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lGENETIC STUDIES ON BREEDING FABA BEAN FOR DROUGHT TOLERANCE: 2 - HETEROSIS AND COMBINING ABILIYY.

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ABSTRACT

Selection for physiological characteristic and evaluation the performance and degree of drought tolerance of the six selected faba bean cultivars and their F_1 crosses were tested under two levels of soil moisture. Randomized complete blocks design with three replicates was used in each experiment, (normal & stress environments) during the two growing seasons 2006/07, 2007/08 at North Sinai Research Station, Desert Research Center. The results indicated that significant mean squares due to genotypes were obtained for all characters under both environments and the combined data. The ratio of specific combining ability (S.C.A.) × environment (Env.) /S.C.A. was much higher than ratios of general combining ability (G.C.A.) × environment Env./G.C.A. for all characters except plant height and number of branches. The parental Giza 429 (P_4), Giza 716 (P_5) and Giza 2 (P_6) gave positive and significant (ĝi) for yield and one or more of its components under normal and stress irrigation as well as the combined data. Meanwhile, the cross combination Nubaria 1 (P_4) × Giza 429 (P_1) appeared to be the best promising hybrid for breeding to increase seed yield per plant which gave significant positive $\hat{S}_{ij}$ for yield and some of its component under both environments as well as the combined data.

Keywords: Faba bean genotypes, Heterosis, Combining ability, Drought tolerance.

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important pulse crops produced throughout the world, with roughly 46 million tons of production in 82% of the area in the developing countries. Average seed yield of faba bean is around 1.8 t/ha; as compared with its potential (more than 3 t/ha) under farm conditions that employ improved crop management practices. Environmental variability (cold, heat and drought) and biotic factors effect on faba bean productivity. Drought is the most important limiting factor of faba bean production in the Mediterranean region, mainly in low rainfall and marginal lands in Egypt, Syria, Tunisia, Morocco, Spain and Italy. (ICARDA, 2008).

In Egypt faba bean is the most important food legume, it is the most common fast food in the Egyptian diet, eaten by rich and poor alike. Its acreage and seed yield vary due to seasons and locations. The yield instability is attributed to various biotic and a biotic stresses.

Unpredictable drought is the single most important factor affecting world food security and the catalyst of the great famines of the past.

Moreover, because the world's water supply is fixed, increasing population pressures will ensure that the effects of successive drought are more severe because competitions from industry will increase limit the water available for agriculture. Crops are voracious consumers. At present an unsustainable 70% of the world's water is used for agriculture. Faba bean is known as partially cross-pollinated crop with natural out crossing ranged from 30 – 60 % depending on genetic, environmental, insect pollinator factors and their interactions. Such natural breeding system resulted in some plants in the same variety field is crossbreds improve yield performance and stability. So, progress in breeding faba beans for resistance to biotic and a biotic stress has bean slow and with only few breakthroughs to be considered. Generally, results of many investigators among them Bond *et. al*., (1994); and Abd Elmula *et. al.*. (1999) showed a large variation in the general combining ability and the low levels of specific combining ability in different faba bean crosses. These results are in favor of breeding synthetic varieties; however, after considering the high degree of self-fertilization occurring in the crop, hybrids appear to be more appropriate. Faba bean hybrids have also shown better adaptation to a wide range of biotic conditions as compared to open pollinated or inbred cultivars, expressed in improved fertilization at high temperatures and tolerance to lack of pollinating insects owing to their heterotic auto fertility reduced winter damage and better tolerance to drought stress.

Methods of plant breeding and genetic modification can speed the transition to more efficient water use and considerable success has already been achieved. Hybrid seed likely to be expensive and the economics of commercial production of hybrid faba bean have not yet been worked out. The economic feasibility would be considerably improved if sufficient heterosis were retained in the F_2 generation to make its production of value particularly under the stress conditions. Many investigators registered positive and significant heterobeltiosis for seed yield and its components in faba bean (El-Hosary and Sedhom (1988), El-Hosary *et. al.,* (1992) and El-Hosary *et. al.,* (1997).

The objectives of this study were to estimates the heterosis performance, general and specific combining ability in F_1 of faba bean half-diallel cross for certain quantitative characters under normal irrigation and stress conditions, to improve yield of Egyptian faba bean for drought tolerance.

MATERIALS AND METHODS

This investigation was carried out at North Sinai Research Station, Desert Research Center (DRC), Cairo, Egypt during the two successive growing seasons 2006/ 07 and 2007/ 08. Six cultivars were selected for the study, the name, origin, pedigree and some features of the parental varieties are presented in Table (1).

Table 1:Names, origin, pedigree and features of the six parental genotypes.

Genotype	Origin	Pedigree	Features
$Nubaria_1$ (P_1)	FCRI	Individual plant selection from Spanish variety Reina Blanca.	Large-seeded, foliar disease resistant, coluorless–hilum seed, and drought tolerant.
Sakha 2 (P_2)	FCRI	Reina Blanca × 461 \ 845 \ 83	Foliar disease resistant and drought tolerant.
Sakha 1 (P_3)	FCRI	716 \ 724 \ 88 × 620 \ 283 \ 85	Early and foliar disease resistant
Giza 429 (P_4)	FCRI	Individual plant selection from $Giza_{402}$ variety.	Orbanche resistant.
Giza $_{716}$ (P_5)	FCRI	461 \ 842 \ 83 × 503 \ 453 \ 83	Early, foliar disease resistant and drought tolerant.
Giza 2 (P_6)	FCRI	Individual plant selection from local genetic resources.	Early.

FCRI = Field Crops Research Institute, ARC, Giza, Egypt.

A diallel cross set involving the six parents were made in 2006/07 season under open field and normal conditions. In 2007/08 season, two experiments were conducted. Each experiment included the six parents and their 15 F_1 cross, which were sown on 15th November 2007 and designed in randomized complete blocks (RCBD) with three replications. The two experiments were planted in two adjacent fields to avoid the differences in the soil fertility productivity and irrigated with two levels of soil moisture (at 60-70 and 40-50%) of field capacity in addition to the rainfall. In each experiment, each plot consisted of four ridges and each ridge was 5 m length and 60 cm width with 20 cm between hills. One seed was grown per hill on one side of the ridge. Data of plant height, number of branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, 100-seeds weight and seed yield per plant were recorded on 10 individual plants chosen of the two experiments at random from each plot, and analyzed on individual plant mean basis. An ordinary analysis of variance for RCBD was firstly performed according to Snedcor and Cochran (1967). Heterosis was determined according to Paschal and Wilcox (1975). General and specific combing ability was estimated by employing Griffing's (1956) diallel cross analysis designed as model-1, method-2**.**

RESULTS AND DICUSSIONS

The analysis of variance for each of the stress and normal environments (40-50 % and 60-70 % of field capacity, respectively) as well as the combined data for yield and yield components is presented in (Table-2). The error variances for the two environments were homogenous for all the studied characters consequently the analysis would be valid. Environments (Env.) mean squares were significant for all the studied characters, indicating overall differences between the two environments (normal and moisture stress). The mean values of all characters in the normal environment were significantly higher than those in stress environment.

Significant genotypes mean squares were obtained for all studied characters under both treatments as well as the combined data (Table-2).

This indicates the wide genetic diversity between the parental materials that used in the present study. Significant genotype × environment mean squares were obtained for all studied characters, revealing that the performance of genotypes differed from one environment to another. Also, results showed that mean squares due to parents were significant for all characters except number of pods/plant at the first treatment of soil moisture. Significant mean squares due to interaction between parents and environments were detected for all studied characters except 100-seed weight, indicating that the parents varied in their response to environments. For the exceptional character, however, insignificant mean squares of interaction between parental varieties and environments were recorded revealing high repeatability of the tested parents under different levels of soil moisture. Also it may be reflect the minor role of the non-additive type of gene action on the expression of this character.

Table 2:Observed mean squares from ordinary analysis for all the studied characters from F_1 generation.

S.O.V.	d.f.		plant height (cm)			Number of branches / plant			Number of pods/ plant		
	single	comb.	N	S	C	N	S	C	N	S	C
Environments (Env.)		1			6894.13**			4.57**			782.55**
Rep. In Env.	2	4	10.77**	8.44**	9.61**	0.01	4.77**	4.57**	1.06	30.68**	15.87**
Genotypes (G)	20	20	541.48**	119.01**	329.41**	3.92**	3.44**	3.87**	49.44**	25.74**	61.81**
Parents (P)	5	5	118.49**	117.20**	91.15**	4.59**	5.16**	3.83*	7.52	53.17**	42.51**
Crosses (C)	14	14	511.17**	119.40**	367.55**	3.39**	1.99	2.55*	67.47**	17.78**	72.82**
P. vs. C	1	1	3080.52**	122.67**	986.86**	8.00*	15.24**	22.67**	6.70	0.08	4.11
G × Env.		20			331.09**			3.49**			13.38**
P × Env.		5			144.63**			53.17**			18.18**
C × Env.		14			263.02**			17.78**			12.43**
P. vs. C × Env.		1			2216.33**			0.08			2.67
Error	40	80	5.39	4.14	4.77	1.10	1.66	1.38	4.15	5.63	4.89
G.C.A.	5	5	234.12**	14.60**	99.88**	0.33	1.19	0.48	31.68**	31.14**	60.09**
S.C.A.	15	15	159.62**	48.02**	113.13**	1.63**	1.13*	1.56**	11.41**	1.05	7.43**
G.C.A. × Env.		5			157.91**			1.03			2.73
S.C.A. × Env.		15			94.51**			1.20**			5.03**
Error term	40	80	1.80	1.38	1.58	0.37	0.55	0.46	1.38	1.87	1.62
G.C.A. / S.C.A.			1.52	0.30	0.88	0.19	1.05	0.30	2.77	29.40	8.07
G.C.A. × Env. / G.C.A.					1.58			2.14			0.04
S.C.A. × Env. / S.C.A.					0.83			0.77			0.67
G.C.A. × Env. /S.C.A. × Env.					1.67			0.85			0.54

Table 2: Cont.

S.O.V.	d.f.		Number of seeds/ pod			100-seed weight (m.)		
	Single	Comb.	N	S	C	N	S	C
Environments (Env.)		1			15.37**			2163.16**
Rep. Env.	2	4	0.78*	0.05	0.41	0.66	0.25	0.45
Genotypes (G)	20	20	1.12**	0.84**	1.31**	572.27**	604.47**	1133.81**
Parents (P)	5	5	2.00**	1.29**	2.84**	1147.47**	1056.31**	2198.43**
Crosses (C)	14	14	0.88**	0.61**	0.78**	395.15**	404.46**	755.32**
P. vs. C	1	1	0.01	1.83**	1.03*	175.90**	1145.52**	1109.59**
G × Env.		20			0.65**			42.93**
P × Env.		5			0.44*			5.34
C × Env.		14			0.71**			44.29**
P. vs. C × Env.		1			0.81*			211.83**
Error	40	80	0.18	0.20	0.19	3.74	3.39	3.56
G.C.A.	5	5	0.36**	0.12**	0.42**	646.27**	622.07**	1264.94**
S.C.A.	15	15	0.37**	0.33**	0.44**	38.92**	61.29**	82.266**
G.C.A. × Env.		5			0.06			3.398*
S.C.A. × Env.		15			0.26**			17.94**
Error term	40	80	0.06	0.06	0.06	1.25	1.130	1.18
G.C.A. / S.C.A.			0.97	0.36	0.96	16.60	10.14	15.37
G.C.A. × Env. / G.C.A.					0.14			0.00
S.C.A. × Env. / S.C.A.					0.60			0.21
G.C.A. × Env. /S.C.A. × Env.					0.23			0.18

Table 2: Cont.

S.O.V.	d.f.		No. of seeds / plant			Seed yield (g / plant)		
	single	comb.	N	S	C	N	S	C
Environments (Env.)		1						10964.32*
Rep. In Env.	2	4	8.03	8.03	8.03	8.03	21.92	14.97
Genotypes (G)	20	20	495.35**	495.35**	495.35**	495.35**	317.07**	735.93**
Parents (P)	5	5	182.70**	182.70**	182.70**	182.70**	77.10*	206.32**
Crosses (C)	14	14	473.91**	473.91**	473.91**	473.91**	364.90**	739.13**
P. vs. C	1	1	2358.65*	2358.65*	2358.65*	2358.65*	1099.40**	3339.33**
G × Env.		20						76.48**
P × Env.		5						53.48**
C × Env.		14						81.68**
P. vs. C × Env.		1						118.71**
Error	40	80	4.99	4.99	4.99	4.99	7.22	6.11
G.C.A.	5	5	262.78**	262.78**	262.78**	262.78**	174.26**	415.49**
S.C.A.	15	15	132.56**	132.56**	132.56**	132.56**	82.83**	188.58**
G.C.A. × Env.		5						21.54**
S.C.A. × Env.		15						26.81**
Error term	40	80	1.66	1.66	1.66	1.66	2.40	2.03
G.C.A. / S.C.A.			1.98	1.98	1.98	1.98	2.10	2.20
G.C.A. × Env. / G.C.A.								0.05
S.C.A. × Env. / S.C.A.								0.14
G.C.A. × Env. /S.C.A. × Env.								0.80

N, S, and C refer to normal, stress and combined
***& ** indicates significant at 0.05% and 0.01% levels of probability, respectively.**

Mean squares for parents vs. crosses as an indication to average heterosis overall crosses were of appreciable magnitude for all characters. General and specific combining ability mean squares were significant for all the studied characters in each experiment was devoted for one irrigation treatment as well **as the combined** data, except number of branches/plant for G.C.A. at both treatments and the combined analysis, number of seeds / pod for G.C.A. under stress condition and number of pods/plant for S.C.A. under stress condition**.** The mean performances for the six parental varieties of faba bean at separate environments as well as the combined data are presented in Table (3). The parental variety Nubaria 1 (P_1) gave highest values for 100-seed weight under both levels of soil moisture as well as the combined analysis. The parental variety Sakha 2 (P_2) gave the highest mean values for number of seeds per pod under both levels of soil moisture as well as the combined analysis and attained greater number of seeds per plant under normal irrigation and the combined analysis. Also, it gave the moderate values for other characters.

The parental variety Sakha 1 (P_3) gave the second values for 100-seed weight, while it gave moderate values for other studied characters under the two levels of soil moisture as well as the combined analysis. The parental variety Giza 429 (P_4) gave highest mean values for number of pods/plant under both levels of soil moisture as well as the combined analysis and number of branches under stress irrigation. Meanwhile, it gave the second values for number of seeds/plant under both levels of soil moisture as well as the combined analysis. Also, it gave the moderate values for other traits. Moreover, the parental variety Giza 716 (P_5) expressed the lowest values for 100-seed weight and number of seeds/pod under both levels of soil moisture as well as the combined analysis while; it gave the moderate values for other characters.

The parental variety Giza 2 (P_6) exhibited highest values for plant height under both levels of soil moisture as well as the combined analysis. Also, it gave highest values for number of branches/plant and seed yield/plant with normal irrigation and the combined analysis. Meanwhile, it almost expressed moderate values for the most of other traits.

Data presented in Table (3) showed that crosses mean squares were significant for all the studied characters, revealing an overall difference between these crosses. Significant mean squares due to interaction between crosses and environments were detected for all characters. Such results indicated that these hybrids performed in different way under each environment.

The mean performance of F_1 hybrids in each level of soil moisture as well as the combined data is presented in Table (3). For plant height, the mean values for crosses ranged from 105.33cm. for Sakha 2 (P_2) × Giza 429 (P_4) to 68.00 cm. for Giza 716 (P_5) × Giza 2 (P_6) at normal irrigation; from 85.00 cm for Nubaria 1(P_1) × Giza 429 (P_4) to 66.00cm. for Giza 429 (P_4) × Giza 2 (P_6) under water stress and from 67.83cm. for Giza 716 (P_5) × Giza 2 (P_6) to 89.00 cm. for Nubaria 1(P_1) × Sakha 1(P_3) in the combined data. In continuous, for number of branches/plant, the cross Sakha 1(P_3) × Giza 429 (P_4) had the highest mean value under two levels of soil moisture and the combined data. However the cross Giza 716 (P_5) × Giza 2 (P_6) gave the lowest values at normal irrigation and the combined data, and Nubaria 1(P_1) × Sakha 2 (P_2) under stress irrigation. The cross Giza 429 (P_4) × Giza 2 (P_6) at normal irrigation and in the combined data and Giza 429 (P_4) × Giza 716 (P_5) at stress irrigation gave highest values for number of pods/plant. Meanwhile Nubaria 1(P1) × Sakha 2 (P2) gave lowest one under the two levels of soil moisture and the combined data. The crosses Sakha 2 (P_2) × Giza 716 (P_5) under normal irrigation and in the combined data and Giza 429 (P_4) × Giza 716 (P_5) at stress irrigation gave highest values for number of seeds/pod. On the other hand, the crosses Sakha 2 (P_2) × Giza 429 (P_4) at normal irrigation and the combined data and Sakha 2 (P_2) × Giza 716 (P_5) under water stress exhibited lowest values for this character**.**

The cross Sakha 1(P_3) × Giza 716 (P_5) at stress irrigation and the combined data and Nubaria 1(P_1) × Giza 429 (P_4) at normal irrigation were recorded highest values for seed yield/plant. Whereas, the crosses Sakha 2 (P_2) × Giza 429 (P_4) under stress condition and the combined data and Nubaria 1(P_1) × Sakha 2(P_2) at normal irrigation had the lowest values for seed yield/plant.

For number of seeds/plant, the crosses Giza 429 (P_4) × Giza 716 (P_5) under stress condition and the combined data and Sakha 2 (P_2) × Giza 2 (P_6) under normal irrigation gave highest values. While, the cross Nubaria 1(P_1) × Sakha 2 (P_2) was lowest one in this concern. The cross Nubaria 1(P_1) × Sakha 2 (P_2) had highest values for 100- seed weight under the two levels of soil moisture and the combined data. On the other hand, the cross Giza 429 (P_4) × Giza 716 (P_5) showed lowest one in this respect. It could be concluded that these crosses would be efficient and promising in faba bean breeding program for improving yield and its components under drought conditions.

Heterosis:

Mean squares for parent vs. crosses as an indication to the average heterosis overall crosses was of appreciable magnitude in both environments (normal irrigation at 60-70 % and stress irrigation at 40-50 % of field capacity) as well as in their the combined for all characters except number of pods per plant under the two levels of soil moisture and the combined data, number of seeds per pod under normal irrigation and number of seeds per plant under the two levels of soil moisture Table 2. Significant interaction between parents vs. crosses and environments was detected for number of branches per plant, number of pods per plant and number of seeds per plant, indicating that the heterotic effects were affected by the environmental changes for such characters. F_1 mean performances were significantly higher than parental mean for most characters under study with the two levels of soil moisture.

Heterosis expressed as the percentage deviation of F_1 mean performance from its better parent average values for all the studied characters under the two levels of soil moisture and an average over the two levels of soil moisture, are presented in Table 4. With regard to plant height, five and two crosses exhibited significantly positive heterotic effects relative to better parent under stress irrigation and the combined data, respectively. However, thirteen, five and nine crosses exhibited significant negative heterotic effects relative to better-parent values under normal, stress irrigation and the combined data, respectively. Positive heterosis for plant height was reached before by, Helal (1997), and Omar *et. al.,* (1998). For number of branches/plant, six crosses expressed significant negative heterotic effects relative to better-parent values under the normal, stress irrigation treatments and the combined data

Table 3: Mean performance of faba been genotypes for the studied characters.

Genotype	Plant height (cm.)			No. of branches			No. of pods/ plant			No. of seeds/ pod		
	N	S	C	N	S	C	N	S	C	N	S	C
Nubaria 1 (P_1)	100.7	62.0	81.3	8.0	8.3	8.2	21.0	12.3	16.7	3.0	3.0	3.0
Sakha 2 (P_2)	107.3	70.0	88.7	7.3	6.0	6.7	23.0	15.7	19.3	5.0	4.3	4.7
Sakha 1 (P_3)	101.0	68.0	84.5	6.3	8.3	7.3	24.3	15.0	19.7	4.3	4.3	4.3
Giza 429 (P_4)	88.7	74.0	81.3	7.3	9.3	8.3	25.0	24.0	24.5	4.3	3.0	3.7
Giza 716 (P_5)	97.7	78.0	87.8	7.3	6.3	6.4	23.0	20.7	21.8	3.0	3.0	3.0
Giza 2 (P_6)	103.0	78.0	90.5	10.0	7.0	8.5	21.3	17.3	19.3	4.3	3.7	4.0
$P_1 \times P_2$	103.3	70.0	86.7	8.0	4.3	6.2	13.3	12.3	12.8	4.3	2.7	3.5
$P_1 \times P_3$	100.3	77.7	89.0	7.7	6.7	7.2	17.3	15.7	16.5	4.3	2.7	3.5
$P_1 \times P_4$	91.0	85.0	88.0	6.0	6.0	6.0	21.0	18.7	19.8	4.3	3.3	3.8
$P_1 \times p_5$	94.3	82.0	88.2	7.3	7.3	7.3	19.7	16.3	18.0	4.0	3.7	3.8
$P_1 \times p_6$	75.0	70.0	72.5	7.0	5.7	6.3	19.3	15.0	17.2	4.0	3.3	3.7
$P_2 \times P_3$	86.3	69.3	77.8	6.3	7.0	6.7	18.3	15.0	16.7	4.3	3.7	4.0
$P_2 \times P_4$	105.3	72.3	88.8	7.7	7.0	7.3	25.7	20.0	22.8	3.0	3.0	3.0
$P_2 \times P_5$	91.0	79.3	85.2	7.7	6.7	7.2	20.7	18.3	19.5	4.7	3.7	4.2
$P_2 \times P_6$	84.7	83.0	83.8	7.0	6.7	6.8	25.7	18.3	22.0	4.3	3.0	3.7
$P_3 \times P_4$	81.7	69.7	75.7	8.3	7.7	8.0	20.0	17.0	18.5	3.0	3.0	3.0
$P_3 \times P_5$	69.3	82.0	75.7	7.3	6.7	7.0	22.7	17.7	20.2	4.3	2.3	3.3
$P_3 \times P_6$	68.3	76.3	72.3	6.0	6.3	6.2	22.3	16.0	19.2	4.3	3.0	3.7
$P_4 \times P_5$	70.0	71.0	70.5	7.0	6.3	6.7	27.3	21.7	24.5	4.0	4.0	4.0
$P_4 \times P_6$	75.0	66.0	70.5	6.7	5.7	6.2	31.0	20.3	25.7	3.3	3.3	3.3
$P_5 \times P_6$	68.0	67.7	67.8	4.0	7.0	5.5	29.0	19.0	24.0	3.3	3.0	3.2
Mean	88.7	73.9	81.3	7.2	6.8	6.9	22.4	17.4	19.9	3.9	3.3	3.6
L.S.D. 0.05 %	3.8	3.4	3.6	1.7	2.2	1.9	3.4	3.9	3.6	0.7	0.7	0.7
L.S.D. 0.01 %	5.1	4.5	4.7	2.3	2.9	2.5	4.5	5.2	4.8	0.9	0.9	0.9

Moreover, five, four and five crosses expressed significantly negative heterotic effects relative to better-parent values for number of seeds/plant, under the normal, stress irrigation treatments and the combined data, respectively. Whereas, the cross Nubaria 1(P_1) × Giza 716 (P_5) under normal irrigation and the combined data and Giza 429 (P_4) × Giza 716 (P_5) under stress irrigation, significantly surpassed the better-parent for number of seeds/pod under normal, stress irrigation and the combined data. However, four, seven and seven crosses exhibited significant negative heterotic effects relative to better-parent values under normal, stress irrigation and the combined data, respectively. Abo El-Zahab *et al*., (1994a) and Helal (1997) recorded significant positive heterotic effects for number of seeds/plant

The results also revealed that significant negative and heterotic effects relative to better parent value under the two levels of soil moisture and the combined data were detected for seed yield/plant and 100-seed weight. The components of yield for individual crosses also showed in most cases, less heterosis than yield it. Many investigators reported high heterosis for seed yield of faba bean among them El-Hosary and Sedhom (1988), Hendawy *et al*., (1988), Abul-Naas *et. al.,* (1991), and El-Hosary *et. al.* (1997).

Table 3: Cont.

Genotype	100-seed weight (g.)			No. of seeds/ plant			Seed yield (g./plant)		
	N	S	C	N	S	C	N	S	C
Nubaria 1 (P_1)	118.64	110.86	114.75	63.00	37.00	50.00	64.08	40.13	52.11
Sakha 2 (P_2)	104.46	100.88	102.67	115.00	68.33	91.67	44.35	30.54	37.44
Sakha 1 (P_3)	110.72	108.28	109.50	106.00	64.00	85.00	58.83	38.47	48.65
Giza 429 (P_4)	76.89	72.81	74.85	106.67	72.00	89.33	60.34	30.78	45.56
Giza 716 (P_5)	69.07	66.11	67.59	69.00	62.00	65.50	58.25	41.76	50.00
Giza 2 (P_6)	90.86	86.59	88.72	89.33	63.33	76.33	66.86	40.67	53.77
$P_1 \times P_2$	114.44	101.44	107.94	58.00	32.67	45.33	21.82	13.71	17.76
$P_1 \times P_3$	100.12	96.62	98.37	76.67	41.67	59.17	30.67	16.42	23.54
$P_1 \times P_4$	100.04	97.04	98.54	90.67	62.67	76.67	61.16	38.17	49.66
$P_1 \times p_5$	94.98	90.92	92.95	78.67	59.33	69.00	49.99	38.57	44.28
$P_1 \times p_6$	100.18	85.01	92.59	77.33	50.00	63.67	47.82	27.65	37.74
$P_2 \times P_3$	100.16	92.02	96.09	79.33	55.33	67.33	38.81	21.24	30.03
$P_2 \times P_4$	88.60	73.86	81.23	77.00	60.00	68.50	23.04	12.06	17.55
$P_2 \times P_5$	92.98	71.61	82.30	97.33	67.67	82.50	46.18	18.25	32.21
$P_2 \times P_6$	83.59	76.71	80.15	111.67	55.00	83.34	41.92	15.27	28.60
$P_3 \times P_4$	97.86	83.71	90.79	60.00	51.00	55.50	43.87	39.12	41.50
$P_3 \times P_5$	82.20	70.96	76.58	98.67	41.33	70.00	60.01	42.31	51.16
$P_3 \times P_6$	87.46	73.91	80.68	97.00	51.00	74.00	44.08	34.72	39.40
$P_4 \times P_5$	70.12	66.69	68.40	109.33	86.67	98.00	59.81	39.07	49.44
$P_4 \times P_6$	75.16	68.63	71.89	103.00	68.33	85.67	52.64	31.36	42.00
$P_5 \times P_6$	83.25	73.11	78.18	96.33	57.00	76.67	56.80	29.26	43.03
Mean	92.47	84.18	88.32	88.57	57.44	73.01	49.11	30.45	39.78
L.S.D. 0.05 %	3.19	3.08	3.07	18.15	16.25	16.85	3.69	4.50	4.01
L.S.D. 0.01 %	4.27	4.07	4.05	24.29	21.42	22.27	4.93	5.93	5.31

Table 4: Percentage of heterosis in the F_1 generation relative to better parent for the studied characters.

Cross	Plant height (cm)			Number of branches/ plant			Number of pods/ plant		
	N	S	C	N	S	C	N	S	C
$P_1 \times P_2$	-3.72*	0.00	-2.25	0.00	-48.0**	-24.49*	-42.2**	-21.27	-33.6**
$P_1 \times P_3$	-0.66	14.21**	5.32*	-4.16	-20.00	-12.24	-28.8**	4.44	-16.10
$P_1 \times P_4$	-9.60**	14.86**	8.19**	-25.00*	-35.7**	-28.00*	-16.00*	-22.2**	-19.04*
$P_1 \times p_5$	-6.29**	5.12*	0.37	-8.33	-12.00	-10.20	-14.49	-20.96*	-17.55*
$P_1 \times p_6$	-27.2**	-10.3**	-19.9**	-30.0**	-32.00*	-25.49*	-9.37	-13.46	-11.20
$P_2 \times P_3$	-19.6**	-0.95	-12.2**	-13.63	-16.00	-9.09	-24.7**	-4.25	-15.25
$P_2 \times P_4$	-1.86	-2.25	0.18	4.54	-25.00*	-12.00	2.66	-16.66*	-6.80
$P_2 \times P_5$	-15.2**	1.70	-3.94	4.54	5.26	4.87	-10.14	-11.29	-10.68
$P_2 \times P_6$	-21.1**	6.41**	-7.36**	-30.0**	-4.76	-19.60	11.60	5.76	13.80
$P_3 \times P_4$	-19.2**	-5.85*	-10.5**	13.63	-17.85	-4.00	-20.0**	-29.2**	-24.5**
$P_3 \times P_5$	-31.4**	5.12*	-13.9**	0.00	-20.00	-4.54	-6.84	-14.51	-7.63
$P_3 \times P_6$	-33.7**	-2.13	-20.1**	-40.0**	-24.00	-27.45*	-8.21	-7.69	-2.54
$P_4 \times P_5$	-28.3**	-8.97**	-19.7**	-4.54	-32.1**	-20.00	9.33	-9.72	0.00
$P_4 \times P_6$	-27.2**	-15.4**	-22.1**	-33.3**	-39.3**	-27.45*	24.00**	-15.27	4.76
$P_5 \times P_6$	-33.9**	-13.2**	-25.0**	-60.0**	0.00	-35.3**	26.08**	-8.06	9.92

*** & ** indicates significant at 0.05% and 0.01% levels of probability, respectively.**

Table 4: Cont.

Cross	Number of seeds/ pod			100-seed weight (g.)		
	N	S	C	N	S	C
$P_1 \times P_2$	-13.33	-38.46**	-25.00**	-3.54*	-8.50**	-5.93**
$P_1 \times P_3$	0.00	-38.46**	-19.23*	-15.61**	-12.84**	-14.27**
$P_1 \times P_4$	0.00	11.11	4.54	-15.67**	-12.46**	-14.12**
$P_1 \times p_5$	33.33**	22.22	27.77*	-19.94**	-17.98**	-18.99**
$P_1 \times p_6$	-7.69	-9.09	-8.33	-15.56**	-23.32**	-19.30**
$P_2 \times P_3$	-13.33	-15.38	-14.28	-9.53**	-15.01**	-12.24**
$P_2 \times P_4$	-40.00**	-30.76**	-35.71**	-15.18**	-26.78**	-20.88**
$P_2 \times P_5$	-6.66	-15.38	-10.71	-10.99**	-29.01**	-19.84**
$P_2 \times P_6$	-13.33	-30.76**	-21.42**	-19.97**	-23.96**	-21.93**
$P_3 \times P_4$	-30.76**	-30.76**	-30.76**	-11.61**	-22.68**	-17.08**
$P_3 \times P_5$	0.00	-46.15**	-23.07**	-25.75**	-34.46**	-30.06**
$P_3 \times P_6$	0.00	-30.76**	-15.38	-21.00**	-31.74**	-26.31**
$P_4 \times P_5$	-7.69	33.33**	9.09	-8.80**	-8.41**	-8.61**
$P_4 \times P_6$	-23.07**	-9.09	-16.66	-17.28**	-20.74**	-18.97**
$P_5 \times P_6$	-23.07**	-18.18	-20.83*	-8.37**	-15.56**	-11.88**

Table 4: Cont.

Cross	Number of seeds/ plant			Seed yield (g/plant)		
	N	S	C	N	S	C
$P_1 \times P_2$	-49.56**	-52.19**	-50.54**	-65.95**	-65.84**	-65.91**
$P_1 \times P_3$	-27.67**	-34.89**	-30.39**	-52.14**	-59.07**	-54.81**
$P_1 \times P_4$	-15.00	-12.96	-14.17	-4.56	-4.89	-4.69
$P_1 \times p_5$	14.01	-4.30	5.34	-21.99**	-7.64	-15.02**
$P_1 \times p_6$	-13.43	-21.05	-16.59	-28.47**	-32.01**	-29.81**
$P_2 \times P_3$	-31.01**	-19.02	-26.54**	-34.03**	-44.79**	-38.28**
$P_2 \times P_4$	-33.04**	-16.66	-25.27**	-61.81**	-60.81**	-61.48**
$P_2 \times P_5$	-15.36	-0.97	-10.00	-20.72**	-56.29**	-35.57**
$P_2 \times P_6$	-2.89	-19.51	-9.08	-37.30**	-62.45**	-46.81**
$P_3 \times P_4$	-43.75**	-29.16*	-37.87**	-27.29**	1.67	-14.71**
$P_3 \times P_5$	-6.91	-35.41**	-17.64	2.00	1.32	2.31
$P_3 \times P_6$	-8.49	-20.31	-12.94	-34.07**	-14.63**	-26.72**
$P_4 \times P_5$	2.50	20.37	9.70	-0.88	-6.43	-1.12
$P_4 \times P_6$	-3.43	-5.09	-4.10	-21.26**	-22.89**	-21.88**
$P_5 \times P_6$	7.83	-10.00	0.43	-15.04**	-29.93**	-19.97**

*** & ** indicates significant at 0.05% and 0.01% levels of probability, respectively.**

Combining ability:

Analysis of variances for combining ability for all the studied characters is presented in Table (2). The mean squares associated with general and specific combining ability were highly significant for all the studied characters except number of branches per plant under the two levels of soil moisture and the combined data; with G.C.A. and number of pods/plant under stress irrigation with S.C.A. It is evident that both additive and non-additive gene effects were involved in determining the performance of single cross progeny. Also, when G.C.A./S.C.A. ratio was calculated, it was more than unity for all characters except plant height under stress irrigation and the combined data, number of branches and number of seeds/pod under both environments as well as the combined data, indicating the predominance of additive and additive × additive types of gene action in the inheritance of such characters.

For the exceptional cases, low G.C.A./S.C.A. ratio which less than unity was detected. Such results indicated that non-additive type of gene action was more important than additive one in controlling of these lines. While the under normal irrigation. The genetic variance was previously reported to be mostly due to additive type of gene action for yield and yield components by El-Hosary (1987, El-Hosary *et., al.,* (1992), and Omar *et. al.,* (1998).

The mean squares of interaction between both irrigation treatments and general combining ability were significant for all characters except number of branches/plant, No. of pods/plant and number of seeds/pod under stress condition. These results indicating that the magnitude of additive and additive-by-additive types of gene action varied from irrigation treatment to another. For the exceptional characters, insignificant interaction mean squares were obtained revealing that the magnitude of additive and additive by additive types of gene action did not differ from environment to another.

Significant mean squares of interaction between SCA and irrigation treatments were obtained for all traits, suggesting that the magnitude of non-additive type of gene action was differed from irrigation treatment to another. It is fairly evident that ratios for S.C.A. × Env./S.C.A. was much higher than ratios of G.C.A. × Env./G.C.A. for all characters except plant height and number of branches/plant. Such results indicate that non-additive effects were much more influenced by the irrigation treatments than the additive genetic ones. Specific combining ability was stated by several investigators to be more sensitive to environmental changes than G.C.A. (Gilbert, 1958).

General combining ability effects:

Estimates of ($\hat{g}_i$) effects for individual parental cultivars in each character are given in Table (5). General combining ability effects computed herein were found to differ significant from zero in all characters. High positive values would be interest under all characters in question. The rest of the tested parents expressed negative significant or insignificant ($\hat{g}_i$) for this character.

For plant height P1 and P2 at normal irrigation and the combined analysis and P5 at stress condition, gave significant positive $\hat{g}_i$ effects.

For number of seeds/pod, significant negative ($\hat{g}_i$) were showed for parental varieties Nubaria 1 (P_1), Giza 429 (P_4) and Giza 716 (P_5) under the two levels of soil moisture and the combined data. While the rest of the tested parents expressed significant positive ($\hat{g}_i$) for this character. Results indicated that the parental variety Nubaria 1 (P_1) expressed significant positive ($\hat{g}_i$) for 100-seed weight under the two levels of soil moisture and the combined data revealing that this parent was the best combiner for this character. Also, it was expressed significant positive ($\hat{g}_i$) for plant height with normal irrigation and the combined data, it could be considered as a good combiner for this character.

Table 5: General combining ability effects for all the studied characters.

Parental variety	Plant height (cm)			Number of branches/plant			Number of pods/plant		
	N	S	C	N	S	C	N	S	C
Nubaria 1 (P_1)	5.58**	-1.1**	2.26**	0.24	-0.09	0.06	-2.43**	-2.73**	-3.04**
Sakha 2 (P_2)	8.08**	-0.38	3.84**	0.15	-0.47	-0.15	-0.84	-0.88**	-0.92**
Sakha 1 (P_3)	-1.58**	-0.76	-1.17**	-0.22	0.44	0.11	-1.34**	-1.15**	-0.96**
Giza 429 (P_4)	-2.54**	-0.63	-1.59**	0.03	0.48	0.25	2.94**	2.59**	2.25**
Giza 716 (P_5)	-4.08**	2.61**	-0.73**	-0.26	-0.09	-0.18	1.52**	1.28**	1.04**
Giza 2 (P_6)	-5.46**	0.23	-2.61**	0.07	-0.26	-0.09	0.15	0.88**	1.63**
L.S.D. ($\hat{g}_i$) 0.05%	0.87	0.76	N.S.	N.S.	N.S.	N.S.	0.89	0.39	0.76
L.S.D. ($\hat{g}_i$) .01%	1.17	1.02	N.S.	N.S.	N.S.	N.S.	1.19	0.52	1.02
L.S.D.($\hat{g}_i$-$\hat{g}_j$) 0.05%	1.35	1.18	N.S.	N.S.	N.S.	N.S.	1.38	0.63	1.18
L.S.D. ($\hat{g}_i$-$\hat{g}_j$) 0.01%	1.81	1.58	N.S.	N.S.	N.S.	N.S.	1.85	0.84	1.58
r	0.48	0.71*	0.08	0.45	0.84**	0.57	0.55	0.96**	0.83**

Table 5: Cont.

Parental variety	Number of seeds/pod			100-seed weight (g)		
	N	S	C	N	S	C
Nubaria 1 (P_1)	-0.11	-0.16	-0.13	12.47**	12.93**	12.70**
Sakha 2 (P_2)	0.35**	0.20*	0.27	5.18**	3.51**	4.34**
Sakha 1 (P_3)	0.14	0.04	0.09	5.25**	5.56**	5.40**
Giza 429 (P_4)	-0.19*	-0.04	-0.11	-7.71**	-6.71**	-7.21**
Giza 716 (P_5)	-0.19*	-0.04	-0.11	-10.70**	-10.46**	-10.58**
Giza 2 (P_6)	0.01	4.44	0.00	-4.49**	-4.83**	-4.66**
L.S.D. ($\hat{g}_i$) 0.05%	0.15	0.16	N.S.	0.72	0.69	N.S.
L.S.D. ($\hat{g}_i$) 0.01%	0.21	0.22	N.S.	0.97	0.92	N.S.
L.S.D.($\hat{g}_i$-$\hat{g}_j$) 0.05%	0.24	0.25	N.S.	1.12	1.07	N.S.
L.S.D. ($\hat{g}_i$-$\hat{g}_j$) 0.01%	0.32	0.34	N.S.	1.50	1.43	N.S.
r	0.73*	0.13	0.90**	0.98**	0.95**	0.97**

Table (5): Cont.

Parental variety	Number of seeds/plant			Seed yield (g./plant)		
	N	S	C	N	S	C
Nubaria 1 (P_1)	-14.08**	-10.22**	-12.15**	-0.52	0.19	-0.15
Sakha 2 (P_2)	4.17*	0.65	2.40*	-10.41**	-8.94**	-9.68**
Sakha 1 (P_3)	0.46	-4.22*	-1.88*	-1.08*	2.19**	0.55*
Giza 429 (P_4)	4.17*	8.81**	6.49**	2.18**	1.02*	1.59**
Giza 716 (P_5)	-0.21	4.23*	2.01*	5.69**	4.72**	5.20**
Giza 2 (P_6)	5.50*	0.73	3.11**	4.15**	0.80	2.47**
L.S.D. ($\hat{g}_i$) 0.05%	4.14	3.65	1.83	0.84	1.011	0.43
L.S.D. ($\hat{g}_i$) 0.01%	5.54	4.88	2.43	1.12	1.35	0.58
L.S.D.($\hat{g}_i$-$\hat{g}_j$) 0.05%	6.41	5.66	2.97	1.30	1.56	0.70
L.S.D. ($\hat{g}_i$-$\hat{g}_j$) 0.01%	8.58	7.57	3.95	1.74	2.09	0.94
r	0.71*	0.83**	0.76*	0.81**	0.68*	0.82**

*** and ** indicates significant at 0.05% and 0.01% levels of probability, respectively.**
r = Correlation coefficient between the parental performance and their G.C.A effects.

The parental variety Sakha 1 (P_3) seemed to be the best combiner for number of seed yield/plant under stress condition and 100-seed weight under the two levels of soil moisture and the combined data. The parental variety Giza 429 (P_4) seemed to be good general combiner for number of pods/plant, seed yield/plant and number of seeds/plant under the two levels of soil moisture and the combined data. The parental variety Giza 716 (P_5) expressed positive and significant ($\hat{g}_i$) effects for plant height under stress condition, number of pods/plant and yield / plant under the two levels of soil moisture and the combined data. Such results indicated that the parental variety Giza 716 (P_5) could be considered as excellent combiner for improving for drought tolerant using these characters. The parental variety Giza 2 (P_6) expressed positive and significant ($\hat{g}_i$) effects for number of pods/plant under normal irrigation, seed yield/plant and number of seeds/plant under normal irrigation and the combined data. It is considered as a good combiner for these respects.

Concerning seed yield and its components, it is worth- noting that the parent that possessed high ($\hat{g}_i$) for seed yield might be also so in one or more of yield components. On the other hand, the parent which posses high ($\hat{g}_i$) for one or more of yield components may not necessarily have high general combining ability effect for seed yields itself. It is worth mentioning that ($\hat{g}_i$) for seed yield/plant was largely manifested in parents showing ($\hat{g}_i$) for number of seeds/plant.

Positive significant correlation coefficient values between parental performances and its ($\hat{g}_i$) effects were obtained for all the studied characters under the two levels of soil moisture except plant height, number of branches/plant under normal irrigation and the combined data, number of pods/plant under normal irrigation and number of seeds/pod under stress irrigation. These findings indicate that the intrinsic performance of their general combining ability ($\hat{g}_i$) effects. Therefore, selection among the tested parental population for initiating any proposed breeding program could be practiced either on the basis of mean performance or ($\hat{g}_i$) with similar efficiency

For the rest cases, insignificant correlation coefficient values were detected between the two variables. This disagreement revealed that hybrids characterized with high mean values could be expected by crossing between varieties of low performance for these cases. These results may be due to high magnitude of non-additive gene effects in these cases (Table 2). A rather good agreement between ranking of parental performances and their G.C.A. effects was reported by El-Hosary and Sedhom (1988) and Abul-Naas *et., al.* (1989).

Specific combining ability effects:

Specific combining ability ($\hat{S}_{ij}$) effects of the parental combination computed for all characters in the F_1 generation at the two levels of soil moisture as well as the combined data are presented in Table 6.

For plant height, three, seven and seven hybrids exhibited positive significant specific combining ability ($\hat{S}_{ij}$) effects under the normal, stress irrigation and the combined data, respectively. In the same order, nine, seven and eight hybrids had negative significant $\hat{S}_{ij}$. For plant height, insignificant $\hat{S}_{ij}$ in the rest of the cases was detected. The crosses Nubaria 1(P_1) × Giza 429 (P_4), Sakha 2 (P_2) × Giza 429 (P_4) and Nubaria 1(P_1) × Sakha 2 (P_2) gave the highest $\hat{S}_{ij}$ values in T_2, T_1 and the combined data, respectively. However the three crosses Nubaria 1(P_1) × Giza 2 (P_6) under normal irrigation (T_1) and

Giza 716 (P_5) × Giza 2 (P_6) under the combined data and stress irrigation respectively exhibited negative $\hat{S}_{ij}$ values.

The highest desirable $\hat{S}_{ij}$ effects were obtained in the following crosses at the combined across two irrigation treatments: $P_1 \times P_6$, $P_4 \times P_6$ and $P_5 \times P_6$ for No. of pods/plant, $P_1 \times P_4$, $P_1 \times P_5$ and $P_4 \times P_5$ for No. of seeds/pod, P_1 x P_4, $P_1 \times P_5$ and $P_5 \times P_6$ for 100 seed weight, $P_1 \times P_4$, and p4 × P_5 for No. of seeds/plant and $P_1 \times P_4$, , $P_3 \times P_5$ and $P_4 \times P_5$ for seed yield/plant

Table 6: Specific combining ability effects for all the studied characters from the F_1 generation.

Cross	plant height (cm)			Number of branches / plant			Number of pods/ plant		
	N	S	C	N	S	C	N	S	C
$P_1 \times P_2$	1.00	-2.43*	-0.71	0.45	-1.88**	-0.71	-5.14**	-1.83	-3.49**
$P_1 \times P_3$	7.67**	5.61**	6.64**	0.49	-0.46	0.02	-1.10	2.00	0.45
$P_1 \times P_4$	-0.71	12.82**	6.06**	-1.42*	-1.17	-1.29**	-0.64	0.71	0.04
$P_1 \times p_5$	4.17**	6.57**	5.37**	0.20	0.75	0.48	-0.76	-0.21	-0.49
$P_1 \times p_6$	-13.79**	-3.05**	-8.42**	-0.46	-0.75	-0.61	-1.68	-0.17	-0.92
$P_2 \times P_3$	-8.83**	-3.39**	-6.11**	-0.76	0.25	-0.25	-2.22*	-0.25	-1.24
$P_2 \times P_4$	11.13**	-0.51	5.31**	0.33	0.21	0.27	1.90	0.46	1.18
$P_2 \times P_5$	-1.67	3.24**	0.79	0.62	0.46	0.54	-1.89	0.21	-0.84
$P_2 \times P_6$	-6.62**	9.28**	1.33	-0.38	0.63	0.12	2.53*	1.58	2.06*
$P_3 \times P_4$	-2.87*	-2.80*	-2.84**	1.37*	-0.04	0.66	-3.72**	-2.04	-2.88**
$P_3 \times P_5$	-13.67**	6.28**	-3.69**	0.66	-0.46	0.10	0.15	0.04	0.10
$P_3 \times P_6$	-13.29**	2.99**	-5.15**	-1.01	-0.63	-0.82	-0.76	-0.25	-0.51
$P_4 \times P_5$	-12.04**	-4.85**	-8.44**	0.08	-0.83	-0.38	1.61	-0.25	0.68
$P_4 \times P_6$	-5.67**	-7.47**	-6.57**	-0.59	-1.33*	-0.96*	4.70**	-0.21	2.24**
$P_5 \times P_6$	-11.13**	-9.05**	-10.09**	-2.96**	0.58	-1.19**	3.90**	-0.12	1.89*
L.S.D. ($\hat{S}_{ij}$) 0.05%	2.40	2.11	1.57	1.08	1.33	0.85	2.11	*NS*	1.59
L.S.D. ($\hat{S}_{ij}$) 0.01%	3.21	2.82	2.09	1.45	1.78	1.12	2.82	*NS*	2.11
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.05%	3.59	3.14	2.35	1.62	1.99	1.26	3.14	*NS*	2.38
L.S.D.($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.01%	4.80	4.20	3.11	2.17	2.66	1.67	4.21	*NS*	3.15
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{kl}$) 0.05%	3.32	2.91	0.89	1.50	1.84	0.48	2.91	*NS*	0.90
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.01%	4.44	3.89	1.18	2.00	2.46	0.63	3.89	*NS*	1.19

Table 6: Cont.

Cross	Number of seeds/ pod			100-seed weight (g/plant)		
	N	S	C	N	S	C
$P_1 \times P_2$	0.11	- 0.66**	- 0.27	4.32**	0.80	2.56**
$P_1 \times P_3$	0.32	- 0.49*	- 0.09	-10.07**	- 6.06**	- 8.06**
$P_1 \times P_4$	0.65**	0.26	0.46**	2.81**	6.64**	4.73**
$P_1 \times p_5$	0.32	0.59*	0.46**	0.74	4.27**	2.51**
$P_1 \times p_6$	0.11	0.21	0.16	- 0.27	-7.27**	- 3.77**
$P_2 \times P_3$	- 0.14	0.13	0.00	-2.73**	-1.25	-1.99**
$P_2 \times P_4$	-1.14**	- 0.45	- 0.79**	-1.34	-7.12**	-4.23
$P_2 \times P_5$	0.53*	0.21	0.37*	6.03**	- 5.62**	0.21
$P_2 \times P_6$	- 0.01	- 0.49*	-0.25	- 9.56**	- 6.15**	-7.86**
$P_3 \times P_4$	- 0.93**	- 0.29	-0.61**	7.86**	0.68	4.27**
$P_3 \times P_5$	0.40	- 0.95**	- 0.27	- 4.81**	- 8.31**	- 6.56**
$P_3 \times P_6$	0.20	- 0.33	- 0.07	- 5.77**	-11.00**	- 8.38**
$P_4 \times P_5$	0.40	0.80**	0.60**	- 3.94**	- 0.31	- 2.12**
$P_4 \times P_6$	- 0.47*	0.09	- 0.19	- 5.11**	- 4.00**	- 4.55**
$P_5 \times P_6$	- 0.47*	- 0.24	- 0.36*	5.97**	4.24**	5.11**
L.S.D. ($\hat{S}_{ij}$) 0.05%	0.44	0.46	0.31	2.00	1.90	1.36
L.S.D. ($\hat{S}_{ij}$) 0.01%	0.58	0.62	0.41	2.68	2.55	1.80
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.05%	0.65	0.69	0.47	3.99	3.80	2.69
L.S.D.($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.01%	0.87	0.92	0.62	2.76	2.63	0.77
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{kl}$) 0.05%	0.60	0.64	0.18	3.70	3.52	1.02
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.01%	0.81	0.85	0.23	4.32**	0.80	2.56**

Table 6: Cont.

Crosses	Number of seeds/ plant			Seed yield (g /plant)		
	N	S	C	N	S	C
$P_1 \times P_2$	-20.65**	-15.21**	-17.93**	-16.36**	-8.00**	-12.18**
$P_1 \times P_3$	1.72	-1.33	0.19	-16.84**	-16.43**	-16.63**
$P_1 \times P_4$	12.01*	6.62	9.32*	10.39**	6.49**	8.44**
$P_1 \times p_5$	4.39	7.88	6.13	-4.29**	3.19*	-0.55
$P_1 \times p_6$	-2.66	2.04	-0.31	-4.92**	-3.81**	-4.36**
$P_2 \times P_3$	-13.86*	1.46	-6.20	1.20**	-2.47	-0.63
$P_2 \times P_4$	-19.90**	-6.92	-13.41*	-17.83**	-10.47**	-14.15**
$P_2 \times P_5$	4.80	5.33	5.07	1.79	-7.98**	-3.09**
$P_2 \times P_6$	13.43*	-3.83	4.80	-0.93	-7.04**	-3.98**
$P_3 \times P_4$	-33.20**	-11.04*	-22.12*	-6.33**	5.45**	-0.44
$P_3 \times P_5$	9.85	-16.13**	-3.14	6.30**	4.93**	5.62**
$P_3 \times P_6$	2.47	-2.96	-0.24	-8.10**	1.26	-3.42**
$P_4 \times P_5$	16.80**	16.17**	16.49**	2.83*	2.87*	2.85**
$P_4 \times P_6$	4.76	1.33	3.05	-2.80*	-0.92	-1.86*
$P_5 \times P_6$	2.47	-5.42	-1.47	-2.15	-6.72**	-4.44**
L.S.D. ($\hat{S}_{ij}$) 0.05%	11.38	10.04	7.47	2.31	2.78	1.78
L.S.D. ($\hat{S}_{ij}$) 0.01%	15.22	13.43	9.91	3.09	3.72	2.36
L.S.D.($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.01%	22.72	20.04	14.79	3.45	4.15	2.66
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{kl}$) 0.05%	15.72	13.87	4.21	4.61	5.55	3.52
L.S.D. ($\hat{S}_{ij}$-$\hat{S}_{ik}$) 0.01%	21.03	18.55	5.59	3.19	3.84	1.00

*** & ** indicates significant at 0.05% and 0.01% levels of probability, respectively.**

If the crosses exhibiting high SCA involve both parents who also are good combiners, they could be exploited for breeding varieties as well. Nevertheless, if crosses showing high SCA involve only one good combiner, such combinations would through out desirable transgressive segregates provided that the additive genetic system present in the good combiner, and complementary and epistatic effects present in the crosses act in the same direction to reduce undesirable plant characteristics and maximize the character in view.

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دراسات وراثية على تربية الفول البلدي لتحمل الجفاف: ٢- قوة الهجين والقدرة على التآلف

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أجري هذا البحث خلال موسمي ٢٠٠٦/٢٠٠٧ ، ٢٠٠٧/٢٠٠٨ حيث تم عمل جميع الهجن الممكنة بين ستة آباء مختلفة وراثيا ذات أصول وراثية متباعدة من الفول البلدي وهي (نوبارية١، سخا٢، سخا١، جيزة٤٢٩، جيزة٧١٦، جيزة٢) بنظام Half diallel cross وفي الموسم التالي أقيمت تجربة مصممة في قطاعات كاملة العشوائية ذات ثلاثة مكررات بهدف تقييم الآباء والهجن الناتجة منها تحت مستويين من السعة الحقلية (٤٠-٥٠ %، ٦٠-٧٠ %) تحت ظروف الحقل المفتوح بمحطة بحوث شمال سيناء بمركز بحوث الصحراء.هذا وقد دونت النتائج على عينة من عشرة نباتات اختيرت عشوائيا من كل قطعة تجريبية وقد قدرت قوة الهجين لكل من الصفات المدروسة كنسبة مئوية لانحراف قيمة الهجين عن قيمة الأب الأفضل. وقدرت قيم القدرة العامة والخاصة على التآلف طبقا ل Griffing's (1956) حسب النموذج الأول للطريقة الثانية, لصفات ارتفاع النبات,عدد الأفرع بالنبات. عدد القرون بالنبات ,عدد البذور بالقرن, عدد البذور بالنبات, وزن ال١٠٠ بذرة, محصول البذرة بالنبات /جم.

هذا ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي:

كان التباين الراجع للرى (العادى والمنخفض) معنويا لكافة الصفات تحت الدراسة مع زيادة قيمة المتوسطات تحت ظروف الرى العادى عن الرى المنخفض, كان تباين التراكيب الوراثية لكل الصفات معنويا فى كلا البيئتين وأيضا التحليل المشترك، كما كان تباين التفاعل بين التراكيب الوراثية ومعاملات الرى معنويا لكل الصفات تحت الدراسة. كان التباين الراجع الى الآباء معنويا لكل الصفات المدروسة فيما عدا صفة عدد القرون على النبات للبيئة الأولى (الرى العادى). وكان التباين الراجع الى التفاعل بين الآباء والبيئة معنويا لكل الصفات المدروسة باستثناء صفة وزن ال١٠٠ بذرة.

أعطى الصنف نوبارية ١ أعلى قيم لمتوسط وزن ال١٠٠ بذرة فى كل من البيئتين وكذلك التحليل المشترك, أعطى الصنف سخا ٢ أعلى قيم لمتوسط ارتفاع النبات فى بيئة الرى العادى وعدد البذور بالقرن فى البيئتين وكذلك التحليل المشترك وكذلك عدد البذور فى النبات فى بيئة الرى العادى والتحليل المشترك, تفوق الصنف جيزة ٧١٦ فى صفات عدد الأفرع بالنبات، وعدد البذور بالنبات فى بيئة الرى المنخفض، وكذلك عدد القرون بالنبات فى البيئتين وكذلك التحليل المشترك, أعطى

الصنف جيزة ٢ أعلى قيم لمتوسطات عدد الأفرع بالنبات، ومحصول البذرة بالنبات/جم فى بيئة الرى العادى والتحليل المشترك ، وكذلك ارتفاع النبات فى بيئة الرى المنخفض, كان تباين الهجن معنويا لكل الصفات المدروسة مما يشير الى زيادة درجة الاختلاف بينها فيما عدا عدد الأفرع، كما أن التباين الراجع الى التفاعل بين الهجن والبيئة معنويا لكل الصفات, وأعطى الهجين جيزة ٤٢٩ × جيزة ٢ أعلى القيم المعنوية لصفة عدد القرون بالنبات يتبعه الهجين جيزة ٧١٦ × جيزة ٢ فى كلا البيئتين وكذلك التحليل المشترك, أعطى الهجين سخا ٢ × جيزة ٧١٦ أعلى قيمة معنوية لصفة عدد البذور بالقرن يتبعه الهجين سخا ٢ × سخا ١، جيزة ٤٢٩ × جيزة ٧١٦ فى كلا البيئتين وكذلك التحليل المشترك, أعطى الهجين سخا ١ × جيزة ٧١٦ أعلى قيمة معنوية لصفة محصول البذور بالنبات يتبعه الهجين نوبارية ١ × جيزة ٤٢٩، جيزة ٤٢٩ × جيزة ٧١٦ فى كلا البيئتين وكذلك التحليل المشترك, أعطى الهجين جيزة ٤٢٩ × جيزة ٧١٦ أعلى القيم المعنوية لصفة عدد البذور بالنبات يتبعه الهجين جيزة ٤٢٩ × جيزة ٧١٦، سخا ٢ × جيزة ٢ فى كلا البيئتين وكذلك التحليل المشترك, أعطى الهجين نوبارية ١ × سخا ٢ أعلى القيم المعنوية لصفة وزن ال١٠٠ بذرة يتبعه الهجين نوبارية ١ × سخا ١، نوبارية ١ × جيزة ٤٢٩، سخا ٢ × سخا١ فى كلا البيئتين وكذلك التحليل المشترك, كانت متوسطات أداء الهجن أكثر معنوية من متوسط أداء الآباء للعديد من الصفات تحت الدراسة فى كل من البيئتين (الرى العادى والمنخفض) وكذلك بيانات التحليل المشترك مما يؤكد تأثر قوة الهجين بالتغيرات البيئية تحت الدراسة.

كان التباين الراجع الى القدرة العامة والخاصة على التآلف معنويا لكافة الصفات المدروسة فيما عدا صفة عدد الأفرع بالنبات فى كل من البيئتين (الرى العادى والمنخفض) وكذلك التحليل المشترك مع القدرة العامة على الإئتلاف، عدد القرون على النبات فى بيئة الرى المنخفض مع القدرة الخاصة على الإئتلاف، عدد البذور فى القرن فى بيئة الرى المنخفض مع القدرة العامة على الإئتلاف. كما كان تباين التفاعل بين معاملات الرى وكل من القدرة العامة والخاصة على التآلف معنويا لكل الصفات فيما عدا صفة عدد الأفرع بالنبات فى كل من البيئتين (الرى العادى والمنخفض) وكذلك بيانات التحليل المشترك، عدد البذور فى القرن فى بيئة الرى المنخفض.

كانت أحسن الآباء قدرة على التآلف هي: جيزة ٤٢٩، جيزة ٧١٦، جيزة ٢ وذلك بالنسبة لمحصول البذرة بالنبات وواحدة أو أكثر من مكوناته تحت ظروف الرى العادى والمنخفض والتحليل المشترك. أظهر الهجين نوبارية ١ × جيزة ٤٢٩ قدرة خاصة على الائتلاف عالية بالنسبة للمحصول وبعض مكوناته وذلك في كلا البيئتين والتحليل المشترك بينهما, والهجين سخا ١× جيزة٧١٦ للمحصول وارتفاع النبات تحت ظروف الرى المنخفض ولذا تعتبر من الهجن المبشرة لمواصلة برنامج التربية لرفع إنتاجية محصول الفول البلدي تحت ظروف الجفاف فى الاراضى الصحراوية الجديدة.

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