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INVESTIGATIONS ON FABA BEANS, *Vicia faba* L. 16. F_1 AND F_2 DIALLEL HYBRIDS WITH RECIPROCALS AMONG FIVE PARENTS

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ABSTRACT

The genotypes Giza 3, Giza 40, Giza 429, Giza Blanca and Triple White were diallel crossed and F_1 and F_2's and reciprocals in addition to parents were evaluated in open field.

Significant differences were observed among genotypes for all studied traits. The F_1 hybrids were superior over means of all parents in most of characters. Heterosis was significant and positive for most characters and ranged from 55 % for plant seed yield to 5.9 % for seeds per pod. Significant negative heterosis was detected for position of first podded node (-5.6%) and days to flowering (-8.7 %).

Significant differences were found between F_1 and its reciprocals for most of characters. Some reciprocal cross differences were detected also in F_2. Inbreeding depression occurred in F_2 for most characters and reached 28 % for plant seed yield.

Compared to the better parents, several F_1 hybrids recorded significant positive heterosis for different characters, but negative heterosis occurred too. Inbreeding depression in F_2 was detected in most characters but, inbreeding gain was also found.

Largest part of total genetic variability (judged by GCA/SCA) was due to additive type of gene action for all characters except plant height and seed yield in F_1 which are largely controlled by dominance gene effects.

Different parental combinations showed differing general and specific combining ability for different characters and selection in segregating generation would lead to crop improvement due to genetic divergence of parental genotypes.

The inheritance of blotches on flower wings was studied in four crosses including T.W. (blotchless) and the parents G.40, G. 3, G.429 and G.B. (blotched). The F_1 hybrids possessed blotched wings. The F_2 segregating indicated that this character is controlled by one pairs of factors, with blotched dominant.

The parental genotypes T.W. and G.B. have seeds with colourless hilum. The F_1 plants with parents G.3, G. 40 and G.429 had black hilum and the F_2 segregated into the ratio of 3 black hilum : 1 colourless hilum, revealing that this character is controlled by one gene pair with the black hilum dominant.

Phenotypic correlation coefficients among seed yield and its components were significant in most cases. Plant height, number of branches, pods and seeds/plant were highly correlated with seed yield. Highly significant correlations were found between mean performance of the parents and the mean performance in F_1 and F_2 hybrids for most characters. Also significant positive correlations were found between mean performance of parents and their general combining ability in F_1 and F_2 generations for most characters.

All the genotypes were affected by caging conditions and produced less numbers of branches, pods, seeds and seed yield compared with open field sister plants. The parent T.W. was least affected by caging.

The F_1 plants have intermediate fertility values between their parents. However, the F_2 were higher in autofertility than F_1 hybrids and results indicated the possibility of improvements of autofertility character by crossing between local cultivars and the genotype Triple White.

Key words: ***Faba bean, Diallel, Reciprocal, Heterosis, GCA, SCA, Correlations, Hilum colour, Blotched wings.***

INTRODUCTION

Faba bean, *Vicia faba,* is the most important pulse crops of Egypt. Unfortunately, it suffers from narrow genetic variability (Abdalla 1982). Enriching the useful variability of the crop needs, among other ways, to explore cross breeding methods. Diallel cross technique is employed to provide information concerning nature of gene actions and interactions involved in inheritance of quantitative characters. This will assist the breeders to chose specific breeding procedures.

Therefore, the objectives of these studies were to explore potentiality of different faba bean parents for cross breeding program and to evaluate magnitudes of heterosis and inbreeding depression in hybrids of these used parents.

MATERIALS AND METHODS

Five faba bean genotypes: Giza 3, Giza 40, Giza 429, Giza Blanca and Triple White were used as parents in a diallel mating design including reciprocals in 1994/1995. The F_1 were grown in 1995/1996 to obtain F_2. In 1996/1997 parents (5), F_1's (20), F_2's (20) (including reciprocals) were grown in a Randomized Complete Block design with three replications. The experimental plot consisted of two, one and three ridges for each parent, F_1 and F_2 generation, respectively. Each ridge was 3 m long and 60 cm apart. Seeds were sown at one side of ridges at 20 cm distances. The work was carried out at Sids Agricultural Research Station (ARC).

Data were subjected to regular analysis. If significant genotypic differences were found, sum of squares of genotypes were partitioned to GCA and SCA according to Griffing (1956) Method I, model I.

RESULTS AND DISCUSSION

Mean characteristics of all parents are presented in Table (1). Parents differed significantly in many characteristics. The *major* variety Giza Blanca is characterized by having more branches, fewer numbers of pods and podded nodes per main stem, pods per node and per plant and seeds per plant, but higher seed index, seeds per pod and was late in flowering and maturity.

On the contrary, the *equina* variety Giza 40 had more pods and seeds per plant and flowers and matures earlier. The varieties Giza 3 and Giza 429 possess intermediate characteristics. The introduced genotype Triple White is peculiar in having the least number of branches and the least seed yield and seed index (Table 1).

Table 1. Mean parental characteristics (1996/1997).

Character	Parents					LSD 0.05
	Giza 3	Giza 40	Giza 429	Giza Blanca	Triple White	
Plant height (cm)	139.7	144.0	143.0	135.3	131.3	NS
Branches (No.)	4.3	4.7	4.7	5.7	2.0	1.2
Pod length (cm)	7.5	7.8	7.6	10.9	5.5	0.6
Seeds/ pod (No.)	3.0	2.9	2.9	3.4	2.3	NS
Pods/ main stem (No.)	7.6	8.2	7.2	1.4	13.8	2.8
Podded nodes/main stem (No)	6.7	7.5	6.6	1.4	9.9	1.8
Pods/ node (No.)	1.12	1.07	1.07	1.0	2.02	0.26
Pods/ plant (No.)	38.3	48.2	39.1	14.7	32.8	7.5
Seeds/ plant (No.)	116.0	138.4	111.8	49.8	78.6	10.1
Seed yield/ plant (g)	78.9	84.9	68.7	55.8	35.9	9.5
Seed index (g)	69.0	61.8	62.1	113.1	42.5	7.6
First podded node (No.)	12.1	10.6	11.9	14.6	13.5	2.8
Days to flowering	58.6	52.0	52.9	67.2	55.0	–
Days to maturity	167.0	163.5	165.5	172.5	159.0	–

NS = not significant

Overall performance, heterosis and inbreeding depression:

The mean values of the five parents along with F_1's , F_2's and their reciprocals as well as heterosis and inbreeding depression percentages are presented in Table (2). The overall F_1's were significantly superior over the means of all parental genotypes for all studied characters except number of pods/main stem, number of pods/node and exhibited significant lower podded nodes with early flowering and insignificant early maturity. The F_1 reciprocal exhibited the same trend except number of podded nodes/main stem and position of first podded node which were insignificant with parents but number of days to maturity was significant.

The F_2's had significantly less values than F_1's for all studied characters except number of pods/node which was higher in F_2's. In addition insignificant differences between F_1's and F_2's were found for number of seeds/pod, first podded node, days to flowering and to maturity. The F_2 reciprocals were significantly lower than F_1 reciprocals for 7 characters whereas number of pods/node was higher in F_2 reciprocal than F_1.

Pronounced significant heterosis was found for plant height, number of branches, pod length, number of seeds/pod, number of seeds/plant, seed yield and seed index with a range from 5.9 to 55.0%. Meanwhile, the mean values of F_1, compared to mid parents, were significantly negative and less for number of pods/node, first podded node and days to flowering and recorded highly significant negative heterosis ranging from -16.0 to -5.6%.

Significant inbreeding depression was observed for all characters except first podded node, days to flowering and to maturity but, significant inbreeding gain was observed in F_2 for number of pods/node.

Table 2. Mean characteristics of parents, F_1 and F_2 and their reciprocals as well as heterosis and F_2 deviation percentages.

Character	Parents	F_1	Reciprocal	Heterosis	F_2	Reciprocal	Deviation
Plant height (cm)	138.7 C	153.5 A	157.3 A	12.1**	147.8 B	144.1 B	6.1 **
Branches (No.)	4.3 B	5.2 A	5.1 A	21.0**	4.2 B	4.5 B	16.2 **
Pod length (cm)	7.9 C	8.8 A	9.0 A	12.8**	8.4 B	8.3 B	5.5 **
Seeds/ pod (No.)	2.9 B	3.0 A	3.1 A	5.9**	2.98 A	3.0 A	2.0 *
Pods/ main stem (No.)	7.6 A	8.2 A	6.7 B	-2.6	7.5 A	6.7 B	4.9 *
Podded nodes/main stem (No)	6.4 B	7.5 A	6.3 BC	7.7	6.7 B	6.0 C	8.5 **
Pods/ node (No.)	1.26 A	1.07 C	1.04 D	-16.0**	1.1 B	1.08 BC	-3.1 **
Pods/ plant (No.)	34.6 C	46.6 A	39.6 B	24.5**	33.9 C	34.8 C	20.3 **
Seeds/ plant (No.)	98.9 C	137.8 A	118.7 B	29.7**	99.9 C	91.8 D	25.4 **
Seed yield/ plant (g)	64.8 D	103.9 A	97.2 B	55.0**	71.3 C	73.4 C	28.0 **
Seed index (g)	69.7 D	79.2 B	83.0 A	16.3**	74.3 C	75.3 C	7.8 **
First podded node (No.)	12.5 A	11.6 BC	12.1 AB	-5.6**	11.4 C	12.2 A	5.0
Days to flowering	57.1 A	51.2 D	53.1 BC	-8.7**	51.8 CD	54.0 B	-1.4
Days to maturity	165.5 A	164.8 AB	163.5 B	-0.8	164.6 AB	164.3 AB	-0.2

Means followed by the same letter(s) are not significantly different at 5% level of probability.
*, ** Significant at 5% and 1% level of probability, respectively.

Similar results to the previously presented were reached by Bond (1966), Khalil (1969), Abdalla (1977a,b), El-Hosary (1982, 1984), De Pace and Filippetti (1983), Filippetti *et al* (1985), Filippetti and Ricciardi (1988), Torres *et al* (1993), Abd El-Aziz (1993), El Badawy (1994), Hendawy *et al* (1994), Melchinger *et al* (1994) and Schill *et al* (1995)

Our results also indicated that high heterosis in the F_1 may be followed by considerable reduction in F_2 performance. These results are in agreement with those of Abdalla (1977a) and Bargale and Billore (1990) Habetinek *et al* (1985) reported that F_2 populations surpassed their better parental lines.

Qualitative characters

1- The blotches on flower wings

The T.W. parent possesses blotchless flowers whereas Giza 40 has blotches on flower wings. In the hybrid G. 40 x T.W., the F1 plants possessed dark blotched on flower wings indicating dominance of this character. The F_2 plants segregated into 213 plants with blotched flowers and 85 with blotchless flowers. This segregation fits the ratio of 3:1 (X^2 = 1.99) suggesting monogenic inheritance of this character.

The variety Giza 3 has dark blotches on flower wings whereas the Triple White parent has white wings. The flowers of the F1 hybrid plants G.3 x T.W. has blotched wings. The F_2 plants segregated into 230 possessing blotched wings and 70 plants with blotchless wings of flowers. This segregation fits the ratio of 3:1 (X^2 = 0.44) assuming monogenic inheritance and dominance of blotched wings over blotchless. The hybrid Giza 429 (blotched wings) x Triple White (blotchless) has blotched wings of flowers (dominant). Segregation in F_2 fitted the expected ratio of 3:1 (X^2 = 0.11) where 226 plants have blotched wings against 72 with blotchless suggesting monogenic inheritance.

The variety Giza Blanca possesses blotched wings contrary to Triple White and the hybrid T.W. x G.B. has blotched wings. Segregation in F_2 showed 234 plants having blotched wings against 61 with blotchless wings. This segregation fits the ratio of 3:1 (X^2 = 2.93) indicating dominance of blotched wings and that this character is controlled by one pair of genes.

The inheritance of the blotches on wings agree with the monogenic inheritance of this character in other crosses (Abdalla 1977a and Abdalla and Fischbeck 1983).

2- The hilum colour of seeds

The Giza 40 parent has seeds with black hilum whereas the Triple White parent has colourless hilum of seeds.

The F_1 plants G.40 x T.W. possess seeds with black hilum. The F_2 plants segregated into 235 plants possessing seeds with black hilum against 63 with colourless-hilumed seeds. This segregation fits the ratio of 3:1 (X^2 = 2.37) indicating monogenic inheritance of this character with the dominance of black hilums of seeds over colourless ones.

The seeds of Giza Blanca have colourless hilum, but Giza 40 has black hilums of seeds. Seeds of the F_1 hybrid G.40 x G.B. have black hilums. F_2 plants segregated into 230 plants possessing seeds with black hilums and 69 plants having seeds with colourless hilums. This segregation fits the ratio of 3:1 ($X^2 = 0.59$) of monogenic inheritance indicating black hilum to be dominant over colourless with one gene involved.

The seeds of Giza 3 has black hilums whereas those of the Triple White genotype are colourless. The seeds of F_1 plants (G.3 x T.W.) have black hilums and segregation in F_2 gave 224 plants whose seeds possess black hilums and 76 plants with colourless hilumed seeds. This segregation of monogenic inheritance fits the ratio of 3:1 ($X^2 = 0.01$) indicating dominance of black hilum with one gene involved. The hybrid plants Giza 3 x Giza Blanca possess seeds with black hilum contrary to the colourless hilums of parent G.B. The F_2 plants segregated into 213 whose seeds possess black hilum and 85 plants whose seeds have colourless hilums. This segregation fits the 3:1 ratio ($X^2 = 1.99$) indicating also dominance of black hilum and monogenic inheritance.

The F_1 hybrid plants of Giza 429 (seeds with black hilum) x Triple White (seeds with colourless hilums) possess seeds with black hilums (dominant). The F_2 segregated into 222 plants whose seeds have black hilums and 74 with colourless. This segregation fits the 3:1 ratio ($X^2 = 0.07$) of monogenic inheritance.

The F_1 hybrid plants Giza 429 x Giza Blanca have seeds with black hilum (dominant). The F_2 segregation of 233 plants possessing seeds with black hilums against 65 plants with colourless hilums indicated monogenic inheritance (segregation fits 3:1 ratio, $X^2 = 1.60$).

The simple inheritance of this character agrees with the results on other hybrids (Abdalla 1977a and Abdalla and Fischbeck 1983). Introducing such simple inherited characters into the improved varieties will be useful as differentiating characteristics.

Combining ability

Data given in Table (1) revealed wide differences and variability among tested genotypes for all characters under study. The analysis of variance for combining ability (Table 3) suggested significant mean squares for general combining ability (GCA) among all traits in both F_1 and F_2 generations. On the other hand, the results revealed significant mean squares for specific combining ability (SCA) among all characters except number of pods/main stem and number of podded nodes/main stem. Significance of mean squares due to GCA and SCA revealed that both additive and non-additive effects are important for inheritance of various studied characters. Further more, the ratio of GCA variance to SCA variance indicates that GCA effects appeared to be more important than SCA effects for the inheritance of all characters under study. These finding are in accordance with those obtained by Bond (1966, 1967) who reported that the components of yield were in general nearer to additivity than yield. Mahmoud (1977) and Poulsen (1977) found that the non-additive effect was more important than additive for all characters. Similar results were

Table 3. Significance of mean squares due to genotypes, general combining ability (GCA), specific combining ability (SCA) and reciprocal effects.

Character	Genotype		GCA		SCA		Reciprocal		GCA/SCA	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Plant height (cm)	1.94	0.94	27.9	23.1	63.6**	141.13**	123.2**	132.8**	175.7**	270.7**
Branches (No.)	11.58	4.13	0.09	0.36*	0.19**	0.63**	2.2**	2.6**	1.4**	2.55**
Pod length (cm)	50.00	18.55	0.07	0.05	0.18*	0.55**	9.0**	10.2**	4.8**	5.79**
Seeds/ pod (No.)	9.76	12.69	0.026*	0.018	0.024*	0.026	0.41**	0.33**	0.26**	0.2**
Pods/ main stem (No.)	58.28	55.11	0.93	2.22*	0.87	0.92	50.7**	50.7**	27.5**	29.3**
Podded nodes/mains	51.70	43.11	0.63*	1.28*	0.53	0.74	27.4**	31.9**	15.2**	18.6**
Pods/ node (No.)	3.75	1.87	0.0007	0.001	0.04**	0.053**	0.15**	0.099**	0.12**	0.118**
Pods/ plant (No.)	15.15	7.52	5.5	50.8**	20.8**	59.13**	315.2**	444.4**	190.5**	359.6**
Seeds/ plant (No.)	9.87	4.18	42.0	397.2**	166.7**	654.7**	1645.9**	2736.7**	1097.3**	2682.7**
Seed yield/ plant (g)	2.28	0.43	13.8	142.6*	109.2**	635.9**	248.8**	275.5**	277.9**	1110.7**
Seed index	81.72	27.49	10.7	14.5	17.21**	79.1**	1406.4**	2174.8**	739.3**	1204.5**
First podded node (No.)	5.02	5.3	0.82**	0.52	0.89**	1.01**	4.47**	5.35**	4.4**	4.6**
Days to flowering	12.62	9.25	11.7**	8.01**	11.2**	15.4**	141.3**	142.4**	99.1**	100.7**
Days to maturity	4.84	8.99	4.25	2.59	16.3**	8.12	78.9**	73.0**	43.4**	33.3**

*, ** Significant at 5% and 1% level of probability, respectively.

obtained by Homola (1980) but general combining ability was more important in lines with moderate yield. Suso (1980) pointed out that dominance was not important in pod length and number of seeds/pod. Waley (1982) observed that GCA effects were greater than SCA for all traits except plant height. Similar results were detected by El-Hosary (1984, 1985) except seed yield/plant. Habetinek (1985) reported that number of seeds/plant were determined by additive gene action however non-additive gene action was more important for seed yield. Rabie and Abd El Raheem (1988) showed high ratio of GCA/SCA (ranged from 2.687 to 15.53). The ratios were higher in F_2 than F_1 for most traits in the studies of EL-Badawy (1994).

Mean squares due to reciprocal effects were detected for some characters among F_1 and their reciprocals (number of branches/plant, number of pods/main stem, number of podded nodes/main stem, number of pods and number of seeds/plant, seed yield/plant and days to flowering). Meanwhile four characters (number of seeds/pod, number of podded nodes/main stem, first podded node and days to flowering) recorded significant reciprocal effects among F_2. These results indicated the role of maternal effects in the inheritance of different characters (see Abdalla 1977a). Similar results were reached by Poulsen (1977), Homola (1980), Rabie and Abd El Raheem (1988) and Mohamed (1997) but El-Refaey (1987)reported absence of maternal effects in F_2.

General combining ability effects

Data of GCA effects (gi) associated with each parent are presented in Table (4). The results showed that parents G.40, G.429 and T.W were particularly good combiners for numbers of pods/plant and seeds/plant. In addition parent G.40 was good combiner for seed yield/plant. The parent Giza Blanca had positive significant GCA effects for seed index.

On the other hand, the two parents G.40 and T.W. showed substantial and significant negative GCA effects for days to flowering and maturity indicating that they are good combiners for earliness. Similar results were obtained by Ebmeyer (1988) who reported that most of the variability between hybrids was attributed to GCA. Rabie and Abd EL-Raheem (1988) detected the parent Romi to be the best combiner in all characters. Hendawy *et al* (1994) found that Giza 3 and Giza 402 expressed highly significant positive GCA effect for seed yield .

Specific combining ability effects

The data of SCA effects for different characters in F_1 and F_2 generations are presented in Table (5). Different F_1's and F_2's showed varying SCA effects to different characters. Regarding the most important yield components one finds that number of pods/plant, four F_1 hybrids G.40 x T.W., G.3 x G.429, G.3 x T.W. and T.W. x G.B as well as F_2 crosses, G.3 x T.W. and T.W. x G.B exhibited significant positive SCA effects .The SCA effects were significant in the three F_1 crosses (G.40 x T.W., G.3 x G.429 and T.W. x G.B) and three F_2 (G3 x T.W., G.429 x T.W. and T.W. x G.B) for number of seeds/plant.

Only three F_1 hybrids (G.40 x G.B, G.3 x G.429 and T.W. x G.B) in addition two F_2 (G3 x T.W. and T.W. x G.B) exhibited significant or highly significant SCA effects for seed yield/plant.

Table 4. Estimates of general combining ability effects (g_i) of the parental genotypes in the F_1 and F_2 generations for studied characters

Character		Parental GCA effect					S.E.	
		G. 40	G. 3	G. 429	T.W.	G.B.	g_i	g_i-g_j
Plant height (cm)	F_1	2.248	3.348*	1.648	-5.612**	-1.632	1.35	2.14
	F_2	0.79	4.68**	0.91	-4.86**	-1.52	1.11	1.76
Branches/ plant (No.)	F_1	0.063	-0.015	-0.031	-0.731**	0.712**	0.11	0.17
	F_2	0.052	-0.098	0.112	-0.688**	0.622**	0.08	0.12
Pod length (cm)	F_1	-0.27**	-0.20*	-0.21**	-1.02**	1.7**	0.08	0.12
	F_2	-0.237**	-0.207*	-0.177*	-0.97**	1.59**	0.08	0.12
Seeds/pod (No.)	F_1	-0.036	-0.006	0.024	-0.246**	0.264**	0.04	0.06
	F_2	0.002	0.012	-0.028	-0.278**	0.292**	0.03	0.05
Pods/ main stem (No.)	F_1	0.676*	0.146	0.256	2.556**	-3.634**	0.26	0.40
	F_2	-0.064	0.259	0.276	2.929**	-3.401**	0.21	0.33
Podded nodes/ main stem (No.)	F_1	0.664**	0.214	0.294	1.814**	-2.986**	0.21	0.34
	F_2	0.086	0.316*	0.356*	1.906**	-2.664**	0.16	0.26
Pods/ node (No.)	F_1	-0.033**	-0.016*	-0.031**	0.171**	-0.09**	0.01	0.012
	F_2	-0.046**	-0.027**	-0.03**	0.207**	-0.106**	0.01	0.012
Pods/ plant (No.)	F_1	4.828**	1.438	0.788	4.438**	-11.492**	0.73	1.16
	F_2	3.536**	1.406*	1.969**	3.019**	-9.931**	0.57	0.91
Seeds/ plant (No.)	F_1	14.722**	4.027	4.191	5.574*	-28.52**	2.42	3.83
	F_2	10.92**	4.32**	5.614**	1.21	-22.08**	1.41	2.23
Seed yield/ plant (g)	F_1	4.574*	2.304	-0.856	-8.716**	2.694	2.06	3.25
	F_2	4.028**	4.2485**	0.338	-8.052**	-0.562	0.98	1.54
Seed index (g)	F_1	-5.522**	-0.290	-4.612**	-14.330**	24.754**	0.81	1.26
	F_2	-4.408**	0.572	-4.098**	-11.76**	19.692**	0.66	1.04
First podded node (No.)	F_1	-0.645**	0.060	-0.180	-0.452**	1.218**	0.16	0.25
	F_2	-0.816**	0.164	-0.196	-0.166	1.014**	0.12	0.19
Days to flowering	F_1	-2.428**	0.042	-1.268**	-2.798**	6.452**	0.44	0.73
	F_2	-2.538**	-0.068	-1.798**	-2.108**	6.512**	0.33	0.53
Days to maturity	F_1	-2.18**	0.87	0.37	-2.93**	3.87**	0.74	1.17
	F_2	-1.99**	-0.69	1.51**	-2.89**	4.06**	0.45	0.71

*, ** Significant at 5% and 1% level of probability, respectively.

Estimated SCA effects for seed index revealed that two F_1 hybrids (G.3 x G.B. and G.429 x T.W.) and one F_2 (G.3 x G.B) had significant or highly significant SCA effects.

The results of G CA and SCA effects are in agreement with results obtained by EL-Hosary (1984) and Mohamoud (1997).

Reciprocal effects

Estimated values of reciprocal effects (rij) for the studied characters in F_1 and F_2 generations are presented in Table (6). The results showed that

Table 5. Estimates of specific combining ability effects (s_{ij}) of the parental genotypes in the F_1 and F_2 generations for studied traits.

Hybrids	Plant height (cm)		Branches/plant (No.)		Pod length (cm)		Seeds/pod (No.)		Pods/ main stem (No.)		Podded nodes /main stem (No.)		Pods/node (No.)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
G.40 x G.3	5.00	0.66	-0.126	-0.282	0.16	0.027	0.006	0.098	-0.106	-0.386	-0.194	-0.296	0.03	0.016
G.40 x G.429	0.25	-1.87	-0.195	-0.142	0.12	-0.15	-0.07	-0.16**	1.184*	0.632	1.326*	0.514	0.021	0.034*
G.40 x T.W.	0.96	-4.6	0.17	0.158	0.23	0.14	0.146	0.088	0.134	-0.556	0.106	-0.286	-0.121**	-0.123**
G.40 x G.B.	6.33*	7.91**	0.607**	-0.002	-0.19	-0.02	-0.01	0.068	-0.576	-0.826	-0.594	-0.916**	0.034*	0.035*
G.3 x G.429	10.6**	6.89**	0.378	-0.042	-0.15	0.117	0.046	0.078	0.264	-0.376	-0.074	-0.366	0.045**	0.02
G.3 x T.W	0.21	6.31**	0.583*	0.308	0.16	0.06	-0.08	-0.12	-0.286	0.321	0.656	0.384	-0.162**	-0.107**
G3 x G.B.	3.23	0.32	-0.195	-0.152	0.59**	0.15	0.056	-0.04	0.304	0.551	0.156	0.554	0.033*	0.021
G.429 x T.W	3.06	1.08	0.264	0.248	0.52**	0.28	0.136	0.068	-0.396	0.254	-0.274	0.24	-0.126**	-0.084**
G.429 x G.B.	-1.568	-2.76	-0.179	-0.212	0.35	0.07	0.076	0.048	-0.256	0.034	-0.174	0.064	0.024	0.024
T.W. x G.B.	5.492	0.71	0.521*	0.238	0.41*	0.348*	0.046	0.098	-0.656	-0.769	0.056	-0.086	-0.173**	-0.168**
S.E. (S_{ij})	2.79	2.3	0.22	0.16	0.19	0.16	0.081	0.06	0.53	0.43	0.44	0.32	0.015	0.015
S.E.(S_{ij}-S_{ik})	4.28	3.52	0.34	0.42	0.25	0.25	0.12	0.09	0.81	0.67	0.67	0.49	0.02	0.02

*, ** Significant at5% and 1% level of probability ,respectively

Table 5. Continued.

Hybrids	Pods/plant (No.)		Seeds/plant (No.)		Seed yield/ plant (g)		Seed index (g)		First podded node (No)		Days to flowering		Days to maturity	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
G.40 x G.3	-2.008	-3.728**	-5.944	-9.524**	0.896	-5.08*	1.701	1.27	0.548	0.616*	-2.192*	-1.422*	0.18	0.29
G.40 x G.429	-1.058	-0.628	-5.817	-4.814	-0.39	-1.72	3.208	1.938	0.138	0.026	-0.832	-2.192**	1.68	-0.86
G.40 x T.W.	5.092**	-1.576	21.16**	-2.414	6.916	-2.83	2.024	0.748	-0.6	-0.164	-0.352	-1.082	-2.27	-1.01
G.40 x G.B.	0.822	-0.826	4.35	0.816	10.21*	3.632	-0.98	-0.802	0.04	-0.78**	0.648	1.348	-3.07	-1.46
G.3 x G.429	3.682*	-1.046	16.95**	-0.714	9.676*	1.262	-2.06	1.158	-0.052	0.146	-0.952	-0.412	-0.12	-0.21
G.3 x T.W	6.682**	4.354**	6.83	7.186*	4.336	5.65**	-0.79	3.168	-0.496	-0.78**	-1.672	-2.552**	0.18	-5.66**
G3 x G.B.	-1.388	-0.696	-3.38	-4.024	4.176	-1.39	10.39**	0.318 *	0.035	0.186	-0.672	-0.622	-1.12	1.74
G.429 x T.W	1.832	2.191	9.941	7.346*	6.946	3.812	3.509*	1.838	-0.73*	-0.72**	-1.712	-0.172	-1.82	4.99**
G.429 x G.B.	-0.588	-1.309	-2.107	-2.314	6.736	-0.63	2.907	-1.462	0.34	0.196	1.688	0.608	0.38	-1.46
T.W. x G.B.	4.862**	2.641*	16.97**	11.586**	21.86**	12.21**	2.938	1.998	-0.623	-0.234	-2.832**	-1.682*	3.43*	1.44
S.E. (S_{ij})	1.5	1.18	5	2.9	4.24	2.01	1.68	1.35	0.33	0.25	0.92	0.69	1.53	0.92
S.E.(S_{ij}-S_{ik})	2.3	1.81	7.66	4.46	6.5	3.09	2.57	2.08	0.51	0.38	1.4	1.1	2.34	1.41

*, ** Significant at5% and 1% level of probability ,respectively

Table 6. Estimates of reciprocal effects (rij) of the parental genotypes in the F_1 and F_2 generations for studied traits.

Hybrids	Plant height (cm)		Branches/plant (No.)		Pod length (cm)		Seeds/pod (No.)		Pods/ main stem (No.)		Podded nodes /main stem (No.)		Pods/node (No.)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
G.40 x G.3	1.35	5.35	0.25	00	-0.05	0.05	-0.1	-0.1	1.1	0.3	0.8	0.25	0.02	0.01
G.40 x G.429	0.5	-0.35	0.16	-0.35	00	00	-0.05	00	00	0.07	0.2	0.1	-0.03	-0.01
G.40 x T.W.	0.65	5.85*	0.17	-0.15	00	0.2	0.1	0.1	2.65**	0.1	1.8**	0.25	0.06**	-0.01
G.40 x G.B.	-2.7	4.00	-0.05	00	0.1	00	0.15	0.05	0.55	0.6	0.5	0.65	0.01	-0.01
G.3 x G.429	-6.65	3.00	00	00	-0.3	-0.3	00	0.05	1.05	0.35	1.05	0.15	0.03	0.01
G.3 x T.W	-1.7	-3.65	0.84**	-0.15	-0.1	0.25	-0.1	0.1	00	1.4*	00	0.85*	-0.01	0.03
G3 x G.B.	0.3	2.00	-0.5	00	-0.15	0.3	-0.15	-0.25**	0.9	1.2*	0.8	1.15**	0.01	0.01
G.429 x T.W	0.15	5.35	0.5	00	0.05	0.1	-0.05	-0.15*	0.8	-0.55	0.65	-0.55	0.01	0.05*
G.429 x G.B.	-5.8	-2.15	-0.5	-0.15	-0.1	0.05	00	00	0.05	0.5	0.25	0.40	00	0.01
T.W. x G.B.	-5.00	-0.85	-0.5	-0.5*	-0.35	-0.27	-0.1	-0.1	0.15	0.35	0.1	0.20	0.01	0.02
S.E. (S_{ij})	3.38	2.8	0.27	0.19	0.19	0.19	0.098	0.07	0.64	0.53	0.53	0.39	0.018	0.019
S.E.(S_{ij}-S_{ik})	4.78	3.39	0.38	0.27	0.27	0.28	0.14	0.1	0.9	0.74	0.75	0.55	0.03	0.03

*, ** Significant at5% and 1% level of probability ,respectively

Table 6. Continued.

Hybrids	Pods/plant (No.)		Seeds/plant (No.)		Seed yield/ plant (g)		Seed index (g)		First podded node (No)		Days to flowering		Days to maturity	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
G.40 x G.3	5.55**	0.615	14.1*	2.0	10.45*	-1.65	-0.35	-2.3	-0.12	-0.1	0.45	-0.6	0.75	-0.25
G.40 x G.429	4.75**	-1.95	13.0*	-5.0	8.00	-3.2	-0.17	0.3	-0.03	-0.45	-0.6	-0.6	0.25	1.5
G.40 x T.W.	7.85**	-2.25	30.25**	-4.0	13.45*	-1.8	-2.35	1.25	0.28	0.3	-1.05	1.4	-0.5	0.75
G.40 x G.B.	-0.45	2.35	0.25	7.0	1.15	5.35*	0.215	-0.85	-1.03*	-1.55**	-4.7**	-3.25**	2.0	-2.75*
G.3 x G.429	5.9**	-0.4	18.25**	-0.5	4.90	-1.4	-6.04**	0.5	-0.315	-0.85**	0.25	-2.45**	-0.5	0.75
G.3 x T.W	8.55**	-1.75	12.6*	1.0	7.60	0.5	-3.53	0.45	0.27	-0.25	1.2	-0.8	1.5	2.00
G3 x G.B.	3.65	1.65	5.7	-0.5	3.85	-2.05	-3.22	-3.15	-1.00*	-0.2	-0.65	-0.25	-0.5	0.25
G.429 x T.W	3.05	-2.45	10.89	-10.6**	5.55	-2.85	-0.55	3.05	0.205	0.05	0.25	1.25	0.00	0.75
G.429 x G.B.	-1.4	-0.8	-2.45	-1.5	-9.65	-0.7	-1.39	1.1	-0.365	-0.75*	-1.00	0.45	1.5	0.75
T.W. x G.B.	-2.5	0.5	-7.3	1.0	-11.7*	-3.05	-2.34	-5.0*	-0.3	-0.15	-3.65**	-6.05**	1.75	-2.25
S.E. (S_{ij})	1.82	1.43	6.06	3.52	5.14	2.44	2.03	1.64	0.4	0.3	1.11	1.83	1.85	1.12
S.E.(S_{ij}-S_{ik})	2.57	2.03	8.57	4.98	7.27	3.45	2.87	2.32	0.57	0.43	1.57	1.2	2.62	1.58

*, ** Significant at5% and 1% level of probability ,respectively

the (rij) effects were significant for all characters whether in some F_1 or F_2 or in both generations. These results are in agreement with those obtained by Abdalla (1977a) and Abdalla and Fischbeck (1983) who found significant reciprocal cross differences among hybrids and von Kittlitz (1986) who reported that reciprocal effects were significant for number of seeds/plant and pods/plant.

Phenotypic correlation coefficients

Phenotypic correlation coefficients among the studied characters for parents, F_1 and F_2 generations are given in Table (7). The results revealed significant positive relationship between plant height and each of number of branches, pods/plant and seed yield/plant. Positive associations were detected between number of branches and pod length, number of seeds/pod, seed yield and seed index. The number of pods/plant was positively correlated with plant height, number of podded nodes/main stem, pods/main stem, seeds/plant and seed yield. In the same time, the number of seeds/plant was correlated with number of podded nodes/main stem, pods/main stem, pods/plant and seed yield.

The correlations between seed yield/plant and each of plant height, branches, pod length, number of seeds/pod, pods/plant and seed index were significantly positive. However, highly significant negative correlation was found between seed yield and number of pods/node. Weight of 100-seed was positively and significantly correlated with branches, pod length, number of seeds/pod and seed yield. The earliness characters: first podded node, days to flowering and days to maturity were significantly correlated, and were in good relationship with branches, pod length, number of seeds/pod and seed index. On the other hand, significant negative correlation was found between the earliness characters and number of podded nodes/main stem, pods/main stem, pods/plant and seeds/plant.

These results provide a good indication that the most important components for high seed yield production in faba bean are the number of branches, plant height, number of pods/plant and seeds/plant, followed by, number of seeds/pod and seed index. These results agreed with those of Bond (1966) and Abdalla (1979) who reported that yield was closely correlated with number of pods, seeds/plant and seed weight and Mahmoud *et al* (1978), Gad EL-Karim (1987), El-Refaey (1987), El-Keredy *et al* (1988a,b), Abdel Hafez *et al* (1988), El-Gamal *et al* (1990) and Omar *et al* (1992).

Data presented in Table (8) show the correlation coefficient between mean performance of the parents their F_1 and F_2 hybrids and their general

Table 7. Correlation coefficients among fourteen characters estimated for parents, F_1 and F_2.

Character	Branches/plant (No.)	Pod length (cm)	Seeds/pod (No.)	Pods/main stem (No.)	Podded nodes /main stem (No.)	Pods/node (No.)	Pods/plant (No.)	Seeds/plant (No.)	Seed yield/plant (g)	Seed index (g)	First podded node (No)	Days to flowering	Days to maturity
Plant height	0.478**	0.212	0.206	-0.031	-0.099	-0.336*	0.392**	0.277	0.699**	0.226	-0.034	-0.117	-0.071
Branches		0.741**	0.634**	-0.546**	-0.620**	-0.686**	0.074	-0.071	0.743**	0.700**	0.344*	0.448**	0.437**
Pod length			0.846**	-0.836**	-0.871**	-0.638**	-0.468**	-0.614**	0.388**	0.971**	0.604**	0.741**	0.670**
Seeds/pod				-0.793**	-0.818**	-0.645**	-0.346*	-0.562**	0.347*	0.824**	0.469**	0.618**	0.633**
Pods/ main stem					0.983**	0.505**	0.711**	0.821**	-0.032	-0.855**	-0.657**	-0.817**	-0.548**
Podded nodes/ main stem						0.631**	0.637**	0.756**	-0.131	-0.875**	-0.609**	-0.774**	-0.563**
Pods/ node							0.003	0.149	-0.474**	-0.579**	-0.044	-0.211	-0.377**
Pods/ plant								0.960**	0.569**	-0.528**	-0.620**	-0.680**	-0.374**
Seeds/ plant									0.423**	-0.659**	-0.660**	-0.740**	-0.487**
Seed yield/ plant										0.351*	-0.038	-0.029	0.114
Seed index											0.657**	0.758**	0.621**
First podded node												0.798**	0.520**
Days to flowering													0.598**

Table 8. Correlation coefficients among parents and their F_1 and F_2 hybrids and general combining ability in F_1 and F_2 generations.

Character		X-F_1	X-F_2	GCA F_1	GCA F_2
Plant height	Parents	0.822	0.543	0.905*	0.740
	X-F_1		0.919*	0.986**	0.986**
	X-F_2			0.844	0.967**
	GCA F_1				0.952*
Branches/ plant	Parents	0.822	0.861	0.956*	0.973**
	X-F_1		0.939*	0.953*	0.904*
	X-F_2			0.941*	0.955*
	GCA F_1				0.984**
Pod length	Parents	0.963**	0.964**	0.985**	0.987**
	X-F_1		1.00**	0.995**	0.993**
	X-F_2			0.995**	0.994**
	GCA F_1				1.00**
Seeds/pod	Parents	0.916*	0.973**	0.975**	0.986**
	X-F_1		0.952*	0.982**	0.947**
	X-F_2			0.980**	0.998**
	GCA F_1				0.984**
Pods/ main stem	Parents	0.938*	0.964**	0.978**	0.987**
	X-F_1		0.952*	0.990**	0.955**
	X-F_2			0.971**	0.995**
	GCA F_1				0.982**
Podded nodes/ main stem	Parents	0.992**	0.961**	0.997**	0.985**
	X-F_1		0.959**	0.999**	0.980**
	X-F_2			0.961**	0.995**
	GCA F_1				0.983**
Pods/ node	Parents	0.531	0.833	0.981**	0.984**
	X-F_1		0.895*	0.684	0.669
	X-F_2			0.920*	0.919**
	GCA F_1				0.999**

Character		X-F_1	X-F_2	GCA F_1	GCA F_2
Pods/ plant	Parents	0.751	0.750	0.891*	0.991**
	X-F_1		0.978**	0.969**	0.943*
	X-F_2			0.954*	0.956*
	GCA F_1				0.990**
Seeds/ plant	Parents	0.667	0.694	0.867	0.919*
	X-F_1		0.983**	0.950*	0.898*
	X-F_2			0.949*	0.922*
	GCA F_1				0.987**
Seed yield/ plant	Parents	0.197	0.626	0.848	0.972**
	X-F_1		0.734	0.686	0.369
	X-F_2			0.865	0.791
	GCA F_1				0.922*
Seed index	Parents	0.997**	0.994**	0.999**	0.998**
	X-F_1		0.997**	1.00**	0.999**
	X-F_2			0.997**	0.999**
	GCA F_1				0.999**
First podded node	Parents	0.886*	0.938*	0.947*	0.972**
	X-F_1		0.986**	0.988**	0.966**
	X-F_2			0.996**	0.993**
	GCA F_1				0.993**
Days to flowering	Parents	0.886*	0.938*	0.947*	0.972**
	X-F_1		0.986**	0.988**	0.966**
	X-F_2			0.996**	0.993**
	GCA F_1				0.993**
Days to maturity	Parents	0.921*	-0.017	0.964**	0.912*
	X-F_1		-0.185	0.991**	0.937*
	X-F_2			-0.125	–0.178
	GCA F_1				0.938*

combining ability in F_1 and F_2 .Results revealed significant positive correlations between mean performance of the parents and their mean performance in F_1 and F_2 hybrids for all characters under study except plant height, number of branches, pods/node, pods, seeds and seed yield/plant in F_1 and F_2 and maturity in F_2. Results also showed that highly significant positive correlations existed between mean performance of parents and their general combining ability in both generations except plant height in F_1 and number of seeds and seed yield/plant in F_2 .On the other hand, general combining ability in F_1 and F_2 were high positively correlated for all studied characters. Similar results were obtained by (Ebmeyer 1988) who found a strong relationship for all characters between the *per se* performance and the general combining ability

Caged-grown versus field-grown plants

In the same season 1996/1997, the same sets of parents, F_1's and F_2's were sown under insect free cage (Abdalla *et al* 1999). It was a chance to evaluate caged materials relative to their sisters grown in the open field.

Table (9) presents data of performance of caged-grown plants relative to field grown ones assuming the latter to be 100.In general caged grown plants were taller and produced less number of branches (about 50% in the *major* variety G.B.). Also they flowered and matured earlier. This general behavior was observed in parents, F_1 and F_2 generations. The *major* variety (G.B.) was more sensitive to caging than *equina* varieties. Similar results were found by Abdalla and Fishbeck (1983) who reported the results of crossing *paucijuga*, *minor*, *equina* and *major* types of faba bean and performance of F_1 and F_2 hybrids among different combinations.

Concerning pods and seeds characteristics one observes that these characters were badly affected by caging. They were more depressed by caging than the vegetative, flowering and ripening characteristics. The same holds true also for F_1 and F_2 generations. Average relative performance of F_1 and F_2 were respectively (40.0, 43.1%) for pods/plant, (87.8, 89.7%) for seeds/pod, (33.3, 37.3%) for seeds/plant, (32.5, 38.8%) for seed yield. Seed index of different generations was not affected and sometimes was slightly improved under cage.. Significant reciprocal differences occurred in all characters.

Parental genotypes and hybrids differed in tolerating caging effects. Parent T.W. was least affected by caging. It is obvious from Table (9) that T.W. has transmitted its caging tolerance to its hybrids with other parents.

Table 9. Relative performance of caged materials relative to sister stocks grown in the open field.

Genotypes	Plant height (cm)		Branches (No)		Pod length (cm)		Seeds/pod (No.)		Pods/main stem (No.)		Podded nodes/main stem (No.)	
G.40 (P_1)	107.6		74.1		78.7		88.1		59.2		53.3	
G.3 (P_2)	118.0		68.4		90.9		84.0		41.3		44.4	
G.429 (P_3)	103.4		54.4		80.5		94.6		69.2		62.5	
T.W. (P_4)	111.7		125.0		71.5		103.8		76.1		74.6	
G.B. (P_5)	114.3		50.7		78.7		83.3		71.4		71.4	
Mean	111.0		74.5		80.1		90.8		63.4		61.2	
Generation	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
1 x 2	104.2	102.2	88.1	78.1	71.3	84.7	107.1	75.7	39.0	56.4	42.2	60.2
2 x 1	102.9	108.1	60.8	63.0	76.5	89.9	79.1	80.5	59.9	66.5	63.5	47.1
1 x 3	118.3	116.6	60.0	82.7	87.4	81.6	85.2	97.2	37.8	57.6	39.0	50.3
3 x 1	118.1	112.5	66.3	75.0	83.4	80.7	83.1	88.6	39.1	52.5	42.2	53.0
1 x 4	117.5	117.7	89.1	99.4	85.9	85.9	66.2	84.3	49.4	67.5	56.1	68.7
4 x 1	116.0	118.0	91.4	92.8	89.3	90.4	87.1	89.6	84.1	63.9	86.7	72.1
1 x 5	107.7	107.5	68.0	58.7	90.7	80.7	93.3	76.6	55.6	78.2	56.8	74.2
5 x 1	112.0	114.8	62.2	75.9	78.3	84.2	86.1	70.0	73.5	90.1	73.5	94.2
2 x 3	112.7	106.1	75.1	53.0	83.1	73.0	92.7	96.9	62.1	36.8	64.7	31.4
3 x 2	109.6	115.9	55.3	66.2	91.0	86.6	101.0	92.0	59.4	77.1	68.0	78.6
2 x 4	110.4	114.5	78.1	82.8	67.8	82.0	67.3	99.2	37.0	51.5	35.1	61.8
4 x 2	113.1	110.9	88.0	84.4	77.7	75.8	80.5	88.3	69.0	50.8	72.1	56.0
2 x 5	106.4	106.1	80.0	61.0	89.0	76.7	89.0	91.0	48.1	37.7	50.0	73.3
5 x 2	105.8	110.6	66.3	70.1	91.1	97.4	88.8	82.4	58.8	76.0	58.8	76.0
3 x 4	114.7	107.9	77.3	108.8	90.8	87.6	98.9	108.3	50.4	68.9	57.2	76.5
4 x 3	108.2	112.5	103.2	74.2	82.3	95.0	87.9	101.8	58.4	64.1	64.9	73.2
3 x 5	115.2	108.0	77.2	69.8	89.4	96.9	106.0	101.4	62.8	75.6	58.3	77.4
5 x 3	98.7	110.4	63.3	63.3	91.4	85.9	103.2	95.1	52.6	53.2	45.1	51.8
4 x 5	107.0	109.8	76.1	79.0	93.2	98.7	86.2	88.8	48.7	62.4	49.6	68.7
5 x 4	98.6	100.5	72.1	73.8	85.3	88.7	67.7	75.7	47.7	80.4	47.7	78.1
Mean	109.9	110.5	74.9	74.7	84.8	86.1	87.8	89.2	54.7	63.4	56.6	66.1
L.S.D. $_{0.05}$	9.1		18.1		NS		18.2		NS		NS	

Table 9. Cont.

Genotype	Pods/node (No)		Pods/plant (No)		Seeds/plant (No)		Seed yield/plant (g)		Seed Index (g)		First podded node (No)	
G.40 (P_1)	113.8		36.1		31.3		31.7		102.7		118.7	
G.3 (P_2)	94.7		33.1		26.4		29.0		112.6		105.4	
G.429 (P_3)	105.3		50.5		31.9		29.6		100.1		127.3	
T.W. (P_4)	72.8		55.9		57.9		58.6		114.1		95.6	
G.B. (P_5)	100.0		34.6		29.2		27.9		103.3		95.9	
Mean	97.3		42.0		35.3		35.4		106.6		108.6	
Generation	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
1 x 2	92.2	95.2	36.0	44.2	31.2	30.5	29.5	34.1	99.2	107.2	113.4	113.1
2 x 1	94.3	103.6	35.3	31.1	27.6	26.4	28.0	29.8	103.9	113.3	119.8	108.0
1 x 3	97.1	98.2	35.1	39.3	27.7	36.6	25.8	36.5	93.8	96.4	99.6	125.2
3 x 1	92.6	95.6	48.7	42.2	39.7	36.0	36.0	36.7	91.1	100.6	112.0	112.7
1 x4	89.7	96.1	46.4	64.1	29.8	53.5	32.4	45.1	106.5	103.0	104.6	107.3
4 x 1	99.0	90.4	51.3	57.8	42.8	45.3	44.3	49.8	102.3	128.8	100.7	99.0
1 x 5	98.0	102.4	44.5	37.7	38.2	30.8	35.6	29.4	89.2	97.8	94.8	127.8
5 x 1	100.0	99.0	26.1	44.2	22.1	30.9	20.1	33.0	91.9	106.3	117.7	128.2
2 x 3	95.3	97.3	39.1	30.7	35.8	30.4	38.6	34.8	110.3	117.5	102.9	126.8
3 x 2	93.5	100.2	35.0	39.2	34.7	35.3	36.4	35.3	105.8	101.6	91.7	111.8
2 x 4	102.0	84.7	28.7	44.0	217	42.6	21.8	42.6	110.6	99.2	127.2	110.1
4 x 2	90.9	92.0	47.9	46.4	34.3	40.5	34.3	42.2	94.5	103.0	111.9	118.4
2 x 5	97.1	99.6	29.4	30.0	28.3	26.6	27.9	29.4	97.5	117.4	94.9	102.1
5 x 2	98.0	100.0	42.0	34.1	35.9	30.1	31.1	33.1	86.9	107.5	89.8	126.6
3 x 4	90.1	85.6	44.2	58.8	41.9	56.1	43.6	54.4	103.2	97.0	113.8	104.6
4 x 3	903	90.2	49.1	43.0	44.4	44.1	41.8	47.8	101.1	108.9	121.4	104.3
3 x 5	100.0	98.0	32.3	47.1	35.3	44.5	32.3	45.3	91.1	103.0	110.6	116.4
5 x 3	133.4	100.0	29.1	34.1	32.9	33.5	27.9	33.1	96.0	101.5	96.1	109.5
4 x 5	99.0	93.5	39.1	46.5	32.8	37.0	33.1	39.7	101.4	110.8	94.3	98.7
5 x 4	100.0	102.4	40.4	47.0	29.4	35.1	28.7	35.3	99.1	99.6	106.1	102.0
Mean	97.6	96.2	40.0	43.1	33.3	37.3	32.5	38.8	98.8	106.0	106.2	112.6
$L.S.D_{0.05}$	16.1		18.46		15.97		9.92		16.0		19.5	

For number of seeds/pod only one parent T.W. had high number of seeds/pod under cage compared with field conditions and recorded relative percentage of 103.8 followed by Giza 429 (94.6%).

Regarding number of pods/plant, the parental genotypes T. W. and Giza 429 had relative percentages 55.9 and 50.5%, respectively. In general the F_1 means had intermediate values between their parents and nearby to better parent in most cases. However, the F_2 exceeded F_1 and parents.

Concerning number of seeds/plant and seed yield the local cultivars expressed lower relative percentages compared with the parental genotype T.W. The hybrids including T.W. as parent had high relative percentage in F_1. Meanwhile the F_2 expressed higher relative percentage than F_1.

It is known that insect pollination in faba bean results in increasing seed yield. (El-Sherbeeny 1970). This increase is due to role of insects in affecting fertilization either through tripping and/or through transfer of pollen. The ability of a plant to set seed in the absence of pollinating insects (Drayner 1959), is known as autofertility. Autofertility may be measured in a number of ways. Hayes and Hanna (1968) tripped all the flowers on alternate nodes up the stem, and the ratio of seed set after tripping to seed set in the absence of tripping provided measure of autofertility. The ratio of seeds to flowers also provides another measure and seed set in the absence of insect pollinators (plants grown in insect free cages) compared to seed set in their presence (plants grown in open fields) can also be used as measure (Abdalla 2000).

Performance of parents grown under insect free cages compared to plants grown in open field stems from two groups of factors (see Abdalla and Fischbeck 1983) The pollination and fertilization group and the climatic group (temperature, humidity, light, wind, ..etc). Therefore comparison between pod and seed set under cage and in open field can not be merely considered a measure of autofertility because of the two groups of factors involved. Autofertility provides yield stability in absence of the fluctuating pollinating agents. Consequently some breeders may be interested to include this characteristic in the developed stocks. But most breeders prefer to breed for heterozygosity-heterogeneity that will result in stability and high yield. It worth mention that, the parent T.W. is highly autofertile. Similar results were found by Kambal (1969) who reported that the local Sudanese line T.W. to be highly autofertile.

The present results indicate that the autofertility characteristic may be transferred from T.W., to F_1 and F_2 by crossing. And the most of the best combinations as judged from autofertility involved high x high autofertility parents. Abdalla and Fischbeck (1983) (see also Abdalla and Fischbeck,

1981) reported that hybridization between different fertility groups improved fertility of low fertility sorts. It is interested to point out that some genotypes expressed high degree of autofertility without good yielding capacity under different conditions. On the other hand some genotypes had relatively low autofertility when merely comparing seed yield under field with seed yield under cage. The values of such materials could be increased by its use in production of synthetics, based on high yield, autofertile hybrids with high general combining ability.

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دراسات على الفول البلدى

١٦- الهجن التبادلية في الجيل الأول والثاني والهجن العكسية بين خمسة آباء

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تم التهجين بين الآباء جيزة ٣، جيزة ٤٠، جيزة ٤٢٩، وجيزة بلانكا والمستورد تريل هوايت فى جميع الاتجاهات وتم الحصول على الجيلين الأول والثانى والهجن العكسية منهما ودراسة سلوكهما مع الآباء.

واظهرت النتائج التباعد الوراثى للآباء وتفوق متوسط الجيل الأول على متوسط الآباء فى معظم الصفات واظهر التفوق الهجينى تباينا بين ٥٥ % لمحصول بذور النبات الى ٥,٩ % لعدد البذور للقرن. كما ظهر أيضا تفوق هجينى سالب تراوح بين -٥,٦ % لموقع أول عقدة ثمرية على الساق الى -٨,٧ % لعدد الأيام حتى التزهير.

وظهرت فروق معنوية بين صفات الجيل الأول والهجن العكسية منها وكذلك بين صفات بعض الهجن العكسية فى الجيل الثانى. كما اظهر الجيل الثانى تدهورا فى صفاته مقارنة بالجيل الأول وصل الى ٢٨ % بالنسبة لمحصول بذور النبات.

وبالمقارنة بالأب الأحسن (الأعلى قيمة) فان العديد من الهجن اظهر قوة هجين موجبة ومعنوية لصفات مختلفة. وظهر تدهور ظاهر فى صفات الجيل الثانى نتيجة التربية الذاتية فى معظم الصفات.

واظهرت نتائج القدرة العامة والقدرة الخاصة على الائتلاف ان الجزء الأكبر من التباينات الوراثية يعزى الى تأثير الجينات المضيفة لكل الصفات عدا صفتى طول النبات ومحصول البذور فى الجيل الأول والذى اظهر ان التباين الأكبر لتوارثها كان راجعا الى تأثير الجينات غير المضيفة.

واظهرت الهجن وجود الاختلافات بين تأثيرات القدرة العامة والخاصة على الائتلاف حسب الصفات المختلفة كما وضح من النتائج ان الآباء تتباين فى صفاتها مما يتيح الانتخاب فى الأجيال الانعزالية لتحسين هذا المحصول.

وبالنسبة للصفات الوصفية حيث أظهرت صفة وجود بقعة على جناحى الزهرة (فى الآباء جيزة ٣، جيزة ٤٠، جيزة ٤٢٩ وجيزة بلانكا) عند التهجين مع الأب تريل هوايت (الخالى من هذه البقعة) ان الجيل الأول ظهر فيه البقع على الأجنحة بينما اظهر الانعزال فى الجيل الثانى لعدد نباتات نسبة ثلاثة على أزهارها بقع الى واحد أزهاره خالية من البقع مما يدل على سيادة صفة وجود البقع وتوراثها كصفة بسيطة يتحكم فيها زوج واحد من العوامل الوراثية.

اما بالنسبة لصفة البذور ذات السرة عديمة اللون (فى الآباء تريل هوايت وجيزة بلانكا) فانه بالتهجين مع الآباء ذات سرة البذور السوداء (جيزة ٣، جيزة ٤٠، جيزة ٤٢٩) فان النباتات الهجينة كانت بذورها ذات سرة سوداء مما يدل على سيادة صفة السرة السوداء واظهر الانعزال فى نباتات الجيل الثانى نسبة ثلاثة ذات سرة سوداء الى واحد ذو سرة عديمة اللون مما يدل على ان هذه الصفة يتحكم فيها زوج واحد من العوامل الوراثية.

واظهر حساب معامل الارتباط المظهرى بين صفة محصول البذور ومكوناته أنها معنويـــة فـــى معظـــم الحالات. وظهر ارتباط عالى لصفات طول النبات، عدد الفروع، عدد القرون والبذور للنبات مع محصول البـــذور. كذلك كان الارتباط معنويا بين أداء الآباء ومتوسط أداء هجن الجيل الأول وكذلك الثانى فى معظم الصفـــات كذلـــك وضح الارتباط الموجب المعنوى أيضا بين متوسط أداء الآباء والقدرة العامة للائتلاف فى الجيـــل الـــهجينى الأول والجيل الثانى فى معظم الصفات.

وبمقارنة الآباء والهجن المنزرعة فى الحقل العادى بنفس مثيلاتها المنعزلة تحـــت الشـــباك المانعـــة للحشرات (بحث آخر منشور عام ١٩٩٩) ظهر أن جميع التراكيب الوراثية قد تأثرت بالنمو تحت الشباك واعطـــت أعدادا اقل من الفروع والقرون والبذور والمحصول بالمقارنة بالنباتات الاخوة النامية فى الحقل. وكان الأب تريـــل هوايت اقل تأثرا بالزراعة تحت الشباك وأظهرت نباتات الجيل الهجينى الأول خصوبة متوسطة بين الآبـــاء الا ان نباتات الجيل الثانى كانت اكثر خصوبة من نباتات الجيل الأول و أوضحت النتائج انه يمكـــن تحســـين الخصوبـــة الذاتية بتهجين التراكيب المحلية مع الأب تريل هوايت.

المجلة المصرية لتربية النبات ٥: ١٥٥-١٧٩(٢٠٠١)