COMBINING ABILITY AND HETEROSIS ANALYSIS FOR SOME AGRONOMIC TRAITS IN RICE

Ammar M. H. M.
Rice Research Department, Field Crops Research Institute,
Agricultural Research Center, Giza, Egypt

ABSTRACT

This study was carried out at the experimental farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, to study combining ability and heterosis in a diallel mating design among six rice genotypes (excluding reciprocals), using six varieties namely Sakha 101, Sakha 103,Giza177,Giza176 and Giza159 and BL1. An experiment was conducted during 2014, 2015 growing seasons and designed in a randomize complete block with three replications. Data were recorded on eleven traits; heading date, chlorophyll content, flag leaf area, plant height, number of tillers/plant, panicle length, panicle weight, panicle fertility (%),1000-grain weight and grain yield /plant. The results revealed that, the genotypes were highly significant different in all studied characters. The crosses Sakha 103 × BL1 and Giza177 x BL1 showed positive and significant heterosis for mid and better parents for most studied traits. The parent Giza176 was good general combiner for most studied traits. The cross Sakha 101 × BL1 showed positive and highly significant of specific combining ability effects for grain yield and its components.

INTRODUCTION

Rice *(Oryza sativa* L.*)* is one of the most important crops that provide food for about half of the world population and will continue to occupy the pivotal place in global food and livelihood security systems. Genetic variability for agronomic traits is the key component of breeding programs for broadening the gene pool of rice and other crops. In Egypt, rice constitutes one of the main agricultural exports .During 2012 season, the area cultivated with rice was 1.42 million feddans with an average of 4.15 t /fed, and total production of 5.89 million tons (**Rice Research Training Center Proceeding,2012**). The phenomenon of heterosis has been a powerful force in the evolution of plants and it has been exploited extensively in crop production which is the greatest practical achievement of the science of genetics and plant breeding (**Satheeshkumar and Saravanan, 2013**). Heterosis in crops has contributed greatly to global crop production improvement in recent decades (**Schnable and Springer, 2013**). Heterosis describes improved performance of heterozygous F_1 hybrids in terms of stature, biomass, size, yield, speed of development, fertility, resistance to diseases and insect pests, or to climatic rigors of any type compared to the average performance of their homozygous parental inbred lines (**Dan *et al*., 2013**).

The diallel analysis have been used in recent years by many breeders to evaluate parental materials before taking any decisions concerning the type of breeding system to be used in this concern. So, combining ability analysis is the most widely used biometrical tool for classifying lines in terms of their ability to combine in hybrid combinations. With this method, the resulting total genetic variation is partitioned into general combining ability, measuring additive gene action and specific combining ability, measuring non-additive gene action (**Hammoud, 2004**, **Rahimi *et al* 2010 and Muthuramu *et al* 2010**). The main objective of the present investigation is to study the genetic parameters such as heterosis and combining ability for the yield, its components and some agronomic characters in six rice genotypes of diverse origin and their F_1 hybrids.

MATERIAL AND METHODS

Plant materials

The present study was carried out at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr EL-Sheikh, Egypt, during two successive rice growing seasons, 2014 and 2015.Type, parentage and origin of six Egyptian rice cultivars Sakha 101, Sakha 103, Giza177, Giza176, Giza159 and BL1 which used in this study are shown in table (1).

Table 1: Type, parentage and origin of the studied rice varieties

No	Genotypes	Type	Parentage	Origin
1	Giza159	Japonica	Giza 14 / Agami M1.	Egypt
2	Giza176	Japonica	Calrose 76 / Giza 172 // GZ 242-5	Egypt
3	Giza177	Japonica	Giza 171 / Yomji No.1 // Pi no.4	Egypt
4	Sakha101	Japonica	Giza 176 / Milyang 79	Egypt
5	Sakha103	Japonica	Giza 177 / Suweon 349	Egypt
6	BL1	Japonica	Norin 25 B4 / Tjina	Japan

The six genotypes were sown in the summer growing season of (2014) in three sowing dates. A half diallel design was conducted among the six parents to produce fifteen crosses. The hybridization technique of **Jodon (1938)** and modified by **Butany (1961),** was utilized. The parental varieties and the resulted crosses evaluated in a Randomized Complete Block Design (RCBD) Experiment with three replications.

Data collection

Fifteen randomly individual rice plants from each genotype were taken from each replicate to collecte Days to 50% heading (days), plant height (cm), flag leaf area (cm^2), total chlorophyll content

,number of tillers/ plant, panicle length (cm), panicle weight (g), 1000-grain weight (g), fertility percentage and grain yield / plant (g).

Statistical Analysis

Analysis of variance: The data were subjected to Randomized Complete Block Design (RCBD) according to **Snedecor and Cochran (1967).** Hybridization among these six parents were used in the next experiment using method 2, model 1 of **Griffing (1956)** which is fixed. The statistical analysis was conducted following **Singh and Chaudhary (1985)**. **Combining ability estimates :**Data were analyzed according to **Cochran and Cox (1967)** to test the significance of fifteen different genotypes. The analysis of variance was calculated for each character. Then, the differences between genotypes were further partitioned to GCA and SCA, following **Griffing (1956)** (method-2, model-1) as a fixed model. Variances due to general and specific combining abilities were estimated. **The estimation of heterosis**: heterosis of an individual cross for each trait was determined as the increase of the F_1 hybrid mean over either mid parents and better parent, these proposed by **Mather (1949**) and **Mather and Jinks (1982**). While, there are two formulas usually used for estimation of heterosis as follows: (1)-Mid-parents heterosis or heterosis over the mid-parents (MP %). (2)- Heterobeltiosis or heterosis over the better parent (BP %).

RESULTS AND DISCUSSION

Mean Performance

The mean performance of parental varieties and their 15 F_1 hybrids for all studied traits are presented in (Table 2). Regarding plant height the shortest plant height is desirable. The two parents BL1 and Sakha101 were recorded the lowest mean values (98.00 and 89.70cm). Giza159 was the most undesired genotype in this regard, it recorded 130.6 cm. Most crosses involving the tall variety Giza159 recorded generally high mean values. Results showed also that most of the studied parents were 100 cm or shorter than100 cm (except for Giza159), at the same time, most of the crosses exhibited long stature plants. Tall plants usually will have lodging problem and low response to nitrogen fertilizers with low harvest index which is not preferable in case of cereal crops like rice. Concerning days to heading, the best performing parent was Sakha103 since rice breeder is looking for early maturing genotypes to save water and land for intensive cultivation systems. Meanwhile, all parents except Giza159 were desirable genotypes in this regard. Results showed that most of the crosses exhibited desirable values in this regard such as Giza159 x Sakha103and Sakha101 x Sakha103.

For No of tillers / plant most of the parents had desirable values, while most of the crosses had lower number of tillers per plant compared with their respective parents. For flag leaf area results indicated that most of the F_1 values was towards their mid parent values. For panicle length the highest parental value was 25.33cm in Giza176 variety. Results revealed that most of the hybrids had better values for panicle length than their parental genotypes. As panicle weight results showed that few crosses had a higher mean values over their parents but most of crosses recorded generally lower mean values compared with their respective parents. 1000- grain weight mean values for parents ranged from 20.33 to 28.33gm in BL1 and Giza176 respectively. The crosses had in general, higher mean values, indicating the feasibility of improvement for this trait using these set of genotypes. For fertility percentage the parental lines ranged from 98.13% for Giza159 to 91.3 % in Giza176. Generally, most of the crosses showed lower mean values than their respective parents. For weight of grain yield (gm), the highest mean value was recorded in the cross Giza159x Giza176 (63.00gm) Also for the parents Giza176 had the highest mean value (62.33).

Table 2: Mean performance of parental varieties and their F_1 crosses for all studied characters

Genotype	Days to 50% heading	Plant height (cm)	Flag leaf area (cm2	Chlorophyll content (SPAD	No. of Tillers/plant	Panicle length (cm)	Panicle weight (gm)	1000-grain weight (gm	Fertility (%)	Grain Yield /plant (gm)
Giza 159	128.00	130.60	46.23	50.00	29.77	24.33	4.47	24.33	90.13	56.66
Giza176	101.66	100.00	41.97	45.10	20.33	25.33	3.10	28.33	91.30	62.33
Sakha 101	107.00	89.70	25.46	45.27	24.67	24.93	3.58	25.66	96.10	61.33
Sakha103	97.66	99.00	23.17	45.97	23.33	19.27	3.95	26.33	94.56	57.66
Giza 177	98.33	100.00	23.20	47.30	20.00	20.67	4.01	28.00	95.79	46.66
BL1	97.66	98.00	20.27	44.97	19.67	21.73	3.66	20.33	94.04	35.33
Parent's Mean	**106.55**	**95.71**	**30.05**	**46.43**	**22.96**	**22.71**	**3.79**	**25.49**	**93.65**	**53.32**
Parent's Minimum	**97.66**	**89.70**	**20.27**	**44.97**	**19.00**	**19.27**	**3.10**	**20.33**	**90.13**	35.33
Parent's Maximum	**128.00**	**130.60**	**46.23**	**50.00**	**29.77**	**25.33**	**4.47**	**28.33**	**96.10**	**62.33**
Giza159 x Giza176	106.66	125.00	45.43	50.43	25.67	26.53	4.55	25.40	95.93	63.00
Giza159xSakha101	117.66	142.30	34.83	46.00	15.33	25.17	1.33	26.27	12.10	60.33
Giza159 x Sakha103	98.33	125.70	33.77	49.13	18.67	23.60	2.59	24.33	80.70	56.67
Giza159 x Giza177	103.67	125.70	39.30	44.47	19.67	23.67	3.51	25.66	87.86	55.33
Giza159 x BL1	102.66	133.60	25.70	46.60	19.33	23.90	4.31	25.33	90.94	47.33
Giza176 x Sakha101	102.33	98.30	37.70	49.50	19.00	24.93	4.06	27.40	95.82	62.00
Giza176 x Sakha103	99.33	93.60	34.40	50.43	26.33	24.60	3.58	26.66	90.06	61.00
Giza176 x Giza177	97.67	98.70	43.17	49.33	28.33	23.33	2.81	24.00	92.83	61.00
Giza176 x BL1	105.00	95.00	29.63	47.27	21.00	24.00	3.53	24.17	93.59	37.66
Sakha101 x Sakha103	98.33	99.00	31.47	48.00	17.00	23.50	2.95	31.70	89.63	62.33
Sakha101 x Giza177	100.00	104.00	34.57	47.00	24.00	24.53	2.73	27.00	80.35	48.66
Sakha101 x BL1	103.66	108.60	35.23	49.93	22.33	22.53	3.27	27.00	93.34	51.33
Sakha103 x Giza177	99.00	93.30	28.43	47.60	16.00	21.67	3.34	27.37	94.39	54.00
Sakha103 x BL1	100.66	95.00	25.13	49.90	25.00	23.10	3.82	25.60	96.92	45.66
Giza177 x BL1	100.33	115.00	29.80	46.87	19.00	24.37	2.92	26.00	80.57	48.33
F_1 Mean	**102.35**	**110.18**	**33.90**	**48.16**	**21.11**	**23.96**	**3.28**	**26.25**	**85.00**	**54.30**
F_1 Minimum	**98.33**	**98**	**26.2**	**41**	**23**	**21.67**	**98**	**26.2**	**23**	**63.00**
F_1 Maximum	**117.66**	**117**	**45.43**	**50.43**	**28.3**	**26.53**	**117**	**33.9**	**28.3**	37.66
L.S.D. at 5%	4.02	3.80	4.57	2.53	3.33	**1.01**	**0.43**	**10.37**	**4.54**	**8.92**
L.S.D. at 1%	5.32	5.02	6.04	3.35	4.41	**1.33**	**0.57**	**13.71**	**6.04**	**11.81**

Analysis of variance and combining ability estimation

The results in **Table 3** showed that there were highly significant differences among the genotypes, the parents, and their F_1 crosses for all traits. The mean squares of the interaction between parents and their crosses were highly significant for all traits. These results indicating the significance of heterosis. These finding are coherent with that of **Mazal (2008)** and **Anis (2013)**. Both general and specific combining ability variances were found to be highly significant for all studied traits, indicating the importance of both additive and non-additive genetic variances in determining the inheritance of the studied traits. The estimated GCA/SCA ratios were found to be greater than unity for all studied traits these finding indicated that the additive type of gene action played a major role in the inheritance of these traits. Therefore, it could be concluded that selection procedure based on the accumulation of additive effect would be successful in improving these traits Dominance controls the inheritance of some traits and it is generally towards earliness, tall plants, long, heavy and large number of panicles (**Li and Chang, 1970)** On the contrary, the importance of additive genetic variances have been reported by **El-Mowafi and Abd El-Hadi (2005) and Awad Allah (2006).** The presence of additive and non-additive effects of some characters were in agreement with those reported by **Ahmed (2004) and Hammoud (2004).**

Table 3: Estimates of the mean squares of 21 genotypes, six parents, their 15 crosses, their interaction, general combining ability (GCA) and specific combining ability (SCA) for studied traits

Source of variance	d.f	Days to 50% heading	Plant height	Flag leaf area	Chlorophyll content	No .of tillers/plant	Panicle length (cm)	Panicle weight (gm)	1000 grain weight(gm)	Fertility (%)	Grain Yield /plant (gm)
Replications	2	0.02^{ns}	4.53^{ns}	14.31^{ns}	1.68^{ns}	4.34^{ns}	0.52^{ns}	0.01^{ns}	0.48^{ns}	0.007	27.63^{ns}
Genotypes	20	164.35^{**}	2157.0^{**}	189.50^{**}	27.79^{**}	62.34^{**}	13.01^{**}	4.20^{**}	22.50^{**}	0.42**	428.20^{**}
Parents (P)	5	432.25^{**}	2904.8^{**}	410.17^{**}	38.82^{**}	61.84^{**}	21.10^{**}	0.95^{**}	34.43^{**}	0.21**	738.67^{**}
Crosses (F_1)	14	77.58^{**}	1386.9^{**}	121.67^{**}	22.58^{**}	62.91^{**}	9.06^{**}	5.37^{**}	17.65^{**}	0.22**	353.56^{**}
P x F_1	1	292.20^{*}	13075.0^{**}	221.92^{**}	65.66^{**}	53.97^{**}	43.53^{**}	0.31^{*}	47.75^{**}	4.22**	58.33^{ns}
Error	40	9.38	5.53	5.43	1.92	4.26	0.39	0.07	1.76	0.02	25.98
GCA	5	122.97^{ns}	1058.91^{**}	152.73^{**}	16.92^{**}	17.09^{**}	9.33^{**}	1.92^{**}	6.95^{**}	0.12**	408.55^{**}
SCA	15	17.69^{**}	390.81^{**}	17.27^{**}	4.10^{**}	15.15^{**}	1.52^{**}	0.80^{**}	5.25^{**}	0.14**	20.91^{**}
Error	40	2.35	1.38	1.36	0.48	1.06	0.10	0.02	0.44	0.01	6.50
GCA / SCA		6.95	2.71	8.84	4.13	1.13	6.15	2.28	1.33	1.33	9.54

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

General Combining ability estimates

Highly significant positive values of GCA effects would be interest in most traits under study except for days to 50% heading, plant height, whereas the highly significant negative values would be useful from the breeder's point of view. From the above mentioned results (table4), it could be concluded that Giza176 is considered as a good combiner for improving the some traits such as plant height, flag leaf area, chlorophyll content, number of tillers/plant, panicle length and spikelet fertility and grain yield/plant while, Sakha101 was a good combiner for 1000-grain weight and grain yield/plant.

Table 4: Estimates of the general combining ability effects for vegetative traits

Genotype	Days to 50% heading	Plant height (cm)	Flag leaf area	Chlorophyll content	No. of tillers/plant	Panicle length (cm)	Panicle weight (gm)	1000 grain weight(gm)	Fertility (%)	Grain Yield /plant (gm)
Giza 159	4.55**	21.74**	4.858**	0.006ns	-1.63**	0.66**	0.143**	-8.05**	-0.874**	4.074**
Giza176	1.68**	-4.22**	6.010**	0.088ns	1.037**	1.113**	0.003ns	4.615**	-0.199ns	5.00**
Sakha 101	2.65**	-0.778**	-0.231ns	-0.920**	-0.704**	0.731**	-0.469**	-6.95**	1.204**	6.037**
Sakha103	-2.11**	-7.59**	-3.690**	-0.416**	0.407*	-1.632**	-0.324**	3.248**	0.908**	4.407**
Giza 177	-1.06**	-1.93**	-1.027**	-0.823**	0.407*	-0.910**	0.921**	2.409**	0.282*	-0.889*
BL1	-0.40*	-11.59**	-5.179**	-0.897**	2.074**	-0.491**	0.015ns	3.461**	-1.211**	-8.778**
L.S.D at 5%	**0.401**	**0.36**	**0.191**	**0.312**	**0.449**	**0.097**	**0.041**	**0.436**	**0.205**	**0.787**
L.S.D at 1%	**0.536**	**0.55**	**0.256**	**0.418**	**0.602**	**0.148**	**0.063**	**0.666**	**0.313**	**1.201**

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

Specific Combining Ability (SCA) effects of tested crosses for studied traits:

From the results in **Table 5**, The crosses Giza176 x Giza177, Sakha101 x BL1, Sakha103 x Giza177, and Giza159 x BL1 showed highly significant estimates of SCA effects for plant height, days to 50% heading , flag leaf area, chlorophyll content and number of tillers/ plant. Meanwhile, crosses Sakha101 x BL1, Giza177 x BL1, Giza159 x Giza176 and Sakha103 x Giza177 showed highly significant estimates of SCA effects for all panicle length, panicle weight, fertility%, 1000- grain weight and grain yield characters. they found to be the best cross combinations for this two traits Sakha101 x BL1 and Giza177 x BL1.

Table 5: Estimates of specific combining ability for eleven studied traits

Genotype	Days to maturity	Plant height	Flag leaf area	Chlorophyll content	No. of tillers / plant	Panicle length	Panicle weight	Spikelet fertility %	1000.grain weight	Yield grain weight
Giza159 x Giza176	-2.730**	-1.852**	1.989**	1.613**	5.176**	0.895**	0.610**	1.277**	0.294ns	3.009**
Giza159xSakha101	6.009**	12.03**	-2.370**	-1.813**	-3.417**	-0.09ns	-2.140**	-60.98**	-0.243ns	-0.694ns
Giza159 x Sakha103	-8.287**	2.185**	0.022ns	0.817**	-1.164**	0.706**	-1.029**	-2.587**	-1.880**	-2.731**
Giza159 x Giza177	-3.620**	-3.481**	2.893**	-3.443**	-0.194ns	0.051ns	1.563**	5.416**	0.080ns	1.231ns
Giza159 x BL1	-8.324**	14.18**	-6.556**	-1.235**	-2.194**	-0.134ns	0.359**	7.440**	1.239**	1.120ns
Giza176 x Sakha101	4.046**	0.815ns	2.804**	1.102**	-3.528**	1.592**	0.587**	-0.127ns	0.513ns	1.676ns
Giza176 x Sakha103	1.046ns	-3.852**	-0.496ns	2.035**	3.806**	1.258**	0.104ns	-5.887**	-0.220ns	0.676ns
Giza176 x Giza177	-1.287ns	-4.519**	5.607**	1.343**	5.806**	-0.731**	-0.697**	-2.281**	-2.261**	5.972**
Giza176 x BL1	2.343**	1.481**	-3.774**	-0.650*	-3.194**	-0.482**	-0.282**	-2.577**	-0.602*	-9.472**
Sakha101 x Sakha103	-2.213**	-1.963**	2.811**	0.609ns	-3.787**	0.540**	-0.054ns	5.249**	3.409**	0.972ns
Sakha101 x Giza177	-1.213ns	-2.630**	3.248**	0.017ns	3.213**	0.851**	-0.311**	-3.188**	-0.665*	-7.398**
Sakha101 x BL1	-1.250ns	11.70**	8.067**	3.024**	-0.120ns	-1.568**	-0.073ns	8.750**	0.828**	3.157**
Sakha103 x Giza177	2.824**	-6.481**	0.574ns	0.113ns	-5.898**	0.347**	0.160**	0.642ns	-0.002ns	-0.435ns
Sakha103 x BL1	0.787ns	4.852**	1.426**	2.487**	1.435**	1.362**	0.329**	2.123**	-0.276ns	-0.880ns
Giza177 x BL1	-0.213ns	19.18**	3.430**	-0.139ns	-4.565**	1.906**	-0.603**	-13.38**	0.750**	7.083**
L.S.D at 5%	1.375	1.055	1.046	0.621	0.926	0.282	0.120	1.268	0.596	2.287
L.S.D at 1%	1.614	1.239	1.228	0.730	1.088	0.331	0.141	1.489	0.700	2.686

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

Heterosis estimates:

High positive estimates of useful heterosis, expressed as the percentage deviation of F_1 mean performance from standard heterosis, better parent and mid-parent would be great interest, except for plant height and days to heading characters, whereas the negative estimates are the preferable in rice breeding studies **(Abd Allah, 2000).** Data of heterosis estimates over mid, better parents for vegetative and yield traits are presented in Table (6 and 7).

Results showed that all the crosses were moving towards tallness when one of the parents was tall**.** The cross Sakha103 x Giza177 followed by Giza176 x Sakha103 scored highest negative significant value of heterosis over mid-parent for plant height character. Meanwhile, Giza176 x Sakha103 showed highest negative significant value of heterosis over better parent for the same trait. These findings are coherent with that of **El-Refaee (2002) and Hammoud (2004)**. For days to 50% heading**,** highly significant and desirable negative heterosis estimates over mid-parent were scored in five crosses namely, Giza159 x Sakha103, Giza159 x BL1, Giza159 x Giza177, Giza159 x Giza176 and Sakha101 x Sakha103, their estimated values were (- 12.85,- 12.50, - 8.39, - 7.11 and - 3.91), respectively . on the other hand, heterosis estimates over better parent were negative significant in only one cross Giza159 x BL1 (-3.75). **Suresh *et al.* (1999)**, **El-Mowafi (2001)**, **El-Refaee (2002), Hammoud (2004) and Sedeek (2015)** reported similar trends of heterosis concerning days to 50% heading. In respect to number of tillers**/** plant**,** four crosses gave positive and highly significant heterosis estimates over mid-parent and ranged from 20.61 in the cross Giza176 x Sakha103 to 40.49 in the cross Giza176 x Giza177. Also, the same three crosses gave positive highly significant estimates of heterosis over better parent namely Giza159 x Giza176, Giza176 x Sakha103 and Giza176 x Giza177 (26.27,12.86 and 39.35,respectively). The results mentioned above are in a full agreement with that of **El-Refaee (2002)**. For chlorophyll content and flag leaf area the best cross Sakha101 x BL1 positive significant and highly significant estimates of heterosis over mid and better -parent . Sakha101 x BL1 showed highest positive significant value over better and mid-parent for flag leaf area trait. The crosses Giza 159 x Giza176, Sakha101 x Giza179 and Giza177 x BL1 scored highest significant values of over better and mid-parent for panicle length characters. These findings are in agreement with reports of **El-Refaee (2002) and Abd El-Lateef *et al*. (2003)**.

Meanwhile, for panicle weight the cross Giza176 x Sakha101 was highest significant value over mid and better parent but the cross Giza177x BL1 and Sakha101 x BL1 record highest significant value over mid and better parent for 1000 - grain weight.

Table 6: Estimates of heterosis relative to better parent and mid parent in F_1 crosses for all studied traits

Genotype	Heading date		Plant height		Flag leaf area		Chlorophyll content		No. of tillers / plant	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
Giza159 x Giza176	4.92*	-7.11**	-4.34**	8.38**	-1.73ns	3.02ns	0.86ns	6.06**	26.27**	28.35**
Giza159 x Sakha101	9.97**	0.14ns	8.92**	29.19**	-24.66**	-2.84ns	-8.00**	-3.43ns	-37.86**	-30.85**
Giza159 x Sakha103	0.68 ns	-12.85**	-3.83*	9.44**	-26.96**	-2.69ns	-1.74ns	2.39ns	-19.97**	-13.16ns
Giza159 x Giza177	5.42**	-8.39**	-3.83*	8.96**	-15.00**	13.20**	-11.06**	-8.59**	-1.65ns	-0.83ns
Giza159 x BL1	-3.75*	-12.50**	2.30ns	52.18**	-44.41**	-22.71**	-6.80**	-1.86ns	-34.85**	-21.65**
Giza176 x Sakha101	0.66ns	-1.92ns	-1.67ns	3.69*	-28.98**	-14.61**	0.06ns	3.16ns	-22.98**	-15.56*
Giza176 x Sakha103	1.71ns	-0.34ns	-6.33**	-5.86**	-10.17*	11.81*	9.34**	9.55**	12.86ns	20.61**
Giza176 x Giza177	-0.68ns	-2.33ns	-1.33ns	-1.33ns	-18.03**	5.63ns	9.70**	10.75**	39.35**	40.49**
Giza176 x BL1	3.28ns	0.80ns	-5.00*	31.03**	2.86ns	32.48**	4.29ns	6.77**	-29.22**	-16.00**
Sakha101 x Sakha103	0.68ns	-3.91*	0.00ns	4.95**	-29.39**	-4.77ns	4.81ns	4.96*	-31.09**	-29.17**
Sakha101 x Giza177	1.70ns	-2.60ns	4.00*	9.66**	-3.66ns	11.33*	0.43ns	8.71**	-2.72ns	7.45ns
Sakha101 x BL1	-2.81ns	-2.96ns	21.19**	61.39**	23.56**	29.40**	4.42ns	5.22*	-24.74**	-17.81**
Sakha103 x Giza177	1.36ns	1.02ns	-6.67**	-6.20**	35.73**	42.06**	-0.63ns	1.54ns	-31.42**	-26.15**
Sakha103 x BL1	3.07ns	-1.47ns	-4.04*	31.94**	38.35**	54.08**	10.29**	10.66**	-15.74**	-5.66ns
Giza177 x BL1	2.03ns	-2.11ns	15.0**	58.62**	10.22ns	20.43**	-4.94*	2.71ns	-35.96**	-23.50**
L.S.D at 5%	3.83	3.32	3.32	3.83	22.56**	22.64**	0.63ns	2.07ns	3.36	2.91
L.S.D at 1%	5.09	4.41	4.41	5.09	8.49ns	15.73*	8.55**	9.74**	4.47	3.87

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

Table 7: Estimates of heterosis relative to better parent and mid parent in F_1 crosses for all studied traits

Genotype	Panicle length (cm)		Panicle weight (gm)		1000 grain weight(gm)		Fertility (%)		Grain Yield /plant (gm)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
Giza159 x Giza176	4.74*	6.85**	1.79ns	20.21**	-2.24ns	1.28ns	-10.35ns	-3.54ns	1.07ns	5.88*
Giza159 x Sakha101	0.96ns	2.19ns	-70.25**	-66.96**	-87.67**	-87.59**	2.34ns	5.07ns	-1.63ns	2.26ns
Giza159 x Sakha103	-3.00ns	8.26**	-42.06**	-38.48**	-17.76**	-16.24**	-7.60ns	-3.95ns	-1.73ns	-0.87ns
Giza159 x Giza177	-2.71ns	5.20*	-21.48**	-17.22**	-10.47**	-9.39**	-8.33ns	-1.91ns	-2.35ns	7.10*
Giza159 x BL1	-1.77ns	3.78ns	-3.58ns	6.03ns	-7.33**	-5.35*	4.11ns	13.43ns	-16.47**	2.90ns
Giza176 x Sakha101	4.11ns	6.59**	43.62**	21.56**	-30.25**	-28.99**	6.44ns	11.00ns	-15.29**	13.83**
Giza176 x Sakha103	-1.58ns	-0.80ns	13.41*	1.56ns	-0.29ns	2.26ns	-3.29ns	1.48ns	-0.53ns	0.27ns
Giza176 x Giza177	-2.88ns	10.31**	-9.37ns	-20.96**	-4.76ns	-3.09ns	-5.88ns	-2.44ns	-2.14ns	1.67ns
Giza176 x BL1	-7.90**	1.43ns	-29.93**	4.44ns	-3.09ns	-0.76ns	-15.29*	-14.79*	-2.14ns	11.93**
Sakha101 x Sakha103	-5.25*	2.00ns	-3.55ns	-21.65**	-0.48ns	0.99ns	-14.70*	-0.68ns	-39.57**	-22.87**
Sakha101 x Giza177	5.92**	10.57**	27.25**	-28.06**	0.78ns	2.61ns	-17.65*	-7.89ns	-31.02**	-4.44ns
Sakha101 x BL1	-5.74**	6.33**	-25.32**	-9.67ns	-6.73**	-5.98**	20.38**	21.92**	-1.63ns	4.76ns
Sakha103 x Giza177	-1.60ns	7.59**	-31.92**	-16.08**	-16.39**	-16.25**	-3.57ns	0.62ns	-20.65**	-9.88**
Sakha103 x BL1	-9.63**	-3.43ns	-10.66ns	0.39ns	-2.87ns	-1.82ns	5.19ns	17.39*	-16.30**	6.21ns
Giza177 x BL1	8.02**	11.91**	4.73ns	-23.86**	-18.16**	-17.54**	15.19*	23.20**	-11.41**	22.10**
L.S.D at 5%	**1.02**	**0.89**	**0.44**	**0.38**	**3.99**	**4.60**	**3.32**	**3.83**	**3.32**	**3.83**
L.S.D at 1%	**1.36**	**1.18**	**0.58**	**0.50**	**5.30**	**6.11**	**4.41**	**5.09**	**4.41**	**5.09**

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

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الملخص العربى

دراسه القدره على الإئتلاف وقوه الهجين لبعض الصفات الحقليه فى الأرز

مجاهد حلمى مصطفى عمار

قسم بحوث الأرز – معهد بحوث المحاصيل الحقليه- مركز البحوث الزراعيه – الجيزه- مصر

أجريت هذه الدراسه فى المزرعه البحثيه لمركز البحوث والتدريب فى الأرز بسخا خلال موسمى الزراعه 2014 و 2015 لدراسه وراثه بعض الصفات الخضريه والمحصوليه فى الأرز.
أظهر تحليل التباين إختلافات عاليه المعنويه بين التراكيب الوراثيه لكل الصفات المدروسه كما كانت كل من القدره العامه والخاصه على الإئتلاف معنويه لكل الصفات المدروسه مما يدل على أهميه الفعل الإضافى للجينات فى وراثه هذه الصفات.
كانت نسبه القدره العامه على الإئتلاف أكبر من الوحده لكل الصفات المدروسه مما يدل على أهميه الفعل الإضافى للجينات فى وراثه هذه الصفات.أظهر الصنف جيزه 176 أفضل الأباء فى القدره على التألف كما كانت قوه الهجين عاليه المعنويه موجبه بالنسبه لمتوسط أفضل لأباء فى الهجن التاليه
Sakha101 x BL1 وSakha101 x BL1 and Giza177 x BL1فى معظم الصفات المدروس