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DIALLEL CROSSES FOR IMPROVING FABA BEAN (*Vicia faba* L.) UNDER RAIN-FED CONDITIONS
I. YIELD AND YIELD COMPONENTS

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The present study was conducted during 1998/99 and 1999/2000 seasons to estimate the types and relative amount of genetic variance components and their interactions with environments for yield and yield components in faba bean. A half diallel set of crosses involving seven parental varieties were utilized under two environments, normally irrigated every 45 days in addition to the amount of rainfall, and with second, dry method of sowing was, used and one supplemental irrigation at sowing, then after, plants were left to grow under rainfall conditions.

Significant genotype mean squares were obtained for all traits in both environments and in the combined data.

The ratio of Specific Combining Ability, S.C.A. x Environment/S.C.A. was higher than of General Combining Ability, G.C.A. x Environment/G.C.A. for all traits except number of pods/plant. The parental varieties Giza blanka and Giza-717 gave significant positive $\hat{g}_i$ for yield and one or more of its components in all crosses. The combination Giza blanka x Giza-461 and Giza-717 x Moshtohor-103 appeared to be the best promising for breeding to increase seed yield per plant which gave significant positive $\hat{S}_{ij}$ for yield and some of its component in both environments as well as the combined data.

Keywords: crosses, faba bean, rainfed, heterosis, yield, general and specific combining abilities.

Faba bean (*Vicia faba*, L.) is a protein crop for temperate regions. In Egypt, there is a possibility of increasing the cultivated area. Therefore, it is important to obtain higher yielding varieties through breeding programs for the new reclaimed areas under rain-fed conditions. The breeder should know the type of gene action of the quantitative traits because this is the main determinate in the choice of selection and breeding procedures. Drought tolerance in native plant species is often defined as survival, but in crop species it should be defined in terms of productivity (Passioura, 1983). Fischer and Maurer (1978) noted that quantification of drought tolerance should be based on grain yield under dry conditions in the absence of an understanding of specific mechanisms of tolerance. Hence, there is a need to look at the methods that has been used to quantify drought tolerance.

The aim of this investigation was to estimate the heterotic performance, and general and specific combining ability in F_1 of Faba bean diallel cross for certain quantitative characters in an attempt to improve yielding potentiality of Egyptian Faba bean under the previous stress conditions.

MATERIALS AND METHODS

This study was carried out in wire green-house in the headquarters (1998/99) and at Maryout Research Station, Alexandria Governorate (1999/2000), Desert Research Center where the soil is sand clay loam, non-saline (Ec 4.83 ds/m), calcareous (27.73% CaCO3) and 0.81% organic matter. Seven parents of wide divergent origins of faba bean were used in the present study, i.e., Giza blanka (P1), Giza-717 (P2), Triple white (P3), Giza-643 (P4), Giza-461 (P5), Moshtohor-109 (P6) and Moshtohor-103 (P7). The last two lines produced from plant breeding program at Dept. Agron., Fac. Agric. Moshtohor, Zagazig Univ., Egypt (EL-Hosary, 1989).

In 1999/2000 season, two experiments were conducted, each experiment included the seven parents and their 21 F1 hybrids, which were sown in a randomized complete block design with three replications. The first experiment was normally irrigated every 45 days in addition to the rainfall. In the second experiment, dry method of sowing was used and one supplemental irrigation at sowing was added, then after, plants were left to grow under rainfall conditions. The amount of rainfall was 132 mm along the growing season.

The obtained data for each trait were analyzed on individual plant mean basis. An ordinary analysis of variance was firstly performed according to Snedecor and Cochran (1967).

Heterosis was also determined according to Paschal and Wilcox (1975) for individual crosses as the percentage deviation of F_1 mean performance from the better parent mean (BP) for each experiment as well as the combined analysis as follows:

$$\text{The better parent heterosis} = [(\overline{F_1}-\overline{BP}) / \overline{BP}]\times 100$$

General and specific combining ability estimates were obtained by employing Griffing's (1956) diallel cross analysis designated as model–1 method-2 from each experiment and over both experiments.

RESULTS AND DISCUSSION

The analysis of variance for each of the two environments (irrigated and rain-fed) as well as the combined data for yield and yield components is presented in table (1). Environments mean squares were significant for all the studied traits.

Significant genotype mean squares were obtained for all traits in both experiments as well as the combined data. This indicates the wide diversity between the parental materials used in the present study. Significant genotype x environment mean squares were obtained for all studied traits, revealing that the performance of genotypes differed from one environment to another.

Results also showed that mean squares due to parents were significant for all the studied traits. Significant mean squares due to interaction between parents and environments were detected for all the studied traits except for number of seeds/plant and 100-seed weight, indicating that the parents varied in their response to environment in these traits.

The mean performances of seven parental varieties and/or lines of faba bean at separate experiments as well as the combined data are presented in table (2). The variety Giza blanka gave the highest values for seed yield, number of seeds/plant, and 100-seed weight in both environments as well as the combined analysis. Meanwhile, it had moderate values for number of pods/plant. Also, the variety Giza-717 ranked the second for 100-seed weight and seed yield/plant while it was moderate for the other traits. The variety Triple white gave moderate values for most traits. The variety Giza-643 ranked the second over the tested parents for number of seeds/plant, especially under normal irrigation it ranked the third for seed yield/plant and it was moderate for other traits. The parents Giza-461, Moshtohor-109, and Moshtohor-103 gave moderate to low values for all the studies traits.

For number of pods/plant, the cross Triple white x Giza-461 showed significant higher mean values in both environments as well as in the combined data followed by cross Giza-blanka x Moshtohor-109 under normal irrigation and cross Giza-717 x Triple white under both rainfall and the combined data. While, the crosses Giza-717 x Moshtohor-109 , Giza-717 x Moshtohor-103 , Triple white x Moshtohor-103 , Giza-643 x Moshtohor-109 , Giza-461 x Moshtohor-109 and Giza-461 x Moshtohor-103 gave the lowest number of pods/plant in the combined data.

The two crosses Giza-blanka x Triple white and Giza-blanka x Giza-717 under normal irrigation, two crosses Giza-blanka x Giza-461 and Giza-blanka x Giza-717 under both rain-fed and the combined data gave the highest number of seeds/plant. However the cross Giza-461 x Moshtohor-109 was the lowest one in this respect.

Regarding seed yield/plant, the two crosses Giza-blanka x Triple white and Giza-blanka x Giza-717 under normal irrigation, the cross Giza-blanka x Giza-461 under rainfed, and the two crosses Giza-blanka x Giza-461 and Giza-blanka x Triple white in the combined data showed significant higher mean values compared with other crosses. Therefore, the crosses involving Giza blanka exhibited higher seed yield/plant. Generally, the four crosses Giza-blanka x Giza-717, Giza-blanka x Giza-461, Giza-blanka x Triple white, and Giza-717 x Moshtohor-103, four crosses, Giza-blanka x Giza-461, Giza-717 x Triple white, Giza-717 x Moshtohor-109 and Triple white x Moshtohor-109 and four crosses; Giza-blanka x Triple white, Giza-blanka x Giza-717, Giza-blanka x Giza-461, and Giza-717 x Moshtohor-103 gave the highest seed yield/plant under normal irrigation, rainfall and the combined data, respectively. The high seed yield/plant of the previous crosses could be attributed to high values of one or more of yield components.

Mean squares for parent vs. crosses as an indication to average heterosis overall crosses was of appreciable magnitude in both environments (normal irrigation and rain-fed) as well as in their combined for all traits (Table 1). Significant interaction between parents vs. crosses and environments was detected for number of pods/plant, indicating that the heterotic effects were affected by the environmental changes for such trait.

Heterosis expressed as the percentage deviation of F_1 mean performance from better parent average values for all traits studied at both environments and an average over the two environments, are presented in table (3).

With respect to number of pods per plant, eight, six and eight crosses had significant positive heterotic effects relative to better parent in the irrigated and rain-fed as well as in the combined analysis, respectively. However, the crosses; Triple white x Giza-461, Giza-717 x Triple white, Giza blanka x Giza-717 and Giza blanka x Giza-461 exhibited significant positive heterotic effect relative to better parents, and these were true in irrigated, rain-fed condition and over both environments. Significant positive heterotic effects for number of pods per plant over the better parents were recorded by EL-Hosary (1983), Abd EL- Raheem and Ismail (1986), EL-Hosary (1988), Abul-Naas *et al.*, (1991), Abo EL-Zahab *et al.*, (1994a) and Helal (1997).

For number of seeds/plant, six, three and seven crosses had significant positive heterotic effects relative to better parent in the normal and rainfall irrigations as well as in the combined data, respectively. However, the crosses; Giza blanka x Giza-461 and Giza-717 x Triple white had significant positive heterosis relative to better parents in the two environments and their combined data. Significant positive heterotic effects for number of seeds/plant were recorded by EL-Hosary (1983), Abd EL-Raheem and Ismail (1986), Abo EL-Zahab *et al.*, (1994a) and Helal (1997).

TABLE (1). Mean squares from ordinary analysis and combining ability for all the studied traits from the F_1 generation under irrigated and rain-fed conditions as well as over both environments.

S.O.V.	d.f.		No. of pods/plant			No. of seeds/plant			Seed yield/plant (g)			100-seed weight (g)		
	Single	Comb.	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Reps. In Env.	2	4	3.63	7.74	5.68	31.88	133.18	82.53	49.10	4.95	27.02	10.81	7.53	9.17
Environments		1			20763.5**			79826.2**			59658.8**			247373.2**
Genotypes(G)	27	27	162.91**	100.60**	223.85**	844.13**	343.91**	935.22**	703.43**	190.63**	591.52**	192.50**	199.10**	337.53**
Parents(P)	6	6	140.55**	28.79**	135.08**	332.79**	188.17*	446.95**	307.01**	126.81**	330.90**	290.37**	398.69**	662.81**
Crosses (C)	20	20	138.47**	114.05**	212.76**	962.23**	355.12**	999.45**	842.06**	193.79**	658.91**	121.36**	109.96**	166.63**
P x C.	1	1	785.80**	262.30**	978.08**	1550.2**	1054.13**	2580.4**	309.37**	510.31**	807.11**	1028.05**	784.42**	1803.91**
G × Env.		27			39.65**			252.81**			302.56**			54.07**
P × Env.		6			43.27*			74.02			102.92**			26.26
C × Env.		20			39.74**			317.89**			376.93**			64.69**
P. vs C. × Env.		1			70.03*			23.93			12.57			8.56
Error	54	108	16.90	7.51	12.21	35.01	68.22	51.61	23.49	10.48	16.98	19.19	20.98	20.08
G.C.A.		6	53.20*	27.87*	29.44*	569.19**	220.92**	349.48**	438.18**	113.03**	219.93**	62.88**	95.44**	75.71**
S.C.A.		21	54.61**	35.14**	39.56**	199.15**	84.27**	100.56**	176.28**	49.41**	63.92**	64.53**	58.08**	50.69**
G.C.A. × Env.		6			51.64**			440.63**			331.27**			82.62**
S. C.A. × Env.		21			50.21**			182.86**			161.77**			71.89**
Error term	54	108	5.63	2.50	4.06	11.67	22.74	17.20	7.83	3.49	5.66	6.39	6.99	6.69
G.C.A/S.C.A			0.97	0.79	0.74	2.86	2.62	3.48	2.49	2.29	3.44	0.97	1.64	1.49
G.C.A. × Env. / G.C.A.					1.75			1.26			1.51			1.09
S.C.A. × Env. / S.C.A.					1.27			1.82			2.53			1.42

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

Comb.= Combined

G.C.A.= General Combining Ability

S.C.A. = Specific Combining Ability

TABLE (2). Genotypes mean performance for the studied traits under irrigated and rainfed conditions as well as over both environments.

Genotypes		No. of pods/plant			No. of seeds/plant		
		Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Giza blanka	(P_1)	20.533	14.967	17.75	59.933	39.833	49.880
Giza-717	(P_2)	9.867	7.767	8.82	44.600	32.533	38.570
Tripe-white.	(P_3)	20.467	15.867	18.17	31.167	18.233	24.700
Giza-643	(P_4)	26.400	13.767	20.08	59.900	28.600	44.250
Giza-461	(P_5)	23.800	13.967	18.88	43.233	27.867	35.550
Moshtohor-109	(P_6)	32.167	17.333	24.75	41.700	17.100	29.400
Moshtohor-103	(P_7)	20.133	15.867	18.00	40.500	25.300	32.900
$P_1 \times P_2$		30.400	19.233	24.82	96.933	51.267	74.100
$P_1 \times P_3$		32.333	12.833	22.58	97.000	38.833	67.920
$P_1 \times P_4$		28.067	14.100	21.08	48.500	38.600	43.550
$P_1 \times P_5$		30.867	23.267	27.07	77.100	65.667	71.380
$P_1 \times P_6$		42.933	16.700	29.82	61.167	23.333	42.250
$P_1 \times P_7$		28.833	20.433	24.63	62.933	39.833	51.380
$P_2 \times P_3$		38.600	31.733	35.17	54.933	45.733	50.330
$P_2 \times P_4$		27.167	15.700	21.43	53.400	31.467	42.430
$P_2 \times P_5$		25.233	16.833	21.03	51.933	40.267	46.100
$P_2 \times P_6$		20.433	15.767	18.10	53.667	42.433	48.050
$P_2 \times P_7$		18.933	16.133	17.53	73.633	36.533	55.080
$P_3 \times P_4$		27.367	20.800	24.08	44.267	24.767	34.520
$P_3 \times P_5$		47.333	38.033	42.68	43.100	33.133	38.120
$P_3 \times P_6$		25.767	16.467	21.12	40.467	29.200	34.830
$P_3 \times P_7$		25.200	15.233	20.22	58.167	31.133	44.650
$P_4 \times P_5$		26.633	16.200	21.42	36.900	30.833	33.870
$P_4 \times P_6$		24.800	12.967	18.88	46.967	35.833	41.400
$P_4 \times P_7$		30.833	14.500	22.67	55.333	18.233	36.780
$P_5 \times P_6$		26.233	14.033	20.13	26.533	17.867	22.200
$P_5 \times P_7$		24.600	16.200	20.40	44.933	31.467	38.200
$P_6 \times P_7$		25.867	17.133	21.50	43.567	33.767	38.670
$\bar{X}$ Overall parents		21.910	14.219	18.064	45.862	27.067	36.464
$\bar{X}$ Overall F_1's		28.973	18.300	23.636	55.783	35.248	45.515
$\bar{X}$ Overall genotypes		27.207	17.280	22.243	53.302	33.202	43.252
L.S.D. $_{0.05}$		3.08	2.52	2.84	3.70	4.37	4.07
L.S.D. $_{0.01}$		3.55	2.90	3.28	4.26	5.04	4.70

TABLE (2). Cont.

Genotypes	Seed yield (g/plant)			100-seed weight		
	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Giza blanka (P1)	65.586	40.178	52.882	109.433	100.867	105.15
Giza-717 (P2)	43.262	30.538	36.900	97.000	93.867	95.43
Tripe-white. (P3)	27.344	13.474	20.409	87.733	73.900	80.82
Giza-643 (P4)	48.140	20.335	34.238	80.367	71.100	75.73
Giza-461 (P5)	35.754	21.448	28.601	82.700	76.967	79.83
Moshtohor-109 (P6)	36.529	12.432	24.481	87.600	72.700	80.15
Moshtohor-103 (P7)	36.342	19.995	28.169	89.733	79.033	84.38
P1 × P2	81.489	31.639	56.714	84.067	62.300	73.18
P1 × P3	84.292	29.190	56.741	86.900	75.167	81.03
P1 × P4	38.978	28.783	33.881	80.367	74.567	77.47
P1 × P5	64.430	50.548	57.486	83.567	76.967	80.27
P1 × P6	39.881	14.700	27.291	65.200	63.000	64.10
P1 × P7	50.514	28.879	39.70	80.267	72.500	76.38
P2 × P3	47.389	35.123	41.256	86.267	76.800	81.53
P2 × P4	44.785	25.415	35.100	83.867	80.767	82.32
P2 × P5	49.371	30.576	39.974	95.067	75.933	85.50
P2 × P6	43.739	33.649	38.694	81.500	79.300	80.40
P2 × P7	65.092	31.699	48.396	88.400	86.767	87.58
P3 × P4	36.225	17.857	27.041	81.833	72.100	76.96
P3 × P5	34.580	25.126	29.854	80.233	75.833	78.03
P3 × P6	33.938	32.893	28.416	83.867	78.400	81.13
P3 × P7	45.738	22.115	33.927	78.633	71.033	74.83
P4 × P5	31.894	24.040	27.967	86.433	77.967	82.20
P4 × P6	39.311	28.344	33.828	83.700	79.100	81.40
P4 × P7	41.610	12.508	27.059	75.200	68.600	71.90
P5 × P6	21.049	13.638	17.344	79.333	76.333	77.83
P5 × P7	34.089	20.915	27.502	75.867	66.467	71.17
P6 × P7	40.735	22.691	31.713	93.500	67.200	80.35
$\bar{x}$ Overall parents	41.851	22.629	32.240	90.652	81.205	85.93
$\bar{x}$ Overall F1's	46.149	26.220	36.185	82.575	74.148	78.36
$\bar{x}$ Overall genotypes	45.075	25.322	35.199	84.595	75.912	80.25
L.S.D. 0.05	3.34	2.73	3.08	3.18	3.25	3.21
L.S.D. 0.01	3.86	3.15	3.56	3.67	3.75	3.71

Comb. = Combined

TABLE (3). Percentage of heterosis in the F_1 generation over better parent for the studied traits under irrigated and rainfed conditions as well as over both environments.

Crosses	No. of pods/plant			No. of seeds/plant		
	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Giza blanka × Giza-717	48.05**	28.51**	39.81**	61.74**	28.70	48.56**
Giza blanka × Tripe-white	57.47**	-19.12	24.31*	61.85**	-2.51	36.17**
Giza blanka × Giza-643	6.31	-5.79	4.98	-19.08*	-3.09	-12.69
Giza blanka × Giza-461	29.69*	55.46**	43.34**	28.64**	64.86**	43.10**
Giza blanka × Moshtohor-109	33.47**	-3.65	20.47*	2.06	-41.42*	-15.30
Giza blanka × Moshtohor-103	40.42*	28.78*	36.85**	5.01	0.000	3.01
Giza-717 × Tripe-white	88.60**	100.00**	93.58**	23.17*	40.57*	30.49**
Giza-717 × Giza-643	2.90	14.04	6.72	-10.85	-3.28	-4.11
Giza-717 × Giza-461	6.02	20.53	11.39	16.44	23.77	19.52
Giza-717 × Moshtohor-109	-36.48**	-9.04	-26.9**	20.33	30.43	24.58*
Giza-717 × Moshtohor-103	-5.96	1.68	-2.59	65.10**	12.30	42.81**
Tripe-white × Giza-643	3.66	31.09**	-19.92*	-26.10**	-13.40	-21.99*
Tripe-white × Giza-461	98.88**	139.70**	126.0**	-0.31	18.90	7.33
Tripe-white × Moshtohor-109	-19.90	-4.99	-14.68	-2.96	60.15*	18.47
Tripe-white × Moshtohor-103	23.13	-3.99	11.28	43.62**	23.06	35.71**
Giza-643 × Giza-461	0.88	15.99	6.64	-38.40**	7.81	-23.46*
Giza-643 × Moshtohor-109	-22.90*	-25.19	-23.7**	-21.59*	25.29	-6.44
Giza-643 × Moshtohor-103	16.79**	-8.61	12.86*	-7.62	-36.25	-16.88
Giza-461 × Moshtohor-109	-18.45	-19.04	-18.65*	-38.63**	-35.88	-37.55**
Giza-461 × Moshtohor-103	3.36	2.10	8.03	3.93	12.92	7.45
Moshtohor. 109 × Moshtohor-103	-19.59	-1.15		4.48	33.47	17.54

Crosses	Seed yield (g/plant)			100-seed weight		
	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Giza blanka × Giza-717	24.25**	-20.51**	7.25	-23.18**	-38.24**	-30.40**
Giza blanka × Tripe-white	28.52**	-27.35**	7.30	-20.59**	-25.48**	-22.94**
Giza blanka × Giza-643	-40.57**	-28.63**	-35.93**	-26.56**	-26.07**	-26.32**
Giza blanka × Giza-461	-1.76	25.80**	8.71	-23.64**	-23.70**	-23.66**
Giza blanka × Moshtohor-109	-39.19**	-63.41**	-48.39**	-40.42**	-37.54**	-39.04**
Giza blanka × Moshtohor-103	-22.98**	-28.12**	-24.93**	-26.65**	-28.12**	-27.36**
Giza-717 × Tripe-white	9.54	15.01	11.80	-11.07**	-18.18**	-14.57**
Giza-717 × Giza-643	-6.97	-16.78	-4.88	-13.54**	-13.96**	-13.74**
Giza-717 × Giza-461	14.12	0.12	8.33	-1.99	-19.11**	-10.41**
Giza-717 × Moshtohor-109	1.10	10.19	4.86	-15.98**	-15.52**	-15.75**
Giza-717 × Moshtohor-103	50.46**	3.81	31.15**	-8.87*	-7.56	-8.23**
Tripe-white × Giza-643	-24.75**	-12.19	-21.02**	-6.73	-2.44	-4.76
Tripe-white × Giza-461	-3.284	17.15	4.38	-8.55*	-1.47	-3.45
Tripe-white × Moshtohor-109	-7.09	69.91**	16.07	-4.41	6.09	0.38
Tripe-white × Moshtohor-103	25.85*	10.60	20.44*	-12.37**	-10.12*	-11.32**
Giza-643 × Giza-461	-33.75**	12.09	-18.32**	4.51	1.30	2.97
Giza-643 × Moshtohor-109	-18.34*	39.39**	-1.20	-4.45	8.80	1.56
Giza-643 × Moshtohor-103	-13.57	-38.49**	-20.97**	-16.20**	-13.20**	-14.79**
Giza-461 × Moshtohor-109	-42.38**	-36.41**	-39.36**	-9.44*	-0.82	-2.90
Giza-461 × Moshtohor-103	-6.20	-2.49	-3.84	-15.45**	-15.90**	-15.66**
Moshtohor. 109 × Moshtohor-103	11.51	13.48	12.58	4.20	-14.97**	-4.78

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

Comb. = Combined

TABLE (4). Estimates of general combining ability effects for parental varieties/or lines regarding studied traits in the F_1 generation.

Parental Variety or line	No. of pods/plant			No. of seeds/plant			Seed yield/plant (g)			100-seed weight (g)		
	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Giza blanka	1.87*	-0.19	0.84	15.23**	7.95**	11.59**	12.53**	4.29**	8.41**	-2.35*	-4.16**	-3.25**
Giza-717	-4.13**	-0.81	-2.47*	5.25**	5.24*	5.25**	6.18**	5.41**	5.79**	4.05**	4.70**	4.37**
Tripe-white.	2.21*	3.18**	2.69**	-7.85**	-5.44*	-6.65**	-4.78**	-1.70*	-3.24**	3.25**	4.20**	3.72**
Giza-643	0.01	-1.83*	-0.91	-2.36*	-3.19*	-2.77*	-2.99*	-2.82**	-2.90*	-2.74*	-1.33	-2.03*
Giza-461	1.20	1.58*	1.39*	-6.61**	1.04	-2.78*	-7.52**	0.57	-3.48**	-1.21	-0.41	-0.82
Moshtohor. 109	1.41	-1.17*	0.12	-2.91*	-2.93	-2.92*	-0.56	-2.80**	-1.68*	-0.39	-1.13	-0.76
Moshtohor .103	-2.57*	-0.76	-1.67*	-0.76	-2.67	-1.72	-2.86*	-2.95**	-2.90*	-0.60	-1.85*	-1.23
L.S.D. 0.05 $\hat{g}_i$	1.47	0.98	1.23	2.12	2.96	2.54	1.73	1.16	1.46	1.57	1.64	1.58
L.S.D. 0.01	1.96	1.31	1.63	2.82	3.94	3.36	2.31	1.54	1.93	2.09	2.19	2.10
r	0.654	0.179	0.448	0.644	0.884**	0.783*	0.817*	0.846*	0.860*	0.075	-0.107	-0.044

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

Comb. = Combined

r = Correlation Coefficient between the parental performance and their G.C.A. effects.

For-100 seed weight, none of the crosses exceeded better parent values. Positive heterosis for 100-seed weight was reached before by Bond (1966), EL-Hosary (1983 and 1984), Abd EL-Raheem and Ismail (1986), EL-Hosary (1987a and 1988), Helal (1997) and Omar *et al.*, (1998).

Concerning seed yield/plant of all combination crosses, four, four and two crosses exhibited significant positive heterotic effects relative to better parent in the irrigated rainfed as well as in the combined data, respectively. In the combined data the two crosses Giza-717 x Moshtohor-103 and Triple white x Moshtohor-103 showed desirable heterotic effects relative to better parent with greatest advantage being 25.8%.

The components of yield for individual crosses also showed in most cases, less heterosis than yield itself. Also, the heterotic effects were lower in rainfall irrigation than those of normal one. Many investigators reported high heterosis for seed yield of faba bean (EL-Hosary 1983, 1984, 1985, 1987a and 1988); EL-Hosary and Sedhom, 1988; Hendawy *et al.*, 1988; Abul-Naas *et al.*, 1991; EL-Hosary *et al.*,1992; Abd-El-Aziz, 1993 and EL-Hosary *et al.*, 1997).

Analysis of variance for combining ability as outlined by Griffing's (1956) model-1 method-2 in each experiment and their combined data for all the studied traits is presented in table (1). The mean squares associated with general combining ability (G.C.A.) and specific combining ability (S.C.A.) were significant for all the studied traits .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 found that all traits except number of pods per plant in both environments as well as the combined data and 100-seed weight under irrigation experiment exhibited G.C.A./S.C.A. ratio exceeded the unity, indicating the predominance of additive and additive × additive types of gene action in the inheritance of such traits.

For the exceptional case of number of pods/plant under rainfed and the combined data, low G.C.A./S.C.A. ratio which less than unity was detected. Such results indicate that non-additive type of gene action was more important than additive one in controlling this trait. The magnitude of additive and non–additive types of gene action were similar for number of pods/plant and 100-seed weight under irrigation experiment. The genetic variance was previously reported to be mostly due to additive type of gene action for yield and yield components by El-Hosary (1983, 1984 and 1985), Abd El-Raheem and Ismial (1986), El-Hosary (1987a and b, and 1988), Hendawy *et al.* (1988), Abul-Naas *et al.* (1989 and 1991), Dawwam (1991), El-Hosary *et al.* (1992), Abd EL-Aziz (1993), Abo El-Zahab *et al.* (1994 b), Kaul and Vaid (1996), Helal (1997), El-Hady *et al.* (1998), Omar *et al.* (1998) and El-Refaey *et al.* (1999).

The mean squares of interaction between irrigation treatments and both types of combining ability were significant for all traits. Such results show that the magnitude of all types of gene action varied from one environment to another. It is fairly evident that the ratios of S.C.A × Env./S.C.A. was higher than the ratios of G.C.A. × Env./G.C.A. for all traits except number of pods/plant. Such results indicate that non- additive gene effects were much more influenced by the irrigation treatments than the additive gene effects . Specific combining ability was stated by several investigator to be more sensitive to environmental changes than G.C.A. (Gilbert, 1958).

General Combining Ability Effects

Estimates of G.C.A. effects ($\hat{g}_i$) for individual parents in each trait in normal irrigation and rainfed as well as in the combined data are presented in table (4). General combining ability effects computed herein were found to be differ significantly from zero in all traits. High positive values would be of interest for all traits in question where high positive effects would be useful from the breeder's point of view.

The parental variety Triple white in both environments as well as the combined data, Giza-461 under rainfall and the combined data, and Giza blanka under normal irrigation had significantly positive $\hat{g}_i$ for number of pods/plant and proved to be good combiners in this respect.

The two parents Giza-717 and Triple white could be considered as excellent parents in breeding program towards releasing varieties characterized by high seed index. The other parents exhibited either significant negative or insignificant $\hat{g}_i$ for this trait.

For seed yield and number of seeds/plant, the two parents Giza blanka and Giza-717 seemed to be good combiners.

Concerning seed yield/plant and its components, it is worth- noting that the parent which 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 yield itself. $\hat{g}_i$ for seed yield/plant was largely manifested in parents showing high $\hat{g}_i$ for number of seeds/plant.

Significant correlation coefficient values between the parental performance ($\bar{x}$) and its hybrids were obtained for number of seeds per plant in rainfall and the combined analysis, seed yield/plant in both environments as well as the combined data (Table 4). This finding indicates that the parental material gave good index of interspecific performance of their general combining ability 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 reveale that hybrids characterized with high mean values could be expected by crossing between varieties of low performance for these cases. A rather good agreement between ranking of parental performance and their G.C.A. effects was reported by EL-Hosary and Sedhom (1988) and Abul-Naas *et al.* (1989).

Specific combining ability effects of the parental combinations were computed in separate environments as well as over environments (Table 5).

The three crosses Triple white x Giza-461, Giza-717 x Triple white and Giza blanka x Giza-717 had significant positive $\hat{S}_{ij}$ for number of pods/plant under the two environments and over both environments.

Considering 100-seed weight, four, two and three crosses combinations showed significant positive $\hat{S}_{ij}$ under irrigated, rain-fed and the combined data, respectively. The cross Giza-717 x Giza-461 under irrigated and cross Giza-717 x Moshtohor-103 under rain-fed and the combined data gave the highest positive values of $\hat{S}_{ij}$ for this trait

Regarding seed yield/plant, five, seven and seven crosses showed significantly positive $\hat{S}_{ij}$ under normal irrigation, rainfall and the combined analysis, respectively. The best combinations were Giza blanka x Giza-461 and Giza-717 x Moshtohor-103 under both irrigation conditions and the combined data. Also, the crosses Giza blanka x Giza-717 under normal irrigation, and Giza-717 x Triple white and Triple white x Giza-643 under rain-fed showed the best $\hat{S}_{ij}$. It could be concluded that the previous crosses seemed to be the best combinations for drought tolerance where it gave significant $\hat{S}_{ij}$ for seed yield/plant as well as most of the yield components under rain-fed conditions.

For all traits the values of $\hat{S}_{ij}$ effects were differed from one environment to another. This finding coincide with that reached before (Table1).

If crosses showing high specific combining ability effects involving only one good combiner, such combinations would show with desirable transgressive segregates, providing that the additive genetic system present in the good combiner as well as the complementary and epistatic effects present in the crosses, act in the same direction to reduce undesirable plant characteristics and maximize the character in view. Therefore, the most of the previous crosses might be of prime importance in breeding to drought tolerant varieties by using traditional breeding procedures.

TABLE (5). Estimates of specific combining ability effects for F_1 crosses regarding studied traits.

Crosses	No. of pods/plant			No. of seeds/plant		
	Irrigation	Rainfall	Comb.	Irrigation	Rainfall	Comb.
Giza blanka × Giza-717	5.45**	2.96*	4.20**	23.15**	4.87	14.01**
Giza blanka × Tripe-white	1.05	-7.43**	-3.19	0.48	-12.38**	-5.95
Giza blanka × Giza-643	-1.01	-1.16	-1.09	-17.67**	0.63	-8.52**
Giza blanka × Giza-461	0.58	4.60**	2.59	15.17**	23.47**	19.32**
Giza blanka × Moshtohor-109	12.44**	0.78	6.61**	31.37**	0.61	15.99**
Giza blanka × Moshtohor-103	2.32	4.11	3.22	-4.84	1.35	-1.74
Giza-717 × Tripe-white	13.31**	12.09**	12.70**	2.96	9.44*	6.19
Giza-717 × Giza-643	4.09	1.06	2.57	-2.79	-3.79	-3.29
Giza-717 × Giza-461	0.95	-1.22	-0.14	-0.02	0.79	0.39
Giza-717 × Moshtohor-109	-4.06	0.47	-1.79	-0.72	10.22**	4.75
Giza-717 × Moshtohor-103	-1.58	0.43	-0.57	15.84**	0.77	8.30*
Tripe-white × Giza-643	-2.05	2.17	0.06	3.88	11.26**	7.57*
Tripe-white × Giza-461	16.71**	15.99**	16.35**	-12.31**	-10.93**	-11.62**
Tripe-white × Moshtohor-109	-5.06**	-2.82	-3.94*	-2.08	4.37	1.14
Tripe-white × Moshtohor-103	-1.64	-4.46**	-3.05	-1.12	8.68*	3.78
Giza-643 × Giza-461	-1.78	-0.84	-1.31	-7.44**	-0.22	-3.83
Giza-643 × Moshtohor-109	-3.82	-1.32	-2.57	-3.77	-2.32	-3.04
Giza-643 × Moshtohor-103	6.19**	-0.19	3.00	5.15	-9.11*	-1.98
Giza-461 × Moshtohor-109	-3.59	-3.66**	-3.63*	-0.69	1.82	0.57
Giza-461 × Moshtohor-103	-1.24	-1.90	-1.57	-1.00	-0.10	-0.55
Moshtohor. 109 × Moshtohor-103	-0.18	1.78	0.80	8.53**	3.53	6.03
L.S.D 0.05	4.28	2.85	3.58	6.16	8.59	7.38
(S_{ij}) 0.01	5.71	3.80	4.75	8.21	11.46	9.77
Crosses	Seed yield (g/plant)			100-seed weight		
	Irrigation	Rainfed	Comb.	Irrigation	Rainfed	Comb.
Giza blanka × Giza-717	25.09**	-5.33**	9.88**	-2.22	-14.16**	-8.19**
Giza blanka × Tripe-white	-8.14**	-6.12**	-7.13**	-20.29**	-12.95**	-16.62**
Giza blanka × Giza-643	-18.29**	1.63	-8.33**	0.86	4.14	2.50
Giza blanka × Giza-461	6.95**	17.99**	12.47**	2.53	5.64**	4.09
Giza blanka × Moshtohor-109	31.75**	1.18	16.46**	5.06*	4.54	4.79*
Giza blanka × Moshtohor-103	-8.08**	1.75	-3.17	-1.37	2.59	0.61
Giza-717 × Tripe-white	-1.89	7.76**	2.94	-10.39**	-5.51**	-7.95**
Giza-717 × Giza-643	-5.59*	-4.45**	-5.02**	-2.04	1.49	-0.28
Giza-717 × Giza-461	-9.39**	-2.43	-5.91**	7.63**	-4.25	1.69
Giza-717 × Moshtohor-109	0.23	8.69**	4.46*	-1.98	2.68	-2.33
Giza-717 × Moshtohor-103	17.32**	5.81**	11.56**	0.36	8.01**	4.81*
Tripe-white × Giza-643	1.84	9.39**	5.62**	-1.41	0.32	-0.54
Tripe-white × Giza-461	-3.69	-7.07**	-5.38**	-7.30**	-3.35	-5.32**
Tripe-white × Moshtohor-109	-5.10*	4.12**	-0.49	-3.58	-0.58	-2.08
Tripe-white × Moshtohor-103	-5.65*	2.69	-1.48	6.26**	-11.06**	-2.39
Giza-643 × Giza-461	-2.01	5.04**	1.52	5.78**	3.82	4.79*
Giza-643 × Moshtohor-109	-1.89	-3.05	-2.47	0.37	-1.35	-0.49
Giza-643 × Moshtohor-103	3.95	-7.96**	-2.01	-6.06**	-4.13	-5.09*
Giza-461 × Moshtohor-109	-2.78	1.33	-0.72	-2.76	1.48	-0.64
Giza-461 × Moshtohor-103	0.44	-2.98	-1.27	-6.92**	-7.17**	-7.04**
Moshtohor. 109 × Moshtohor-103	8.22**	1.88	5.05**	-4.96*	-1.89	-3.43
L.S.D 0.05	5.04	3.37	4.23	4.56	4.77	4.60
(S_{ij}) 0.01	6.73	4.49	5.61	6.08	6.36	6.09

* and ** indicates significant at 0.05 and 0.01 levels of probability, respectively.
Comb. = Combined

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التهجينات التبادلية لتحسين الفول البلدى تحت الظروف المطرية
١- المحصول ومكوناته

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أجريت هذه الدراسة بهدف دراسة مكونات التباين الوراثى وقوة الهجين لصفات المحصول ومكوناته حيث إستخدم لهذا الغرض سبعة آباء مختلفة وراثيا وهى جيزة بلانكا ، جيزة ٧١٧ ، Triple white ، جيزة ٦٤٣ ، جيزة ٤٦١ ، مشتهر ١٠٩ ، مشتهر ١٠٣

وقد أجرى هذا البحث خلال موسمى ٩٨/١٩٩٩ ، ٩٩/٢٠٠٠ حيث تم عمل جميع الهجن الممكنة بين الآباء السبعة بنظام Half diallel cross فى الموسم الأول، وفى الموسم التالى أقيمت تجربتين مصممتين فى قطاعات كاملة العشوائية ذات ثلاثة مكررات بغرض تقييم الآباء والهجن الناتجة منها ، تم رى التجربتين بعد الزراعة فى ٢٠ نوفمبر ١٩٩٩ ثم رى التجربة الأولى بعد ٤٥ يوم و تركت التجربة الثانية للنمو تحت ظروف الأمطار السائدة بمنطقة مريوط التابعة لمحافظة الإسكندرية.

هذا ويمكن تلخيص أهم النتائج المتحصل عليها كما يلى :

كان التباين الراجع لبيئتى الرى (العادى والمطرى) معنويا لكافة الصفات تحت الدراسة مع زيادة قيمة المتوسطات تحت ظروف الرى المعتاد عن الزراعة المطرية. أعطى الصنف جيزة بلانكا أعلى قيم لمتوسطات محصول البذرة بالنبات وعدد البذور وعدد الأفرع بالنبات ودليل البذرة فى كل من البيئتين وأيضا التحليل المشترك. كان تباين الهجن معنويا لكل الصفات المدروسة مما يشير الى زيادة درجة الاختلاف بينها. تفوقت سبعة وتسعة وإثنى عشر هجيناً تفوقاً معنوياً بالنسبة لقوة الهجين مقارنة بمتوسط الابوين لصفة محصول البذرة بالنبات وذلك تحت تأثير ظروف الرى العادى والمطر وبيانات التحليل المشترك بينهما على التوالى. كما أظهرت أربعة وثلاثة وإثنين من الهجن معنوية موجبة لقوة الهجن عند مقارنتها بالأب الأفضل لنفس الصفة والنمو فى البيئات الثابته على التوالى. ومن بيانات التحليل المشترك أظهر هجينين هما جيزة ٧١٧ × مشتهر ١٠٣، Triple white × مشتهر ١٠٣ قوة هجين عالية بالنسبة للأب الأفضل مع أفضلية بنسبة ٢٥,٨%.

كان التباين الراجع الى القدرة العامة والخاصة على التآلف معنويا لكافة الصفات المدروسة. كانت نسبة تباين القدرة العامة على التآلف الى تباين القدرة الخاصة على التآلف ذات قيمة اعلى من الوحدة لكافة الصفات تحت الدراسة فيما عدا صفة عدد القرون بالنبات فى كلا البيئتين وكذلك التحليل المشترك بينهما وكذلك صفة وزن الـــ ١٠٠ بذرة فى ظروف الرى العادى، مما يدل على أن الجزء الأكبر من الاختلافات الوراثية المرتبطة بهذه الصفة كان راجعا الى فعل الجين من النوع المضيف. أظهرت الهجن جيزة بلانكا × جيزة ٤٦١ ، جيزة ٧١٧ × مشتهر ١٠٣ قدرة عالية خاصة على الائتلاف بالنسبة للمحصول وبعض مكوناته وذلك فى كلا البيئتين والتحليل المشترك بينهما وتعتبر من الهجن المبشرة لمواصلة برنامج التربية لرفع إنتاجية محصول الفول البلدى تحت ظروف المطر فى الأراضى الصحراوية الجديدة.