HETEROTIC PERFORMANCE AND COMBINING ABILITY OF DIALLEL CROSSES OF FABA BEAN

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قوة الهجين والقدرة على التآلف فى الفول البلدى

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ملخص البحث

أجرى هذا البحث بهدف دراسة قوة الهجين والقدرة على التآلف لصفات محصول النبات الفردى وبعض مكوناته وأيضا عدد الأفرع بالنبات وارتفاع أول قرن وطول النبات . وقد أستخدم لهذا الغرض خمس سلالات من الفول البلدى ذات أصول وراثية متباعدة وأجريت جميع الهجن التبادلية بين الآباء . ودونت النتائج على النباتات الفردية المحاطه .

وقد حللت النتائج وراثيا بتطبيق مااقترحه جرفنج ١٩٥٦ الطريقة الثانية الموديل الأول ـ هذا ويمكن تلخيص النتائج المتحصل عليها كالآتى :ـ

١ ـ كانت الاختلافات بين التراكيب الوراثية المستخدمة والآباء والهجن معنوية لجميع الصفات تحت الدراسة فيما عدا صفة عدد الأفرع بالنبات .

٢ ـ كانت تأثيرات القدرة الخاصة على التآلف أكبر من تأثيرات القدرة العامة على التآلف لمعظم الصفات المدروسة مما يشير الى أهمية الجزء الغير مضيف فى وراثة هذه الصفات .

٣ ـ أعطت السلالة الأبوية جيزة ٢ أعلى القيم الموجبة والسالبة لتأثيرات القدرة العامة على التآلف لكل من صفتى محصول البذور للنبات وطول النبات على الترتيب كما أعطت السلالة NEB-8 أعلى القيم الموجبة لتأثيرات القدرة العامة على التآلف لمحصول البذور للنبات .

٤ ـ كانت قوة الهجين مقدرة على أساس متوسط الأب الأعلى ٨٥,٢٪ للهجين (NEB-8 x Equadols) ٧١,٧٦٪ للهجن (1.131 x NEB-319).
كما أعطى هذين الهجينين أعلى القيم الموجبة للقدرة الخاصة على التآلف لصفة محصول البذور للنبات وهذه يمكن الاستفادة منها فى برامج التربية لتحسين محصول الفول البلدى .

ABSTRACT

Five parental lines of field beans (Vicia faba, L.) were combined in a diallel cross to obtain information on the magnitude of genetic variation and heterosis expressed in the F_1's using the procedure of Griffing (1956). The studied characters were; number of branches per plant, plant height, pod height, number of pods per plant, number of seeds per pod, 100 seed weight and seed yield per plant.

Differences among genotypes, parents and crosses were found to be significant for all traits studied.

Both general and specific combining ability mean squares were significant for all traits studied except for number of seeds per pod where general combining ability did not reach the significant level. The magnitude of the ratios of GCA/SCA which exceeded the unity, revealed that non-additive type of gene action were the most important expression for all traits except plant height and 100-seed weight.

The parental lines Giza-2 and NEB-319 were the best combiners for stem shortness and low pod possition. Giza-2 and NEB-8 expressed highly significant positive GCA effect for seed yield per plant.

Heterotic effects relative to better parent being of 85.25% and 71.76% for seed yield per plant in the two crosses i.e., (NEB-8 x Equadoles) and (I-131 x NEB-319), respectively.

These two crosses also expressed the highest positive SCA values for seed yield/plant, indicating that the two crosses may be of specific interest in hybrid faba bean breeding programme.

INTRODUCTION

The faba bean, Vicia faba L. is the most important species among vetches. Several varieties are cultivated throughout the near East and the Nile Valley, in Northern Africa, Turkey, in parts of India and Burma and in many parts of Western Asia. It considered as a popular diet in most of Arab countries. As the world population increases, there would be an increasing need for more plant protein, especially in the developing countries.

Faba bean crop has attracted the attention of geneticists and plant breeders to improve the yield, because of its importance for both human and animals nutrition. Their aim was confined in a selection and using different methods of evaluation such as determination of combining ability. Both general and specific combining ability had been shown by many investigators e.g., Bond (1966) who found that most of the variability between crosses was attributed to general combining ability (GCA). Poulsen (1977) and El-Hosary (1981) obtained highly significant general and specific combining ability variances for most of the characters studied.

The aims of this study are to establish (i) the magnitude of heterosis for yield and some of its components in a five-parental diallel crosses among adapted and exotic parental strains, (ii) the effectivness of both general (GCA) and specific combining (SCA) ability to choose the most efficient breeding procedure, and (iii) the importance which should be accorded to the parental lines in a breeding programe depending upon their general and specific combining ability effects.

MATERIALS AND METHODS

This investigation was carried out at Shebin El-Kom Experimental Station during the two successive seasons 1985/86 and 1986/87. Five faba bean varieties (Vicia faba, L.) of wide divergent origins were used as parental lines in the present investigation, i.e., Giza-2 (Egypt), NEB-319 and NEB-8 (Syria, ICARDA), Romi Equadols (France) and I-131 (Libia).

A diallel cross set involving the five parents was made in the winter of 1985/86 in a wire cage green house under normal condition. The ten possible F_1 hybrids with their respective parents were sown in the field in 1986/87, using a randomized complete block design with three replications. Each plot consisted of one ridge of four m. length and 60 cm. width. Hills were spaced by 20 cm. with one seed per hill in one side of the ridge. Dry method of planting was used and the rest of cultural practices were followed as usual for the ordinary faba bean fields in the area.

The traits studied were; number of branches per plant, plant height (cm), pod height (cm), number of pods per plant, number of seeds per pod, 100-seed weight and seed yield per plant (gm). The data were recorded on ten individual plants per plot, randomly sampled from the guarded plants.

General and specific combining ability estimates were obtained by imploying Griffing's (1956) diallel cross analysis designated as method 2 model 1. Heterosis expressed as the percentage of F_1 mean performance from better parent.

RESULTS AND DISCUSSION

Table (1) presents the analysis of variance for both general (GCA) and specific (SCA) combining ability as well as GCA/SCA ratios for all characters studied. Number of branches per plant did not show any significant differences for genotypes, GCA and SCA. These results are disagreement with those obtained by Bond (1966), El-Hosary (1981) and (1987).

Differences among genotypes, parents and F_1 hybrids were found to be significant for all traits except number of branches per plant. F_1 means were found to be significantly lower than parental means for only number of seeds per pod. Though, there were no significant differences between parents and their F_1 hybrids for the rest of the traits investigated.

Table (1) : Mean squares from the analysis of variance and combining ability analyses for all traits studied.

Source of variation	D.F.	No. of branches per plant	Plant height	Pod height	No. of seeds per pod	No. of pods per plant	100-seed weight (gm)	Seed yield per plant (gm)
Blocks	2	1.06	45.43	0.033	0.003	5.55	29.62	8.90
Genotypes	14	0.78	536.22**	3.04**	0.411**	66.07**	797.27**	264.98**
Parents	4	1.31	175.44*	5.29**	0.24*	135.36**	1125.45**	149.71**
Hybrids	9	0.40	741.28**	2.36**	0.366**	42.59**	734.22**	343.99**
Par.Vs.Hybrids	1	2.05	133.81	0.10	1.50**	0.29	51.99	15.04
GCA	4	0.58	943.21**	2.89**	0.090	56.47**	908.34**	92.89**
SCA	10	0.86	373.43**	3.10**	0.539**	69.91**	752.84**	333.82**
Error	28	0.45	38.18	0.29	0.058	4.62	28.40	5.42
GCA/SCA		--	2.53	0.93	0.167	0.81	1.21	0.28

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

For number of seeds per pod, significant SCA along with insignificant GCA variances were obtained revealing that the non-additive type of gene action being the more important part of the total genetic variability in this trait. Concerning the other traits examined, the mean squares associated with both general and specific combining ability was significant, indicating that both additive and non-additive types of gene action were involved in determining the performance of these characters. To reveal the nature of genetic variance which had the greater role, GCA/SCA ratio was computed. For both plant height and 100-seed weight, high ratios which exceed the unity were detected, revealing that the largest part of the total genetic variance associated with these traits being a result of additive and additive by additive types of gene action. With respect to the other four traits, however, non-additive gene action seemed to be high in magnitude indicating its importance as a major contributor in the inheritance of these characters. The types of gene action reported by Abdalla and Fischbeck (1980), Hassan (1982), Mahmoud et al. (1984) and El-Hosary (1987) among stocks of Vicia faba L. is rather confirmed by the type of variation found in the present study.

Estimates of GCA effects "$\hat{g}_i$" for individual parental lines in each trait are presented in Table (2). High positive values would be of interest under all traits in question, except for both plant height and pod height, where high negative values would be useful from the breeder point of view. Concerning pod height, Giza-2 showed significant negative GCA effect. Giza-2 and NEB-319 had the highest significant negative GCA effects for plant height and proved to be good combiners for stem shorteness. For seed yield per plant, Giza-2 and NEB-8 had considerable significant positive GCA effects, and proved to be good combiners in this concern, Giza-2, appeared to be good combiners in this respect. For number of pods per plant, Table (2): Estimates of general combining ability effects.

Parent	Plant height	Pod height	No. of pods per plant	100-seed weight	Seed yield per plant
Giza-2	-39.71**	-3.67**	- 4.56**	5.55**	11.50**
NEB-8	26.39**	-0.17	14.59**	23.35**	16.47**
I-131	8.29**	3.67**	- 6.81**	-36.01**	- 6.27**
Equadols	59.29**	0.20	9.39**	-53.31**	-20.57**
NEB-319	-54.27**	-0.03	-12.61**	61.42**	- 1.13*
$L.S.D._{0.05}(\hat{g}_i-\hat{g}_j)$	3.91	0.34	1.36	3.37	1.47
$L.S.D._{0.01}(\hat{g}_i-\hat{g}_j)$	5.28	0.46	1.83	4.56	1.99

* and ** : Significant differences from zero at 0.05 and 0.01 levels of probability, respectively.

NEB-8 and Equadols possessed considerable positive GCA effects for number of pods per plant and considered to be the best combiners in this concern. The results obtained herein were found to be agreed with those obtained by Leffel and Weiss (1958), Weber et al. (1970), Paschal and Wilcox (1975), El-Hosary (1981), El-Hosary et al. (1986) and Mahmoud and Al-Ayobi (1986).

From the results obtained here, it is clear that the variety which had high GCA effect in seed yield per plant was also found to be good combiner for one or two traits of yield components. For instance, the best combiner for seed yield, NEB-8, was the best combiner for number of pods per plant and 100-seed weight. However, the variety which had high GCA effect for some yield components may not necessarily had high GCA effect for seed yield per plant. For example, though NEB-319 was the best combiner for 100-seed weight, it had significant negative GCA effect for seed yield per plant.

Specific combining ability effects for all possible combinations with respect to the traits studed are presented in Table (3). The most desirable inter and intra-allelic interactions were represented by cross (NEB-8 x NEB-319) for plant height, crosses (I-131 x Equadols) and (I-131 x NEB-319) for pod height and number of pods per plant, crosses (G-2 x I-131) and (NEB-8 x Equadols) for number of seeds per pod, crosses (NEB-8 x Equadols) and (I-131 x NEB-319) fot seed index and crosses (G-2 x NEB-8), (NEB-8 x Equadols) and (I-131 x NEB-319) for seed yield per plant. It is known that SCA would not contribute directly to the improvement of autogamous crops except where commercial exploitation of heterosis is in hand. If the crosses exhibiting high specific combining ability involve one or two cultivars which also proved to be good general combiners, they might be exploited for breeding improved varieties as well. Therefore, the two crosses (G-2 x NEB-8) and (NEB-8 x Equadols) might be of great importance in breeding programmes whether toward hybrid faba bean or for conventional breeding procedure.

Table(3): Estimates of specific combining ability effects for the crosses studied.

Cross	Plant height	Pod height	No. of seeds per pod	No. of pods per plant	100-seed weight	Seed yield per plant
Giza-2 x NEB-8	20.22**	0.21	-0.38**	-0.81	3.87	5.55**
x I-131	18.23**	0.77**	0.35**	-4.49**	0.05	-9.27**
x Equadols	10.71**	-0.44	-0.30**	0.26	-17.05**	-9.39**
x NEB-319	14.41**	-0.24	-0.10	-1.20	-13.04**	-4.40**
NEB-8 x I-131	- 1.98	-0.13	-0.24*	-2.99**	4.16	0.25
x Equadols	20.59**	1.53**	0.51**	-5.70**	33.57**	16.56**
x NEB-319	-23.15**	1.16**	-0.49**	-0.86	- 4.62*	-13.71**
I-131 x Equadols	- 0.98	-0.65**	0.08	5.09**	- 8.52**	- 3.32**
x NEB-319	4.81	-1.55**	-0.46**	8.80**	4.82*	17.20**
Equadols x NEB-319	2.49	-0.32	-0.28**	1.35	-10.84**	- 3.56**
L.S.D.$_{0.05}(\hat{S}_{ij}-\hat{S}_{ik})$	9.58	0.84	0.37	3.33	8.26	3.61
L.S.D.$_{0.01}(\hat{S}_{ij}-\hat{S}_{ik})$	12.89	1.12	0.50	4.48	11.12	4.86
L.S.D.$_{0.05}(\hat{S}_{ij}-\hat{S}_{kl})$	8.74	0.76	0.34	3.05	7.54	3.29
L.S.D.$_{0.01}(\hat{S}_{ij}-\hat{S}_{kl})$	11.77	1.03	0.46	4.09	10.15	4.43

* and ** : Significant differences from zero at 0.05 and 0.01 levels of probability, respectively.

Heterotic effects for each trait relative to better parent are presented in Table (4). Heterosis may result from simple gene action namely dominance effects, especially over-dominance or in conjunction with epistatic effects, i.e., dominance x dominance and dominance x additive types of gene action. Specific combining ability effects illustrate perfectly these types of gene actions. Significant heterosis was detected (Table 4) for most of the crosses which show the positive high values of SCA effect (Table 3) for yield and some of its components. The cross (NEB-8 x Equadols) expressed highly significant heterotic effects for seed yield per plant (85.25%) and seed index (122.83%). The cross (I-131 x NEB-319) showed significant heterotic effect for seed yield per plant (71.76) and number of pods per plant (103.13%) . These two crosses (NEB-8 x Equadols) and (I-131 x NEB-319) which expressed both heterosis and SCA effects for seed yield per plant and at least one of yield components, may be of specific interest in hybrid faba bean breeding programmes. Significant hybrid vigour was previously reported for; plant height by Bond (1966) and El-Hosary et al. (1986), for number of pods by Bond (1966), Hassan (1982) and El-Hosary et al. (1986), for number of seeds per pod by Hayes and Hanna (1968) and El-Hosary (1981) and El-Hosary et al. (1986) and for yield by Mahmoud (1977) and El-Hosary et al. (1986).

From the foregoing results, it could be concluded that both plant height and seed index had considerable amount of fixable genes, i.e., additive gene action. Hence, their improvement could be achieved by selection. For the rest of the traits studied, the best methods for their improvement, may be those which the prevalent role of dominance type of gene action is involved. In cases where structuring of hybrid varieties is economic, e.g., the use of male sterility and fertility restoring genes for example, the two crosses (NEB-8 x Equadols) and (L-131 x NEB-319) would be an outstanding ones.

Table (4): Percentage of heterotic effects relative to better parent for studied traits.

Cross	Plant height	Pod height	No. of seeds per pod	No. of pods per plant	100-seed weight	Seed yield per plant
Giza-2 x NEB-8	8.03	17.46**	-20.94**	-34.46**	-10.95	- 8.34
x I-131	2.32	30.17**	5.26	-44.61**	-31.56**	-68.62**
x Equadols	- 0.17	4.13	-13.75*	- 6.77	-64.36**	-75.87**
x NEB-319	-17.02	6.58	-22.11**	-30.73**	-44.20**	-49.93**
NEB-8 x I-131	2.22	28.57**	-15.48*	-44.33**	37.14**	7.27
x Equadols	30.99**	46.98**	12.14	-45.92**	122.83**	85.25**
x NEB-319	-34.90**	40.63**	-34.21**	-39.20**	-29.33*	-67.73**
I-131 x Equadols	11.73	- 1.29	- 0.93	15.22	-30.89**	-21.46
x NEB-319	7.38	19.28**	-30.00**	103.13**	-28.03**	71.76**
Equadols x NEB-319	15.67	- 3.88	-24.73**	- 7.16	-52.31**	-43.52**

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

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