S.O.V.	d.f	Root length (cm)	Root volume (cm)	Root fresh (g)	Root/shoot %
Replications	3	1.54	10.25	8.63	0.94
Genotypes	20	14.63**	187.54**	112.56**	9.96**
Parents (P)	5	49.84**	277.63**	250.36*	12.15**
Crosses (Cr)	14	3.99**	254.26**	242.12**	18.63**
P. vs Cr.	1	39.62**	299.62**	298.41**	15.42**
Error	60	1.11	4.13	3.24	0.94
G.C.A	5	10.03**	187.36**	151.47**	2.64**
S.C.A	15	3.99**	29.35**	22.63**	4.73**
Error	60	0.45	0.84	0.54	0.37
GCA / SCA		1.82	2.97	1.71	0.95

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

Also, selection procedure based on the accumulation of additive effects would be very successful in improving these characters. However, to maximize selection advance, procedures which are known to be effective in shifting gene frequency when both additive and non-additive genetic variation are involved. The obtained results agreed with those previously observed by El-Abd (2003), Abd El-Lattef (2004), Hammoud (2004), Sinha *et al.* (2006). and Mujataba *et al.* (2007)

Mean performance of parents and their F_1 generation

The performance of parents and F_1 generation are presented in Table 6 shows that the tallest plants were observed in Sakha106 followed by Sakha 104, Giga 178, Cica4 and BG-357-4. While, the shortest ones were exhibited in Hixe 5 5, rice variety. Sakha 106 followed by Hixe 5 5, and Sakha104 were the earlier rice cultivars, while, Giza 178, BG-357-4 and Cica4 were the latest rice cultivars comparing with other rice cultivars. In addition, Sakha106 has a longest panicle (19.81cm), followed by Sakha 104 and Giza178, while Cica4 and Hixe 5 gave the shortest panicle length (10.42 and 11.54 respectvally). Giza178, Sakha 106, Sakha 104 and Cica4 gave the highest number of panicles/ plant. On the other hand high number of filled grains /panicle (108.72 fertile grains) was recorded for Sakha104 followed by Giza178 (102.71), Sakha 106 (99.33) and Cica 4 (90.84), on the other hand the lowest number of field grains/panicle (70.26) was recorded for BG-357-4 rice variety. Lowest sterility% was recorded for Sakha 106 (14.21%) followed by Sakha 104 (15.82%). On the contrary the highest sterility% was recorded for Hixe 5 (29.56%). Heaviest grains (2.62 g /100 grains) weight was recorded from Sakhs 106, followed by Sakha 104 (2.51 g /100 grains) and Giza178 (2.33 g /100 grains). Highest grain yield/plant (26.41 g/plant) was obtained from Sakha 106 followed by Sakha104 (24.33 g /plant). While BG-357-4 rice variety gave the lowest rice grain yield (19.26 g /plant). The rice root characters are presented in table (7). The longest root length was (25.92 cm) obtained from Giza178 rice variety, followed by Sakha 104 and Sakha106 (24.63cm) and (23.51cm) respectively While the shortest root characters was (16.89cm) recorded for Hixe 5 rice variety. Highest root volume, root fresh weight and root/shoot% were obtained from Giza178 rice variety, followed by Sakha 104 and Sakha106. On the contrary lowest main values for these characters were obtained from Hixe 5 rice variety.

The F_1 mean values of plant height ranged between 55.97 for (BG-357-4 X Hixe 5) and 90.36 cm for (Sakha 104 X Sakha106) rice cross, which agree with the target of rice breeders for selection short stature rice genotypes, resistance to lodging and suitable for mechanical harvesting. Moreover, all rice crosses were earlier than the late rice cultivar, Cica 4 from almost 1 to 18 days. Fife rice crosses, Sakha 104 X Hixe 5 (98.01), Sakha 104 X Giza178 (98.15), Sakha 106 X Giza178 (98.53), Sakha104 X Sakha106 (99.47) and Sakha 104 X BG-357-4 (99.57 days), were earlier than the earliest rice cultivar, Sakha 106 (99.84 days). The highest estimated values of panicle length and number of panicles /plant were recorded on Sakha 106 X Giza178 rice cross. Moreover, the largest number of filled grains /panicle was detected for Sakha 104 X Giza178 (119.62 grains) followed by Sakha 104 X Sakha106 (115.94 grains) and Sakha 104 X Cica4

(109.62 grains). On the contrary, the smallest number of filled grains/panicle (69.15 grains) was recorded for BG-357-4 X Hixe 5. Lowest sterility% (12.36%) was recorded from cross Sakha 104 X Giza178 followed by (15.13%) for Sakha 104 X Cica4. The heaviest 100 grain weight (2.51 g) was obtained for Sakha 104 X Sakha 106, followed by (2.43 g) for Sakha 106 X Giza178, (2.42 g) for Sakha 104 X Giza178 and (2.38 g) for Sakha 104 X BG-357-4 rice crosses. Maximum grain yield /plant was observed for Sakha 104 X Sakha106 (27.18 g), followed by Sakha 104 X Giza178 (26.82 g) and Sakha 104 X Cica4 (26.16 g), almost it was ranged between 2.022 and 2.773 ton / faddn., indicating possibility of increasing grain yield through hybridization followed by selection in any traditional breeding programme. The mean values of root characters (Table 7) showed that the longest root (26.37cm) was obtained from Sakha 104 X Giza178, followed by (25.63cm) for Sakha 104 X Sakha106, (24.71cm) for Sakha 104 X Cica4 and (24.69cm) for Giza178 X Cica4. While the shortest root was (20.11cm) recorded from BG-357-4 X Hixe 5.

Table 6: Mean performance of the six parents and their F_1 generation of 6 x 6 diallel cross for some yield and its component characters.

genotypes	Plant height (cm)	Days to 50 % heading	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight (g)	Grain yield /plant (g)
Sakha 104	81.47	100.45	18.31	15.43	108.72	15.82	2.51	24.33
Sakha 106	96.54	99.84	19.81	16.32	99.33	14.21	2.62	26.41
Giza 178	70.23	102.32	16.25	17.61	102.71	19.43	2.33	23.94
Cica 4	66.52	119.32	10.42	10.71	90.84	26.95	2.24	20.65
BG-357-4	60.74	107.23	13.62	10.45	70.26	19.74	2.16	19.26
Hexi 5	58.63	100.36	11.54	9.86	75.55	29.56	2.25	21.25
Sakha 104 X Sakha 106	90.36	99.47	18.41	16.63	115.94	15.31	2.51	27.81
Sakha 104 X Giza 178	72.54	98.15	19.85	17.31	119.62	12.63	2.42	26.82
Sakha 104 x Cica 4	69.42	118.41	13.89	15.35	109.62	15.13	2.37	26.16
Sakha 104 X BG-357-4	65.34	99.75	14.67	9.97	87.37	23.27	2.38	19.98
Sakha 104 X Hixe 5	59.23	98.01	12.45	8.42	72.13	26.15	2.12	26.53
Sakha 106 X Giza 178	79.41	98.25	20.31	17.32	98.26	16.33	2.43	24.13
Sakha 106 X Cica 4	69.52	105.63	19.43	15.25	98.35	25.29	2.36	25.94
Sakha 106 X BG-357-4	65.41	106.24	14.76	10.87	82.10	18.42	2.13	16.11
Sakha 106 X Hixe 5	62.45	108.74	14.18	9.41	98.98	24.98	2.29	15.12
Giza 178 X Cica 4	71.36	105.63	16.75	14.25	99.23	29.10	2.10	23.47
Giza 178 X BG-357-4	65.42	111.32	11.24	9.49	82.11	19.94	2.44	19.29
Giza 178 X Hixe 5	71.35	109.74	12.10	8.13	79.12	25.11	2.14	15.15
Cica 4 X BG-357-4	65.42	105.36	10.14	9.41	85.29	25.12	2.11	16.10
Cica 4 X Hixe 5	58.36	111.47	11.12	5.81	71.14	26.14	2.35	14.14
BG-357-4 X Hixe 5	55.97	110.62	12.13	6.14	69.15	20.85	2.15	14.13
LSD at 0.05	2.16	4.63	2..24	5.46	3..22	0.12	2..27	3..36
LSD at 0.01	3.25	5.92	3.35	6..35	4.49	0.24	3.26	4.01

Highest main of root volume (61.27ml) was recorded for Sakha 104 X Giza178, followed by (60.81ml), Sakha 104 X Cica4, (60.41ml) for Sakha 104 X Sakha106 and (59.82ml) for Sakha 106 X Giza178. Highest mean values for root fresh weight (49.79g) obtaind from Sakha 106 X Giza178, followed by (49.72g)from Sakha 104 X Sakha106. Also, highest root/shoot% (0.42%) recorded from Sakha 104 X Sakha106, followed by Sakha 104 X Giza 178, Sakha106 X Giza178, Sakha 104 X Cica4 and Sakha 104 X BG-357-4 being (0.39%), (0.35%), (0.34%) and (0.32%) respectively On the contrary cross BG-357-4 X Hixe 5 come the last one for all studied root characters.

Table 7: Mean performance of the six parents and their F_1 generation of 6 x 6 diallel cross for some root characters.

genotypes	Root length (cm)	Root volume (cm)	Root fresh weight (gm)	Root/shoot %
Sakha 104	24.63	56.37	47.63	0.32
Sakha 106	23.51	52.42	47.28	0.30
Giza 178	25.92	58.63	48.72	0.34
Cica 4	22.63	49.63	45.92	0.29
BG-357-4	19.27	38.21	32.51	0.25
Hexi 5	16.89	32.74	29.46	0.19
Sakha 104 X Sakha 106	25.63	60.41	49.72	0.42
Sakha 104 X Giza 178	26.37	61.27	49.53	0.39
Sakha 104 x Cica 4	24.71	60.81	47.98	0.34
Sakha 104 X BG-357-4	24.63	59.41	39.41	0.32
Sakha 104 X Hixe 5	22.81	58.63	32.63	0.29
Sakha 106 X Giza 178	25.96	59.82	49.79	0.35
Sakha 106 X Cica 4	23.91	54.92	46.21	0.31
Sakha 106 X BG-357-4	23.69	53.63	35.41	0.30
Sakha 106 X Hixe 5	20.42	51.41	34.72	0.28
Giza 178 X Cica 4	24.69	46.41	49.12	0.31
Giza 178 X BG-357-4	22.82	45.32	45.41	0.28
Giza 178 X Hixe 5	20.41	47.26	39.63	0.29
Cica 4 X BG-357-4	23.41	50.84	46.82	0.28
Cica 4 X Hixe 5	20.26	42.13	32.71	0.24
BG-357-4 X Hixe 5	20.11	34.62	29.71	0.24
LSD at 0.05	3.63	5.42	7.15	0.14
LSD at 0.01	4.01	7.56	8.64	0.22

Estimates of general (GCA) and specific (SCA) combining ability

Obviously, estimate of GCA showed that the parents Sakha 104, Cica4 and Giza178 were found to be good general combiners for grain yield/plant (Table 8). High GCA effect of Sakha 104 was associated with its high GCA effect for panicle length, number of panicles /plant, number of filled grains /panicle, lowest sterility% and 100 grain weight. The good combining ability of cultivar Cica4 was due to high elongation of its panicle and its heavies grains, while the high estimates of general combining ability of cultivar Giza178 for grain yield /plant was due to its highest estimates of panicle length and number of panicles /plant. The results also revealed that among the studied parents, Sakha 104 followed by Cica4 and Giza178 were the best general combiners for tall plant height. Moreover, Sakha 106, and Cica4 were the best general combiners for earliness.

Table 8: Estimates of general combining ability (GCA) effects for yield and its component characters.

Parents	Plant height (cm)	Days to 50 % heading	Panicle length (cm)	No of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight (g)	Grain yield /plant (g)
Sakha 104	-2.84**	6.21**	0.62**	1.24**	7.47**	-1.94**	0.74**	7.22**
Sakha 106	1.77**	-7.54**	-0.99 **	-0.94**	1.12	-0.82*	-1.32**	-6.04**
Giza 178	-4.02**	3.95**	0.36	-1.09**	-2.41**	1.03**	1.08*	3.07**
Cica 4	2.99**	-4.05**	0.59**	1.67**	2.10	1.64**	-0.74**	3.41**
BG-357-4	-1.94**	5.97**	-0.94**	-0.84**	-3.94**	-0.99**	-0.19	-3.28**
Hexi 5	6.48**	3.63**	0.38**	-1.95**	-5.09**	1.23**	0.69**	-4.21**
S.E. at 0.05	0.69	0.87	0.19	0.19	1.12	0.61	0.20	0.94
S.E. at 0.01	1.03	1.35	0.38	0.41	2.34	0.94	0.29	1.45

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

GCA estimates for root characters (Table 9) showed that, the best GCA were recorded for Sakha 104, Sakha 106 and Giza 178 for root length, root volume and root/shoot%. While good GCA for root fresh weight was recorded from Sakha104, Giza 178, Cica 4 and Hixe 5

Table 9: Estimates of general combining ability (GCA) effects for some root characters.

Parents	Root length (cm)	Root volume (cm)	Root fresh weight (gm)	Root/shoot %
Sakha 104	0.34**	0.65**	0.54**	0.22
Sakha 106	0.52**	0.94**	-1.02 **	0.34**
Giza 178	0.63**	0.49**	0.66**	0.17**
Cica 4	-0.41**	-0.82**	0.76**	-0.26*
BG-357-4	-0.75**	-0.93**	-1.23**	-0.45**
Hixe 5	-0.28**	-0.34**	0.37**	-0.36**
S.E. at 0.05	0.16	0.21	0.20	0.13
S.E. at 0.01	0.32	0.39	0.47	0.24

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

Therefore, it may be concluded that crosses involving these parents would result in the identification of superior gerents with favorable genes for grain yield and component characters and other root characters. High GCA effects are related to additive and additive X additive components of genetic variation, the parents with higher positive significant GCA effects are considered as good combiners, while those with negative GCA effects are poor general combiners except for in case of plant height, earliness and sterility%. Similar results were obviously recorded by **El-Abd (2003),** Hammoud (2004), Shehata (2004), Satish and Seetharamaiah (2005), Sharma *et al.* (2005) and Dhakar and vinit (2006).

The estimates of specific combining ability of 15 crosses for 12 yield and its components and root; characters are presented in Tables 10 and 11. It is observed that a total of 9 crosses exhibited positive and significant SCA for grain yield /plant. The promising combinations for grain yield along with at least two of yield component characters were Sakha 104 X BG-357-4, Sakha 104 X Hixe 5, Sakha 106 X Hixe 5 and Giza178 X BG-357-4. It is observed that majority of the crosses with high SCA for grain yield were involved with low / high or high / low or High / high or low / low combining parents. But very few crosses showing low / low general combiners showed high SCA .The cross combinations showing high negative SCA for plant height were Giza178 X Cica4, Sakha 104 X BG-357-4, Sakha 104 X Sakha106, Sakha 106 X Cica4 and Cica4 X Hixe 5. For plant height, positive estimates of SCA are desirable and the good specific combiners were BG-357-4 X Hixe 5, Sakha 104 X Cica4, Sakha 106 X Giza178, Sakha 106 X Hixe 5, Giza178 X BG-357-4 and Sakha 106 X BG-357-4. fore days to 50% heading, highly significant and negative SCA for days to 50% heading (earliness) were Sakha 106 X BG-357-4, Giza178 X Cica4, Giza178 X Hixe 5, Sakha104 X Giza178, Sakha104 X BG-357-4, Sakha106 X Cica4, Sakha106 X Giza178, Sakha106 X Cica4 and Sakha 105 X Giza178. The cross combinations viz., Sakha 106 X Hixe 5, Sakha 104 X Giza178, Sakha 106 X Cica4, Cica4 X BG-357-4 and Sakha104 X Hixe 5 were good specific combiners for panicle length. The best specific combiners for number of panicles /plant were Cica4 X Hixe 5, Saka 106 X Cica4, Sakha104 X Cica4, Sakha 104 X Giza178, Giza178 X Cica4, Sakha 106 X Giza 178, Giza178 X BG-357-4 and Sakha 104 X Sakha 106 showed higher SCA for number of filled grains / panicles.

Table 10: Estimates of specific combining ability (SCA) effects for yield and its component characters.

Crosses	Plant height (cm)	Days to 50 % heading	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight (g)	Grain yield /plant (g)
Sakha 104 X Sakha 106	-5.32**	3.59**	-3.51**	-1.68**	4.02	-3.63**	2.45**	5.31**
Sakha 104 X Giza 178	1.43	-5.69**	4.82**	1.42**	13.84**	-4.82**	2.28**	-6.84**
Sakha 104 x Cica 4	9.12**	-2.84**	-2.57**	-1.36**	15.47**	2.16**	-1.45**	4.26**
Sakha 104 X BG-357-4	-5.47**	-5.63**	-0.63*	2.94**	30.62**	-1.21*	-3.26**	9.63**
Sakha 104 X Hixe 5 5	2.84**	4.64**	2.04**	1.43**	-16.84**	2.65**	-2.29**	9.47**
Sakha 106 X Giza 178	5.22**	-5.03**	1.62**	-3.65**	11.63**	1.28**	1.45**	4.65**
Sakha.106 X Cica 4	-4.63**	-5.22**	3.54**	0.45	15.74**	-3.54**	-2.84**	5.94**
Sakha 106 X BG-357-4	1.84	-9.63**	-2.97**	-1.84**	-9.66**	2.63**	4.28**	0.58
Sakha 106 X Hixe 5	4.63**	-3.52**	4.93**	-1.75**	-35.87**	-4.54**	-3.62**	8.94**
Giza 178 X Cica 4	-5.94**	-7.84**	-3.54**	-1.94**	12.97**	3.27**	-0.63	-0.95
Giza 178 X BG-357-4	3.78**	-5.63**	0.48	-2.63**	4.82	1.94**	-4.01**	7.83**
Giza 178 X Hixe 5	0.67	-7.65**	-2.63**	-0.95**	-5.63*	2.62**	2.13**	-3.65**
Cica 4 X BG-357-4	-0.94	-3.49**	2.56**	-1.42**	-18.94**	2.31**	-2.39**	1.92
Cica 4 X Hixe 5	-4.63**	2.64**	-0.61	1.97**	17.52**	-0.49	-2.01**	-0.85
BG-357-4X Hixe 5	9.84**	1.22*	0.94**	1.32**	17.45**	0.96*	1.94**	5.69**
S. E. at 0.05	1.99	1.14	0.62	0.49	4.97	0.56	0.69	1.93
S.E. at 0.01	2.74	1.32	0.84	0.96	6.02	1.23	1.12	2.74

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

Table 11 : Estimates of specific combining ability (SCA) effects for root characters.

Crosses	Root length (cm)	Root volume (cm)	Root fresh weight (g)	Root/shoot %
Sakha 104 X Sakha 106	-2.95**	3.98**	-4.23**	-0.12
Sakha 104 X Giza 178	3.56**	-6.17**	6.54**	0.42**
Sakha 104 x Cica 4	2.23**	-4.26**	-5.91**	-0.94**
Sakha 104 X BG-357-4	-0.33**	-0.63*	-1.23*	0.38**
Sakha 104 X Hixe 5	1.97**	2.84**	4.29**	0.23**
Sakha 106 X Giza 178	1.32**	-2.36**	4.31**	-0.68**
Sakha 106 X Cica 4	-2.98**	-4.12**	6.32**	0.13
Sakha 106 X BG-357-4	2.43**	-4.98**	-7.63**	-0.91**
Sakha 106 X Hixe 5	3.79**	-5.97**	7.26**	-0.79**
Giza 178 X Cica 4	-2.99**	-4.36**	-6.27**	-1.05**
Giza 178 X BG-357-4	0.36*	-0.98**	1.13	-0.67**
Giza 178 X Hixe 5	2.13**	-4.12**	-6.31**	-0.38**
Cica 4 X BG-357-4	-2.97**	-4.26**	5.27**	-0.52**
Cica 4 X Hixe 5	-0.16	0.34	-0.65	0.89**
BG-357-4X Hixe 5	0.82**	1.15*	2.13**	0.42**
S. E. at 0.05	0.19	1.03	1.22	0.14
S.E. at 0.01	0.43	1.84	1.97	0.78

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

Also cross combination Sakha 104 X Giza178, Sakha 104 X Sakha 106, Sakha 106 X Cica4 and Sakha 104 X BG-357-4 showed high negative sterility%. Six crosses namely, Sakha 106 X BG-357-4, Sakha 104 X Sakha 106, Sakha 104 X Giza178, Giza178 X Hixe 5 and BG-357-4 X Hixe 5. exhibited highly significant and positive SCA effects for100-grain weight. SCA for root characters alliterated in Table 11, eight crosses Sakha106 X Hixe 5, Sakha104 X Giza178, Sakha106 X BG-357-4, Sakha104 X Cica4, Giza178 X BG-357-4, Sakha104 X BG-357-4, Sakha106 X Giza178, BG-357-4 X Hixe 5 were showed highly significant and positive for root length. While three crosses Sakha 104 X Sakha106, Sakha 104 X Hixe 5 and BG-357-4 X Hixe 5 showed highly significant and positive for root volume. Also 7 crosses, Sakha106 X Hixe 5, Sakha104 X Giza178, Sakha106 X Cica4, Giza178 X Hixe 5, Giza178 X BG-357-4, Sakha106 X Giza178 and BG-357-4 showed highly significant and positive for root fresh weight. The best positive SCA for root/shoot% was recorded for Cica4 X Hixe 5, BG-357-4 X Hixe 5, Sakha104 X Giza178, Sakha104 X BG-357-4 and Sakha104 X Hixe 5. Moreover, these cross combinations also included the parents recorded either good or poor GCA for this traits. Through there is a preponderance of non additive gene action for grain yield and most of the yield components in the hybrids resulted in high amount of vigor in F_1, where selection can be postponed to later generation. These findings were in agreement with those of Yu *et al.* (2004), Bagheri *et al.* (2005), Rosamma and Vijayakumar (2005) and Abd –El-Lattef and Badr (2007).

Estimates of better parent heterosis

A large number of crosses exhibited high estimates of heterosis in a desirable direction for different characters under study. The estimates of heterosis for yield and its component characters are presented in Table 12. A greater magnitude of heterosis ranged between (3.83 and 13.08%) was observed in fife crosses for grain yield /plant. The availability of sufficient hybrid vigour in several crosses in respect of grain yield suggests that a hybrid breeding programme could profitably be undertaken in rice under water stress conditions. For plant height, two crosses, Sakha104 X Hixe 5 (-5.17%), and Cica4 X Hixe 5 (-3.33%), recorded significant heterosis in a desirable negative direction. The crosses Sakha104 X Hixe 5, Sakha 104 X BG-357-4 and Sakha106 X Giza178 exhibited highest negative heterosis (-5.45%), (-4.14%) and (-4.04%) for days to 50% heading. Appearance of significant and negative heterosis for days to 50% heading indicated the possibility of exploiting heterosis for earliness. Two only crosses, Sakha104 X Giza178 (5.55%) and Sakha 106 X Giza178 (9.26%), recorded significant heterosis in a desirable positive direction for panicle length. Moreover, highly significant and negative estimates of heterosis were observed for number of panicles /plant in all the studied crosses , the highest estimated value was recorded for Sakha178 X Hixe 5 (-52.94%), while, the lowest estimated value was detected for Sakha 106 X Cica4 (-6.25%). On the other hand, no desirable heterosis was found among all the studied crosses for number of filled grains/panicle which exhibited either non-significant or highly significant estimates in positive direction. Out of fifteen studied crosses, only Two of them, Sakha 104 X Sakha 106 and Sakha104 X Giza178 exhibited significant and highly significant positive estimates of heterosis for number of filled grains /panicle. The estimates of desirable heterosis in Table 12, among the cross for sterility%, in three crosses, varied from -3.84% (Giza178 X Hixe 5), -5.26% (Sakha106 X BG-357-4) to -20.14% (Sakha104 X Giza178). All the studied crosses recorded highly significant heterosis in negative direction for100-grain weight.

Table 12: Estimates of heterosis as a deviation from better parent of the fifteen rice crosses for some, yield and its component characters.

Genotypes	Plant height	Days to 50 % heading	Panicle length (cm)	No. of panicles /plant	No. filled grains /panicle	Sterility %	100-grain weight (g)	Grain yield /plant (g)
Sakha 104 X Sakha 106	11,11**	0,16	-5,26**	-1,84	6,48**	7,14**	-3,84	3,84**
Sakha 104 X Giza 178	2,85	1,01	5,55**	-2,29	10,18**	-20.12**	-4.12*	13,04**
Sakha 104 x Cica 4	4,54**	19,19**	-27,77**	-2,78	0,92	-1.31	-8.24**	13,04**
Sakha 104 X BG-357-4	8,33**	4,04**	-22,22**	-40.12**	-19,44**	53,33**	-8.36**	-17,39**
Sakha 104 X Hixe 5	-5,17**	5,05**	-33,33**	-46,66**	-33,33**	73,33**	-16.25**	13,08**
Sakha 106 X Giza 178	12,85**	4,04**	5,26**	-1,73	-3,92	14,28**	-7,69**	-7,69**
Sakha 106 X Cica 4	4,54**	6,06**	-1.02	-6,25**	-1,01	31,57**	-11,53**	-3,84*
Sakha 106 X BG-357-4	8,33**	7,07**	-26,31**	-37,51**	-17,17**	-5,26**	-19,23**	-38,46**
Sakha 106 X Hixe 5	6,89**	9,09**	-26,31**	-43,75**	-1,01	26,31**	-4,34*	-42,30*
Giza 178 X Cica 4	7,57**	2,94	-1.03	-17,64**	-2,94	52,63**	-8,69**	4,54*
Giza 178 X BG-357-4	8,33**	8,82**	-31,25**	-47,05**	-19,60**	-1.04	4,34*	-13,63**
Giza 178 X Hixe 5	22,41**	9.21**	-25**	-52,94**	-22,54**	-3,84*	-8,69**	-31,81**
Cica 4 X BG-357-4	8,33**	-1,86	-23,07**	-10.54**	-5,55*	31,57**	-4,54*	-20.13**
Cica 4 X Hixe 5	-3,33*	11.14**	-15,38**	-50.24**	-21,11**	-1.13	4,54*	-33,24**
BG-357-4 X Hixe 5	1,72	10.23**	-7,69**	-40.13**	-8.14**	5,26**	-4,54*	-33,33**

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

Concerning estimates of heterosis for root characters as shown in Table 13, highest significant and positive direction was recorded from four crosses namely, BG-357-4 X Hixe 5 (5.26%), Cica4 X BG-357-4 (4.54%), Sakha104 X Sakha106 (4.16%) and Sakha104 X Giza 178 (4.01%). While most of rice crosses gave the highest significant and positive for root volume. Positive estimates of heterosis significant or highly significant was obtained for two crosses Sakha104 X Sakha106 (4.25%) and Sakha104 X Giza 178 (2.08%). On the other hand four rice crosses Sakha104 X Sakha106 (31.25%), Sakha104 X Giza178 (14.70%), Sakha106 X BG-357-4 (13.33%) and Sakha104 X Cica4 (6.25%) showed highly significant and positive direction for root/shoot%.

Table 13: Estimates of heterosis as a deviation from better parent of the fifteen rice crosses for some, root characters.

Crosses	Root length (cm)	Root volume (cm)	Root fresh weight (g)	Root/ shoot %
Sakha 104 X Sakha 106	4,16*	7,14**	4,25**	31,25**
Sakha 104 X Giza 178	4.01*	5,17**	2,08	14,70**
Sakha 104 x Cica 4	-0,82	7,14**	-2,18	6,25**
Sakha 104 X BG-357-4	1,25	5,35**	-18,75**	-3,03
Sakha 104 X Hixe 5	-8,33**	3,57*	-33,33**	-9,37**
Sakha 106 X Giza 178	-1,57	1,72	-0,41	2,94
Sakha 106 X Cica 4	0,43	3,84*	-2,12	3,33
Sakha 106 X BG-357-4	-2,54	1,92	-25,53**	13,33**
Sakha 106 X Hixe 5	-13,04**	-1,92	-27,65**	-6,66**
Giza 178 X Cica 4	-4.12*	-20,68**	-1,03	-8,82**
Giza 178 X BG-357-4	-12.12**	-8,16**	-6,83	-17,64**
Giza 178 X Hixe 5	-20.23**	-4,08*	-18,75**	-14,71**
Cica 4 X BG-357-4	4,54*	2,04	2,22	-3,44
Cica 4 X Hixe 5	-9,09**	-14,23**	-28,88**	-17,24**
BG-357-4 X Hixe 5	5,26*	13,15**	-9,37**	-4.11*

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

From the foregoing discussion, it may be concluded that the crosses, Sakha 105 X IET1444, Sakha 101 X IET1444, Sakha 101 X Sakha 105 and Sakha 102 X Sakha 105 can be rated as the best crosses based on their heterosis in most of the studied traits including grain yield. Thus, it can be exploited in subsequent generations to improve most of the studied traits. Similar results were reported by several scientists like, Zhen *et al.* (2004), Jin *et al.* (2005), Shanthala *et al.* (2006) and Abd EL-lattef et al (2011).

Water intervals

Estimates of amount of water applied, water consumptive use m3/ fed: and actual evapotranspiration in (ETC mm / day) are presented in Table 14. The results indicated that total water applied and water consumptive use were 5003.42 and 4019.01 m^3/ fed, respectively. While the highest water applied and water consumptive use values were 1495.63 and 1100.26 m^3 / fed., respectively, recorded in August. On the other hand, the lowest recorded values were 991.66 and 824.41 m3 /fed., respectively, in September.

Data in Table 14, also, showed that values of ETc increased in August and July followed by June, it was 7.59, 7.36 and 6.57 mm / day respectively. While in September, it was 6.14 mm / day. Concerning potential evapotranspiration (ETp mm / day), the highest ETp (7.96 mm / day) was recorded in August followed by July and June , while the lowest ETp (6.52 mm / day) was recorded in 20 September. Estimation (ETp mm / day) the data showed insignificant differences among the them in pre-harvest period; e.g., months June, July and August value for (ETp mm / day). The evapotranspiration (ETp mm / day) decreased in emergence stage, while, it gradually increased with increasing the age of plant, but decreased with pre-harvest period in 20 September, after that (ETp mm / day) was increased in August, July and June.

Table 14. Water applied m^3/fed., water consumptive use, actual and potential evapotranspiration (mm / day), and Values of crop coefficient (kc).

Months	Water applied M^3/fed.	Water consumptive use m^3/fed.	Evapotr-anspiration mm/day	ETp mm/ day M.P.	K.C%
June	1115.31	996.26	6.57	6.91	0.95
July	1401.26	1099.13	7.36	7.56	0.99
August	1495.63	1100.26	7.59	7.96	0.95
20 sep.	991.66	824.41	6.14	6.52	0.94
total	5003.42	4019.01	27.66	28.95	3.81
mean	1250.81	1004.25	6.91	7.23	0.95

Concerning crop coefficient values (Kc%) in Table 14 , it is clear that the effect of crop characteristics on crop water requirements was observed by crop coefficient, which represented the relationship between reference potential (ETp) and actual crop evapotranspiration (ETc). The values of crop coefficient for irrigation pattern (kc) (Table 14) showed slight increase after planting, but, decreased again at the end of growth season. It could be noticed that the nearest values to average (kc) was that of radiation equation. Same results were reported earlier by Nasir *et al.* (2002), Hussain *et al.* (2003) and Azam *et al.* (2005).

Estimates of grain yield (Kg / fed)., crop and field water use efficiency (CWUE %) and field water use efficiency (FWUE %) are tabulated in Table 15 . The results indicated that the average grain yield was significantly affected by breeding. The maximum values (2773.48 Kg / fed) was found for the second parent (Sakha 106) followed by Sakha104 (2554.46 Kg / fed), Giza178 (2513.71 Kg / fed.), Hixe 5 (2231.15 Kg / fed.) and Cica4 (2168.84 Kg / fed). While, the minimum value was recorded by BG-357-4 it was (2022.32 Kg / fed). From the cross combination foregoing results, the highest average grain yield (2839.51 Kg / fed) was recorded for the first cross, (Sakha 104 X Sakha106), followed by cross Sakha 104 X Hixe 5 (2776.31 Kg / fed), Sakha 104 X Cica4 (2774.11 Kg / fed), Sakha 104 X Giza178 (2771.58 Kg / fed) Sakha 106 X Cica4 (2625.31 Kg / fed) and Sakha 106 X Giza178 (2520.48 Kg / fed). While, the lowest value (1470.85 Kg / fed) was recorded for the cross (BG-357-4 X Hixe 5).

Crop and field water use efficiency (CWUE %)

Data in Table 15 also, illustrated that crop water use efficiency was significantly affected by irrigation methods. The maximum CWUE % value

(0.55) was recorded for the second parent Sakha106 followed by Sakha104, Giza178 and Cica4, bing 0.51, 0.50 and 0.44 (kg / m^3) respectively. While, the minimum value (0.40 kg / m^3) was obtained for BG-357-4. On the other hand, cross Sakha104 X Sakha106, gave the highest value 0.56 (kg / m^3) of crop water use efficiency, followed by the crosses Sakha 104 X Hixe 5 and Sakha104 X Cica4, bing 0.559 and 0.553 (kg / m^3) respectively.

The data showed that the highest crop water use efficiency 0.55 (kg / m^3) was recorded from one m^3 water irrigation in the parent of Sakha 106 and crosses Sakha104 X Sakha106, (0.56 (kg/m^3), Sakha104 X Hixe 5 (0.55 kg/m^3) and Sakha104 X Cica4 (0.55 kg/m^3). Also data indicated the significant effect of irrigation method on FWUE %. The maximum FWUE % value was recorded for the second parent (Sakha 106) followed by Sakha104 and Giza178. Whereas, the minimum value was recorded for BG-357-4 rice varity. On the other hand the highest value of FWUE % was found in cross Sakha 104 X Sakha106, followed by crosses Sakha 104 X Hixe 5 and Sakha 104 X Cica4. These results were in harmony with those obtained by Yasin *et al.* (2003) Mady, (2004) and Ahmed and Karube (2005).

From the foregoing results, the parents Sakha106, Sakha104, Giza178, and Cica4, crosses Sakha 104 X Sakha106, Sakha 104 X Giza178, Sakha104 X Hixe 5 and Sakha 104 X Cica4 could be recommended for growing under drought conditions to obtain the highest rice grain yield and the highest value of saving water at the same time.

Table 15. Crop water use efficiency and field water use efficiency under water stress conditions.

Genotyps	Grain yield /ton/fid.	CWUE%	FWUE%
Sakha 104	2554.46	0.51	0.63
Sakha 106	2773.48	0.55	0.68
Giza 178	2513.71	0.50	0.62
Cica 4	2168.16	0.44	0.53
BG-357-4	2022.32	0.40	0.50
Hixe 5	2231.15	0.44	0.55
Sakha 104 X Sakha 106	2835.51	0.56	0.70
Sakha 104 X Giza 178	2771.58	0.55	0.68
Sakha 104 x Cica 4	2774.11	0.55	0.69
Sakha 104 X BG-357-4	1995.23	0.39	0.49
Sakha 104 X Hixe 5 5	2776.13	0.55	0.69
Sakha 106 X Giza 178	2520.48	0.50	0.62
Sakha 106 X Cica 4	2625.31	0.52	0.65
Sakha 106 X BG-357-4	1680.64	0.33	0.41
Sakha 106 X Hixe 5	1557.32	0.31	0.39
Giza 178 X Cica 4	2515.62	0.48	0.60
Giza 178 X BG-357-4	1993.52	0.39	0.49
Giza 178 X Hixe 5	1576.56	0.31	0.39
Cica 4 X BG-357-4	1682.48	0.33	0.41
Cica 4 X Hixe 5	1471.36	0.29	0.36
BG-35-2 X Hixe 5	1470.85	0.29	0.36
a **Average**	2210.42	0.43	0.54

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تقدير القدرة على التآلف لمحصول الحبوب ومكوناته وبعض صفات الجذور تحت ظروف انخفاض الرطوبة الارضية في محصول الأرز.

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اجريت دراسة القدرة على التآلف وقوة الهجين مقارنة باقضل الاباء لمحصول الحبوب باستخدام نظام الهجن التبادلية بين ستة تراكيب وراثية مختلفة وذلك بدون الهجن العكسية، بمحطة البحوث الزراعية بسخا والجميزة وذلك أثناء موسمى ٢٠١٢ و٢٠١١. تحت ظروف نقص الرطوبة الارضية حيث تمت عملية الرى كل ١٢ يوم دون اشباع التربة.

وكانت أهم النتائج المتحصل عليها كالا تى:-

كانت هناك معنوية عالية لكل من القدرة العامة والخاصة على التالف فى معظم صفات الجذور والمحصول ومكوناتة مما يدل على اهمية الفعل المضيف والغير مضيف فى توارث هذة الصفات. أوضحت النتائج أن النسبة بين كل من تباين القدرة العامة على التآلف الى تباين القدرة الخاصة على التآلف أعلى من الواحد مشيرة إلى أهمية الفعل المضيف للجين فى التحكم فى صفات ارتفاع النبات، عدد الأيام إلى التزهير، عدد النورات الدالية / نبات، و محصول الحبوب / نبات وصفة نسبة المجموع الجذرى الى الخضرى . على النقيض من ذلك، أكدت النتائج على اهمية الفعل الجينى السيادى فى التحكم فى السلوك الوراثى لصفات طول النورة الدالية، عدد الحبوب الممتلئة / للدالية ووزن الألف حبة. بين الأباء، كان الصنف سخا ١٠٦ أكثر الأباء قدرة عامة على التآلف´لجميع الصفات المدروسة عدا التبكير، . وكانت التراكيب الوراثية سخا ١٠٤ و جيزة 178 و سيكا 4 أفضل الآباء قدرة عامة على التآلف لمعظم الصفات المدروسةوكذلك الهجن الناتجة من هذة الاباء. هذا وقد أعطت التراكيب الوراثية سخا ١٠٤ X بى جى -٥-٢، سخا ١٠٤ X هكسى ٥ و سخا ١٠٦ X هكسى٥ و جيزة ١٧٨ X بىجى -٥-٢أعلى قدرة خاصة على التآلف لصفتى عدد الحبوب الممتلئة / للدالية و محصول النبات / نبات. أظهرت ثمانية هجن سخا ١٠٦ X هكسى ٥ و سخا ١٠٤ X جيزة ١٧٨ وسخا 106 X بى جى -٥-٢ و سخا ١٠٤ X سيما ٤ وجيزة ١٧٨ X بىجى -٥-٢ و سخا ١٠٤ X بىجى -٥-٢ وسخا ١٠٦ X جيزة ١٧٨ و بى جى -٥-٢ X هكسى ٥ قدرة خاصة على التآلف مرغوبة وعالية المعنوية وموجبة ، لصفة طول الجذر . إضافة الي ذلك كانت التراكيب الوراثية سخا ١٠٤ X سخا١٠٦ وسخا ١٠٤ X هكسى ٥ ' وبى جى -٥-٢ X هكسى ٥ أفضل الهجن قدرة خاصة علي التآلف لصفات حجم الجذر. كما كانت افضل كفائة للاستهلاك المائى للاباء سخا ١٠٦ و سخا ١٠٤ و جيزة ١٧٨ وسيكا ٤ وكذالك التراكيب الوراثية الناتجة من هذة الاباء

كما اوضحت النتائج ان كمية المياة المضافة للتراكيب الوراثية المدروسة تراوحت من ٤٠١٩,٠١ الى ٥٠٠٣,٤٢ متر مكعب للفدان كما ان المتر المكعب من المياة اعطى اعلى كمية حبوب تراوحت بين ٥٥٠ و٥١٠ و ٥٠٠ و ٤٩٠ جرام حبوب من المتر المكعب من المياة للاصناف سخا ١٠٦ و سخا ١٠٤ وجيزة ١٧٨ وسيكا ٤ على التوالى وكذلك الهجن الناتجة من هذة الاباء.

بناء على النتائج المشار اليها يمكن التوصية بزراعة سخا ١٠٦ و سخا ١٠٤ وجيزة ١٧٨ وسيكا ٤ على التوالى وكذلك الهجن الناتجة من هذة الاباء. تحت ظروف نقص الرطوبة الارضية وذلك لتفوقهما فى محصول الحبوب وذلك بستخدام اقل كمية مياة.

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