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Estimate of Heterosis and Combining Ability in Faba Bean (*Vicia faba L.*)

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ABSTRACT

The present experiment was carried out to assess the general combining ability (GCA) and specific combining ability (SCA) of seven important commercial cultivars of *Vicia faba L.* of faba bean and their 21 F_1 and F_2 generations. The data were analyzed using Griffing's Model I Method II. Significant differences were found for all traits evaluated. Combining ability analysis of variance revealed significant differences for GCA and SCA effects among the parents and hybrids for almost all traits. The results suggested the presence of additive and non-additive gene action for almost all of the traits. The results (G.C.A) for seven parents revealed that the commercial variety Nubaria 3 had significant and positive G.C.A effects for 50% flowering, days to maturity and plant height, while the variety Giza 2 showed significant and negative G.C.A. effects for number of branches/plant, seed yield/plant, number of pods/plant and 100 seed wight. The good combiners for earliness was the parent Giza 716 and Giza 2, while for seed yield/plant and number of pods/plant was the parent Misr 3, But the parent Giza 843 was considered as the best combiner for number of branches/plant. Estimates of (S.C.A.) effects revealed that significant SCA effects were observed for some crosses. Moreover, the best combinations were (Nubaria 3 x Giza 2) for 50% flowering and number of pods/plant. (Giza 843 x Misr 3) for Days to maturity, seed yield/plant and wight 100 seed /plant. (Nubaria 3 x Giza 843) for number of branches/plant, (Sakha 3 x Giza 402) for plant height.. It can be concluded that possibility of use the superior crosses for improving faba bean traits by breeding processes and selection in sequent generations

INTRODUCTION

Faba bean (*Vicia faba* L.) is the important legume crop in the world. And it is the most important source of plant protein for both human and animals in the Mediterranean area. In addition, faba bean is one of the most efficient fixers of the atmospheric nitrogen fertility through bidogical N_2-fixation. Faba bean is a self-pollinating plant with significant levels of out-cross and inter-cross, ranging from 20 to 50% depending on genotype and environmental effect (Suso and Moreno, 1999). The genetic improvement of crop desired traits depends on the nature and magnitude of genetic variability and interactions involved in the inheritance of these traits which can be estimated using diallel cross technique (Ibrahim, 2010).

Information on heterosis and combining ability helps the breeders to choice of suitable parents. Generally, combining ability analysis is associated with additive effects of genes while SCA is attributed primarily to non-additive (dominance and epistasis) genes. Also, identification of gene action such as additive, dominance and epistatic effects are very important for any breeding program. In addition, heritability estimates and the magnitude of the genetic variability for the different traits are very useful to identify the best progenies. Therefore, the breeder should evaluate the potentialities of the available germplasm for new recombination's and eventually combining ability which have proved to be of considerable use in breeding methods.

The objectives of this investigation were to study:

Mean performance of faba bean hybrids, estimate the general and specific combining abilities, heritability, and quantify the types of gene action for earliness and yielding ability in some faba bean crosses.

MATERIALS AND METHODS

This investigation was carried out during three winter growing seasons; 2016/2017, 2017/2018 and 2018/2019. The three seasons were performed in the Agricultural Experimental Farm of Al-Azhar University (Assiut branch). Seven genetically diverse genotypes of faba bean (*Vicia faba* L.) wildly different in their agronomic characters were used as parental varieties in this study. The description and origin of these genotypes is shown in Table (1).

In the (2016/2017) season, the seven parental genotypes were sown in a field in two planting dates with two weeks apart to obtain enough flowers for crossing. Parents were crossed in all possible combinations except reciprocals to produce 21 F1 hybrids. These parents were crossed again in (2017/2018) season to obtain more hybrids seeds (F1's) for all combinations. Also, the (F1's) seed were left to give the F2 seeds.

In the (2018/2019) season, The forty nine genotypes (seven parents and twenty one for both F1 and F2) were sown in a Randomized Complete Block Design (R.C.B.D) with three replications. Planting was carried out on 30 October (2018). Plants were grown on rows, 3 m long and 60 cm apart, in single seeded hill spaced at 20 cm. Each parent was represented by two rows/plot, while Fl hybrid was represented by two row/plot and each F2 cross was represented by four rows/plot. The agriculture practices of irrigation, fertilization, used as recommended for faba bean production. The data were recorded on the mean of ten guarded plants/plot for both of parents and F1 hybrids, and thirty guarded plants for F2 generation. The following characters were measured as follows:

Table 1. Origin and some characteristics of the seven studied faba bean (*Vicia faba*) parental genotypes.

Genotypes	Pedigree	Origin
1-Giza 716	Cross (461 1842183 x 5031 453/83 x I L B 938	Egypt
2-Sakha 3	Promising line 716/402/2001 derived from cross716 (Giza461 X 503/453/83)	Egypt
3-Nubaria 3	Selected from Ahnacia line	Egypt
4-Giza 2	through hybridization	Egypt
5-Giza 402	through hybridization	Egypt
6-Giza 843	561/2076/85 X 461/845/83	Egypt
7-Misr 3	L667 x (Cairo 241 x Giza 461)	Egypt

A - Morphological characters:

1. Days to 50% flowering (The number of days to 50% flowering were calculated from the date of sowing to the date of opening of 50% of the flowers in a plant of the genotype.).
2. Days to maturity (number of days from sowing to 95% maturity of pods).
3. Plant height at harvest (cm), distance from the soil surface to the top of the main stem.
4. Number of branches/plant.

B - Yield and its components:

1. Number of pods/plant.
2. Seed yield/plant (gm).
3. 100-seed weight (gm).

Statistical analysis:

Statistical analysis was made on an entry mean basis. The variation among parents, F_1 and F_2 crosses was partitioned into general and specific combining abilities as illustrated by Griffing (1956) Method 2, Model I as shown in table 2.

Table 2. Mean squares for the assumption of Method (2), Model (1) of Griffing's (1956) and expectation of mean squares.

Source of variation	D.F.	M.S.	Expectation Model 1
Replications	b-1	M_b	$\sigma^2_e + a\,\theta\,(b)$
Genotypes	a-1	M_v	$\sigma^2_e + b\,\theta\,(v)$
Parents	(p-1)		
Crosses	(c-1)		
Parents v.s. crosses	1		
g.c.a.	(p-1)	M_g	$\sigma_e^2 + (p+2)\left(\frac{1}{p-1}\right)\sum g_i^2$
s.c.a.	p(p-1)/2	M_s	$\sigma_e^2 + \frac{2}{p(p-1)}\sum_i \sum_j s_{ij}^2$
Error	(b-1)(a-1)	M_e	σ_e^2

Heterosis estimates:

Heterosis values was made according to (Halluer and Miranda, 1981).

A)-Heterosis from the mid-parent:

Heterosis was determined as the percentage of increase or decrease of F_1's means over the average of its parents(M.P):

$$\textbf{Heterosis \%} = \frac{\overline{F_1} - \overline{M.P}}{\overline{M.P}} \times 100$$

b)-Heterosis from the better-parent:

It was also determined as the percentage of increase or decrease of F_1 mean over the better parent (B.P):

$$\textbf{Heterosis \%} = \frac{\overline{F_1} - \overline{B.P}}{\overline{B.P}} \times 100$$

L.S.D for better parent heterosis = t× $(3M.S.E/2r)^{1/2}$

L.S.D for mid parent heterosis = t× $(M.S.E/r)^{1/2}$

Where: t is the value of tabulated t at a stated level of probability for the experimental error degrees of freedom; r is the number of replications.

RESULTS AND DISCUSSION

The mean of the seven parental cultivars and their 21 for F_1 and F_2 hybrids were estimated for all the studied traits and the results are presented in Tables (3) and (4).

Mean performance of the studied parental cultivars ranged from 46 -53 (P_1– P_3); 144.33 -153.33 (P_1 - P_2); 134.2 -157.00 (P_5 –P_6); 3.03 - 4.67 (P_2 –P_6); 18.73- 30.6 (P_4 –P_7) ; 54.67 – 83.67 (P_4 –P_7); 73.67 - 93.33 (P_4 –P_1) for 50% flowering, date maturity, plant height, number of branches/plant, number pods/plant, seed yield/plant and 100 seed wight respectively. Meanwhile, means of F_1 hybrids were extended with a range 46.67 for cross (P_3 x P_6) and (P_5 x P_6) - 52.33 for cross (P_1 x P_7); 141.67 for cross (P_1 x P_5) - 152.67 days for cross (P_1 x P_2); 136.47 cm for the cross (P_6 x P_7) - 159.33 cm for the cross (P_3 x P_4); 2.77 for cross (P_2 x P_3) – 5 for cross (P_5 x P_7); 19.2 for cross (P_1 xP_4) –30.93 for cross (P_4 x P_7); 59.67 gm for cross (P_1 x P_7) - 80.33 gm for cross (P_6 x P_7) and 74.67 for the cross (P_2 x P_7) - 91.67 for the cross (P_4 x P_5) for the above- mentioned traits, respectively. Meanwhile, means of F_2 hybrids were extended with a range 45.33 for cross (P_5 x P_7) -51.33 for cross (P_3 x P_6) ; 144.33 for cross (P_6 x P_7) -151.67 days for cross (P_2 x P_3); 136 cm for the cross (P_1 x P_6) -160.8 cm for the cross (P_3 x P_7); 3 for cross (P_4 xP_6) – 5.07 for cross (P_5 x P_7); 19.07 for cross Giza 716 x Misr 3 (P_1 x P7) - 29.47 for crosses (P_6 x P_7); 55.33 gm for cross (P_2 X P_6) - 85.33 gm for cross (P_6 x P_7) and 75.67 gm for the cross (P_4 xP_5) - 92.33 gm for the cross (P_3 x P_5) for 50% flowering, date maturity, plant height, number of branches/plant, number pods/plant, seed yield/plant and 100 seed wight, respectively.

Table 3. Mean performances for 50% flowering, date maturity, plant height and number of branch/ plant parents and F_1 and F_2 generations

Traits	50% Flowering		Days to maturity		Plant height		Number of branches /plant	
	F1	F2	F1	F2	F1	F2	F1	F2
P1	46.00	46.00	144.33	144.33	145.47	145.47	4.53	4.53
P2	49.33	49.33	153.33	153.33	140.93	140.93	3.03	3.03
P3	53.00	53.00	151.00	151.00	153.73	153.73	4.47	4.47
P4	52.67	52.67	149.33	149.33	152.00	152.00	3.17	3.17
P5	50.00	50.00	150.67	150.67	134.20	134.20	3.43	3.43
P6	49.00	49.00	149.33	149.33	157.00	157.00	4.67	4.67
P7	48.33	48.33	148.33	148.33	143.87	143.87	3.43	3.43
P1XP2	48.33	49.00	152.67	150.00	140.93	140.53	4.57	4.03
P1XP3	49.00	48.00	151.33	150.33	149.33	146.67	3.43	3.50
P1XP4	47.00	49.33	147.67	148.33	155.60	146.13	4.47	3.93
P1XP5	48.67	49.67	141.67	147.67	154.13	145.20	3.40	4.13
P1XP6	47.33	48.67	150.33	149.00	155.20	136.00	4.10	3.77
P1XP7	52.33	49.33	148.00	148.67	151.67	143.33	4.67	4.43
P2XP3	47.33	47.33	151.00	151.67	154.33	155.60	2.77	3.23
P2XP4	47.33	48.00	149.33	150.33	158.67	146.27	3.30	3.67
P2XP5	48.00	49.33	148.67	148.67	157.07	149.80	3.80	3.73
P2XP6	47.67	45.67	147.00	149.00	154.87	150.07	4.90	3.80
P2XP7	47.67	47.67	145.67	149.33	153.00	148.93	4.03	4.00
P3XP4	47.67	49.00	143.67	151.33	159.33	154.73	3.33	3.70
P3XP5	49.67	49.33	148.33	149.00	152.40	159.00	4.53	4.67
P3XP6	46.67	51.33	148.00	148.67	154.67	154.07	4.97	4.77
P3XP7	51.00	49.67	147.00	150.33	142.67	160.80	4.60	3.93
P4XP5	47.67	49.67	142.00	147.00	146.47	150.47	4.50	3.83
P4XP6	49.00	50.00	147.00	146.33	145.20	146.60	3.03	3.00
P4XP7	47.67	47.33	147.33	146.67	148.80	149.13	4.63	3.87
P5XP6	46.67	47.67	145.00	147.33	149.60	153.67	4.93	3.93
P5XP7	48.33	45.33	150.00	146.00	143.07	147.07	5.00	5.07
P6XP7	50.00	46.33	143.00	144.33	136.47	144.60	3.10	4.20
L.S.D5%	1.48	1.57	1.45	1.49	2.36	2.66	0.41	0.33
L.S.D1%	1.97	2.1	1.93	1.99	3.15	3.55	0.55	0.44

Combining ability:

Mean squares due to both general (G.C.A) and specific (S.C.A) combining ability Table (5) were highly significant for all characters studied, indicating the importance of both additive and non-additive genes effects in the inheritance of these characters. The ratio of G.C.A / S.C.A for F_1 and F_2 hybrids decreased from unity for all characters suggesting that non-additive type of gene action was more important in the inheritance of these trait or appeared to be under the central of epistatic effect. Similar results were reported by EL-Harty *et al*. (2007), Alghamdi. (2009),Haridy (2009), and Mourad *et al*. (2011).

A-General combining ability:

Estimates of GCA effects (gi) Tables (6), (7) for F_1 and F_2 generations showed that. Giza 716 (P_1) had positive and highly significant G.C.A effects for Number of branches/plant and 100 seed wight, while it displayed a negative and highly significant G.C.A effects for date 50% Flowering, Days to maturity, Number of pods/plant, Plant height in F_2 only and seed yield/plant in F_2 only, it also showed non- significant values for plant height and seed yield/plant in F_1 only.

Sakha 3 (P_2) had positive and highly significant G.C.A .effects for Days to maturity, 100 seed wight, while it revealed a negative and highly significant G.C.A effects for 50% Flowering, Number of branches/plant, Number of pods/plant and seed yield/plant, and it displayed negative significant values for plant height and Number of pods/plan in F_2 only

Nubaria 3 (P_3) had positive and highly significant G.C.A .effects for 50% Flowering, Days to maturity, Plant height and seed yield/plant, while it displayed non- significant values for Number of pods/plant and 100 seed wight.

Giza 2 (P_4) had positive and highly significant G.C.A .effects for Plant height and 50% Flowering in F_2 only, while it displayed a negative and highly significant G.C.A effects for Days to maturity in F_1 only, Number of branches/plant, Number of pods/plant, seed yield/plant and 100 seed wight, while it showed positive significant values for 50% Flowering in F_2 only.

Giza 402 (P_5) had positive and highly significant G.C.A .effects for Number of branches/plant and seed yield/plant in F_1 only, while it showed a negative and highly significant G.C.A effects for Days to maturity and plant height, while it revealed non- significant values for 50% Flowering.

Giza 843 (P_6) showed positive and highly significant G.C.A .effects for plant height and Number of branches/plant, while it displayed a negative and highly significant G.C.A effects for Days to maturity, 50% Flowering in F_1 only, while it revealed non- significant values for Number of pods/plant, seed yield/plant in F_2 only and 100 seed wight in F_1 only.

Misr 3 (P_7) had positive and highly significant G.C.A .effects for Number of branches/plant in F_2 only, Number of pods/plant and seed yield/plant, while it showed a negative and highly significant G.C.A effects for Days to maturity Plant height and 100 seed wight.

Table 4. Mean performances for Number pod/plant, seed yield/plant and 100 seed wight of parents and $F_1$and F_2 generations.

Traits	Number pod/plant		seed yield/ plant		100 seed wight	
	F_1	F_2	F_1	F_2	F_1	F_2
P1	22.07	22.07	67.33	67.33	93.33	93.33
P2	19.80	19.80	57.67	57.67	89.00	89.00
P3	21.40	21.40	79.00	79.00	81.00	81.00
P4	18.73	18.73	54.67	54.67	73.67	73.67
P5	20.20	20.20	66.67	66.67	76.33	76.33
P6	20.13	20.13	69.00	69.00	75.33	75.33
P7	30.60	30.60	83.67	83.67	74.00	74.00
P1XP2	22.40	22.13	66.00	83.00	86.33	83.33
P1XP3	22.13	21.80	79.00	71.33	79.00	84.67
P1XP4	19.20	20.87	66.00	62.33	81.67	86.67
P1XP5	23.93	20.00	68.67	75.33	90.00	89.00
P1XP6	24.87	22.13	66.67	76.33	90.67	86.67
P1XP7	24.47	19.07	59.67	61.00	80.67	84.00
P2XP3	23.53	21.93	68.00	73.67	88.33	86.00
P2XP4	24.53	25.60	74.67	65.67	81.33	80.00
P2XP5	26.53	24.07	65.67	69.00	89.33	85.00
P2XP6	24.93	23.60	74.67	55.33	91.33	83.33
P2XP7	23.40	23.53	75.00	61.00	74.67	88.33
P3XP4	26.33	26.27	78.33	72.00	85.00	79.67
P3XP5	25.13	20.40	62.00	63.33	84.67	92.33
P3XP6	24.40	27.13	66.00	68.67	84.33	79.33
P3XP7	22.33	26.73	68.33	64.00	78.33	79.67
P4XP5	23.27	24.53	66.33	80.00	91.67	75.67
P4XP6	22.27	20.47	60.00	72.00	81.67	78.33
P4XP7	30.93	22.13	68.33	62.33	79.67	87.33
P5XP6	27.13	23.67	66.67	79.00	78.67	80.00
P5XP7	24.47	25.13	79.67	83.00	83.33	81.67
P6XP7	22.73	29.47	80.33	85.00	85.33	83.33
L.S.D5%	1.75	2.95	3.06	4.02	4.16	3.66
L.S.D1%	2.34	3.49	4.07	5.36	5.55	4.88

Table 5. Mean squares of genotypes, general combining ability (GCA) and specific combining ability (SCA) and their ratios for yield and its components in cotton for F_1 and F_2 generations.

S.O.V	df	Days to 50% flowering	Days to maturity	Plant height	Number of branches /plant	Number pod/plant	seed yield/plant	100 seed wight
				F_1				
Replicates	2	0.012	0.679	2.225	0.029	0.6	0.869	2.298
Genotypes	27	9.776**	28.1**	136.448**	1.558**	26.254**	234.067**	101.37**
GCA	6	2.678*	9.901**	54.868**	0.42**	9.994**	76.29**	56.28**
SCA	20	3.424**	9.214**	42.801**	0.548**	8.397**	78.517**	27.364**
Error	54	0.271	0.259	0.694	0.021	0.382	2.002	2.149
GCA / SCA		0.085	0.12	0.143	0.084	0.133	0.108	0.239
				F_2				
Replicates	2	0.464	0.583	0.406	0.037	3.013	0.25	1.714
Genotypes	27	9.981**	12.037**	123.706**	0.861**	28.013**	162.302**	84.633**
GCA	6	5.339**	10.307**	87.906**	0.466**	15.574**	76.78**	60.663**
SCA	20	2.752**	2.214**	27.901**	0.236**	7.556**	47.621**	18.939**
Error	54	0.307	0.277	0.879	0.014	0.83	1.157	1.662
GCA / SCA		0.229	0.575	0.358	0.226	0.244	0.181	0.379

In F_1 and F_2 generations showed that the P_1, P_2, P_3, P_4, P_5, P_6 and P_7 were very good combiner parents for (50% Flowering, Days to maturity, Number of branches/plan and 100 seed wight), (50% Flowering and 100 seed wight), (Plant height and seed yield/plant), (Plant height), (Number of branches/plant), (Plant height and Number of branches/plant) and (Days to maturity, Number of pods/plant and seed yield/plant) respectively. Similar results were reported by EL-Harty *et al.* (2007), Haridy (2009), Alghamdi. (2009), Ibrahim. (2010), Mourad *et al*. (2011), Haridy and Amein (2011), Yamani. (2012), Farag and Afiah. (2012), Mona *et al.* (2012), Obiadalla-Ali *et al.* (2013), Saad *et al.* (2015).

B-Specific combining ability:

Specific combining ability effects of F_1 and F_2 generations are show in Tables (6) and (7). Concerning 50% flowering, hybrid Giza 716 x Misr 3 highest significant and positive SCA value in both generation. while The crosses Nubaria 3x x Misr 3 in F_1 and Giza 716 x Sakha 3 in F_2 had lowest significant and positive SCA. On the other hand , the crosses Nubaria 3 x Giza 843,Giza 402 x Misr 3 in F_1 and Sakha 3x Giza 843 in F_2 had significant and the highest negative SCA effect and it could be considered the most desirable cross for improving early flowering. In the F_1 and F_2 generations, the crosses Giza 716 x Nobarea 3 and Giza 2xGiza 402 had the lowest negative SCA value respectively. The present results confirm the finding of Saad *et al.*(2015), Obiadalla-Ali *et al* (2013).

Regarding to date maturity for F_1 and F_2 generation showed that the hybrids Giza 716 x Giza 402, Nubaria 3 x Giza 2, Giza 2 x Giza 402, Giza 843 x Misr 3 and Sakha 3 x Giza 843 in F_1 generation and the crosses Sakha 3 x Giza 402, Giza 843 x Misr 3, Giza 2x Giza 843 and Giza 2 x Misr 3 in F_2 generation exhibited highly significant and negative SCA effects. While, Giza 716 x Giza 843 was highly significant and positive GCA effects in both generations. The present results confirm the finding of Yamani (1998), Salama and Mohamed (2004) and Mourad *et al.*(2011).

Table 6. Estimates of general and specific combining ability effects for 50% Flowering, Days to maturity, seed cotton yield/plant and Number of branches/plant in faba bean varieties.

Traits	50% Flowering		Days to maturity		Plant height		Number of branches/plant	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Giza 716	-0.54**	-0.48**	-0.31	-0.90**	0.05	-4.29**	0.16**	0.16**
Sakha 3	-0.50**	-0.51**	1.98**	1.66**	0.38	-1.59**	-0.31**	-0.32**
Nubaria 3	0.87**	1.15**	0.91**	1.40**	2.54**	5.66**	0.04	0.15**
Giza 2	0.24	0.93**	-0.83**	-0.23	2.3**	1.1**	-0.29**	-0.34**
Giza 402	-0.06	0.08	-0.68**	-0.42*	-2.91**	-1.53**	0.09*	0.09*
Giza 843	-0.47**	-0.29	-0.46**	-0.68**	1.41**	1.29**	0.24**	0.15**
Misr 3	0.46**	-0.88**	-0.61**	-0.83**	-3.77**	-0.64*	0.07	0.11**
L.S.D5%	0.32	0.34	0.32	0.33	0.52	0.58	0.09	0.07
L.S.D1%	0.43	0.46	0.42	0.43	0.69	0.77	0.12	0.1
P1XP2	0.69	1.20*	3.10**	0.40	-9.16**	-2.01**	0.69**	0.26*
P1XP3	-0.02	-1.46**	2.84**	0.99*	-2.93**	-3.13**	-0.8**	-0.74**
P1XP4	-1.39**	0.09	0.92*	0.62	3.58**	0.89	0.57**	0.19
P1XP5	0.57	1.28*	-5.23**	0.14	7.33**	2.6**	-0.88**	-0.05
P1XP6	-0.35	0.65	3.21**	1.73**	4.07**	-9.43**	-0.33*	-0.48**
P1XP7	3.72**	1.91**	1.03*	1.55**	5.72**	-0.16	0.4**	0.24*
P2XP3	-1.72**	-2.09**	0.21	-0.23	1.75*	3.11**	-0.99**	-0.52**
P2XP4	-1.09*	-1.20*	0.29	0.06	6.32**	-1.67	-0.13	0.4**
P2XP5	-0.13	0.98	-0.53	-1.42**	9.93**	4.5**	-0.01	0.04
P2XP6	-0.06	-2.31**	-2.42**	-0.82	3.41**	1.94*	0.94**	0.04
P2XP7	-0.98*	0.28	-3.60**	-0.34	6.73**	2.74**	0.24	0.29**
P3XP4	-2.13**	-1.87**	-4.31**	1.32**	4.82**	-0.46	-0.44**	-0.03
P3XP5	0.17	-0.69	0.21	-0.82	3.1**	6.45**	0.38**	0.5**
P3XP6	-2.43**	1.69**	-0.34	-0.9	1.05	-1.31	0.66**	0.54**
P3XP7	0.98*	0.61	-1.19*	0.92	-5.77**	7.36**	0.46**	-0.25*
P4XP5	-1.20*	-0.13	-4.38**	-1.19*	-2.59**	2.47**	0.67**	0.16
P4XP6	0.54	0.57	0.40	-1.6**	-8.18**	-4.22**	-0.94**	-0.74**
P4XP7	-1.72**	-1.50**	0.88	-1.12*	0.6	0.25	0.82**	0.18
P5XP6	-1.50**	-0.91	-1.75**	-0.42	1.44	5.49**	0.58**	-0.24**
P5XP7	-2.43**	-0.31	-1.60**	-0.27	6.61**	7.42**	0.74**	-0.19
P6XP7	1.31**	-1.28*	-3.82**	-1.68**	-10.84**	-4.47**	-1.24**	0.01
L.S.D5%	0.94	1.00	0.92	0.95	1.5	1.69	0.26	0.21
L.S.D1%	1.25	1.33	1.22	1.26	2.00	2.25	0.35	0.28

Table 7. Estimates of general and specific combining ability effects for Number pod/plant, seed yield/plant and 100 seed wight in seven faba bean varieties.

Traits	Number pod/plant		seed yield/ plant		100 seed wight	
	F1	F2	F1	F2	F1	F2
Giza 716	-0.89**	-1.53**	0.4	-1.45**	3.3**	4.33**
Sakha 3	-0.46**	-0.38	-4.15**	-1.6**	2.67**	2.44**
Nubaria 3	-0.27	0.35	1.18**	2.88**	-0.41	0.19
Giza 2	-0.57**	-0.73*	-4.08**	-3.41**	-1.89**	-3**
Giza 402	0.2	-0.63*	2.51**	-1.26**	0.56	-0.63*
Giza 843	-0.28	0.32	1.55**	-0.15	-0.3	-2.26**
Misr 3	2.27**	2.6**	2.59**	4.99**	-3.93**	-1.07**
L.S.D5%	0.38	0.56	0.88	0.67	0.91	0.8
L.S.D1%	0.51	0.75	1.17	0.89	1.21	1.07
P1XP2	0.11	1.06	16.7**	-0.17	-2.8*	-6.19**
P1XP3	-0.35	-0.01	-0.3	8.35**	-7.06**	-2.6*
P1XP4	-2.99**	0.14	-4.04**	1.65	-2.91*	2.58*
P1XP5	0.99**	-0.83	2.37	2.17**	2.98*	2.55*
P1XP6	2.39**	0.36	4.33**	-0.94	4.5**	1.84
P1XP7	-0.56	-4.99**	-12.04**	-13.09**	-1.87	-2.01
P2XP3	0.63	-1.03	6.59**	-2.5*	2.91*	0.62
P2XP4	1.93**	3.72**	3.85**	10.46**	-2.61	-2.19
P2XP5	3.16**	2.09*	0.59	-0.69	2.94*	0.44
P2XP6	2.04**	0.68	-12.11**	7.2**	5.8**	0.4
P2XP7	-2.04**	-1.67*	-7.48**	2.39*	-7.24**	4.21**
P3XP4	3.53**	3.66**	4.85**	9.65**	4.13**	-0.27
P3XP5	1.57**	-2.31**	-10.41**	-8.83**	1.35	10.03**
P3XP6	1.31*	3.48**	-4.11**	-5.94**	1.87	-1.34
P3XP7	-3.3**	0.8	-9.81**	-8.76**	-0.5	-2.19*
P4XP5	0	2.91**	11.52**	1.8	9.83**	-3.45**
P4XP6	-0.53	-2.11*	4.48**	-5.65**	0.69	0.84
P4XP7	5.59**	-2.72**	-6.22**	-2.46*	2.31	8.66**
P5XP6	3.58**	1	4.89**	-1.13	-4.76**	0.14
P5XP7	1.03	-1.29*	3.85**	-6.28**	-1.13	-1.05
P6XP7	-2.9**	3.57**	10.81**	6.28**	6.39**	3.92**
L.S.D5%	1.11	1.64	2.55	1.94	2.64	2.32
L.S.D1%	1.48	2.19	3.4	2.59	3.52	3.1

For plant height, Giza 843 x Misr 3 crosses showed highly significant and negative SCA values in both generations. In the F_1 the crosses Sakha 3 x Giza 402,Giza 716 x Giza 402 and Sakha 3xMisr 3 had the highly significant and positive SCA values. While, the crosses Nubaria 3xMisr 3 and Giza 402xMisr 3 showed highly significant and positive SCA values in F_2. Therefore, the cross Giza 402 x Misr 3 could be considered as the best combination for plant height. Similar results were reported by Attia (2002), Darwish *et al.* (2005), Haridy *et al* (2009), Abd El-Aty *et al.* (2016), Abdalla *et al.*(2017b) and Soad *et al.*(2018).

Concerning number of branches/plant, Estimates of SCA effects Table (6) for F_1 and F_2 generations showed that the hybrids Sakha 3 x Giza 843, Giza 2 x Misr 3, Giza 402 x Misr 3, and Giza 716 x Sakha 3 in the F_1 generation and the hybrids Nubaria 3 x Giza 843 , Nubaria 3 x Giza 402 and Sakha 3 x Giza 2 in the F_2 generation exhibited highly significant positive SCA effects. While, the crosses Giza 843 x Misr 3 in F_1 and Giza 2 x Giza 843 in F_2 showed the highest negative SCA value . The crosses Sakha 3 x Giza 843 and Nubaria 3 x Giza 843 could be considered the best combinations for number of branches/plant in F_1 and F_2 generations respectively. The results were in agreement with those obtained by Yamani. (1998) and Haridy *et al.* (2009).

For Number of pods/plant , Estimates of SCA effects, Table (7) for F_1 and F_2 generations showed that cross Giza 2 x Misr 3 and Sakha 3 x Giza 2 exhibited the highest positive SCA value in the F_1 and F_2 generations, respectively. The cross Sakha 3 x Giza 2 could be considered the best combination for number of pods/plant in both generations.

For seed yield/plant, Estimates of SCA effects Table (7) the crosses Giza 716 x Sakha 3, Sakha 3 x Giza 2 showed the highest significant and positive SCA values and recorded 16.7 and 10.4 for F_1 and F_2 generations, respectively. On the other hand, the cross Giza 716 x Misr 3 in both generations showed the highest significant negative SCA values and recorded -12.03 and -13.03, respectively. Thus the crosses Giza 716 x Sakha 3 and Sakha 3 x Giza 2 could be considered the best combinations for seed yield/plant in both generations.

For 100 seed wight Estimates of SCA effects, Table (7) for F_1 and F_2 generations. In the F_1 hybrids, the cross Giza 2 x Giza 402 showed the highest positive SCA value, while the cross Giza 2 x Giza 843 had the lowest one and the cross Sakha 3 x Misr 3 showed the highest negative SCA value, while the cross Nubaria 3 x Misr 3 had the lowest one. In the F_2 generation, the cross Nubaria 3 x Giza 402 showed the highest positive SCA value, while the cross Giza 402 x Giza 843 had the lowest one, and the cross Giza 2 x Giza 402 showed the highest negative SCA value.

Heterosis:

Data in Table (8),(9) showed that there were significant values for the heterosis over mid and better parent for all studied traits, indicating that heterosis played an important role in the inheritance of these traits. For 50% flowering (P_1xP_7) and (P_6xP_7) showed highly positive significant values for heterosis over mid parents. Highly positive significant value for heterosis over better parent were found in (P_1xP_3), (P_1xP_7) and (P_1xP_5). For Date maturity (P_1xP_2), ($P_{1X}P_3$) and (P_1xP_6) showed highly positive significant values for the heterosis over mid parent and better parent. (P_1xP_5), (P_2xP_4), (P_2xP_5) and (P_2xP_7) had desirable highly positive significant values for the heterosis over mid and better parent for Plant height. (P_3xP_7), (P_4xP_7) and (P_5xP_7) had desirable highly positive significant values for the heterosis over mid and better parent for Number of branches/plant.

Table 8. Heterosis as percentage of mid-parents (M.P) and better Parent (B.P) in the F_1 crosses for 50% flowering, Date maturity, Plant height and Number branch/plant

Traits	50% flowering		Date maturity		Plant height		Number branch/plant	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
P1XP2	1.4*	5.07**	2.58**	5.77**	-1.58	-3.12*	20.7**	0.74**
P1XP3	-1.01	6.52**	2.48**	4.85**	-0.18	-2.86*	-23.7**	-24.26**
P1XP4	-4.73**	2.17**	0.57	2.31**	4.62**	2.37*	16.02**	-1.47**
P1XP5	1.39*	5.8**	-3.95**	-1.85*	10.23**	5.96**	-14.64**	-25**
P1XP6	-0.35	2.9**	2.38**	4.16**	2.62*	-1.15	-10.87**	-12.14**
P1XP7	10.95**	13.77**	1.14	2.54**	4.84**	4.26**	17.15**	2.94**
P2XP3	-7.49**	-4.05**	-0.77	0	4.75**	0.39	-26.22**	-38.06**
P2XP4	-7.19**	-4.05**	-1.32*	0	8.33**	4.39**	6.45**	4.21**
P2XP5	-3.36**	-2.7**	-2.19**	-1.33	14.17**	11.45**	17.53**	10.68**
P2XP6	-3.05**	-2.72**	-2.86**	-1.56*	3.96**	-1.36	27.27**	5**
P2XP7	-2.39**	-1.38	-3.43**	-1.8*	7.44**	6.35**	24.74**	17.48**
P3XP4	-9.78**	-9.49**	-4.33**	-3.79**	4.23**	3.64**	-12.66**	-25.37**
P3XP5	-3.56**	-0.67	-1.66*	-1.55*	5.86**	-0.87	14.77**	1.49**
P3XP6	-8.5**	-4.76**	-1.44*	-0.89	-0.45	-1.49	8.76**	6.43**
P3XP7	0.66	5.52**	-1.78**	-0.9	-4.12**	-7.2**	16.46**	2.99**
P4XP5	-7.14**	-4.67**	-5.33**	-4.91**	2.35*	-3.64**	36.36**	31.07**
P4XP6	-3.61**	0	-1.56*	-1.56*	-6.02**	-7.52**	-22.55**	-35**
P4XP7	-5.61**	-1.38	-1.01	-0.67	0.59	-2.11	40.4**	34.95**
P5XP6	-5.72**	-4.76**	-3.33**	-2.9**	2.75**	-4.71**	21.81**	5.71**
P5XP7	-1.69*	0	0.33	1.12	2.9**	-0.56	45.63**	45.63**
P6XP7	2.74**	3.45**	-3.92**	-3.6**	-9.28**	-13.08**	-23.46**	-33.57**
L.S.D5%	1.28	1.48	1.25	1.45	2.05	2.36	0.36	0.41
L.S.D1%	1.71	1.97	1.67	1.93	2.73	3.15	0.48	0.55

Table 9. Heterosis as percentage of mid-parents (M.P) and better Parent (B.P) Number pod/plant, Seed yield/plant and 100 seed wight /plant in the F_1 crosses.

Traits	Number pod/plant		Seed yield/plant		100 seed wight/plant	
	M.P	B.P	M.P	B.P	M.P	B.P
P1XP2	7.01**	1.51	32.8**	23.27**	-5.3**	-7.5**
P1XP3	1.84*	0.3	-2.51	-9.7**	-9.37**	-15.36**
P1XP4	-5.88**	-12.99**	2.19	-7.43**	-2.2	-12.5**
P1XP5	13.25**	8.46**	12.44**	11.88**	6.09**	-3.57
P1XP6	17.85**	12.69**	11.98**	10.63**	7.51**	-2.86
P1XP7	-7.09**	-20.04**	-19.21**	-27.09**	-3.59	-13.57**
P2XP3	14.24**	9.97**	7.8**	-6.75**	3.92*	-0.75
P2XP4	27.34**	23.91**	16.91**	13.87**	0	-8.61**
P2XP5	32.67**	31.35**	10.99**	3.5	8.06**	0.37
P2XP6	24.87**	23.84**	-12.63**	-19.81**	11.16**	2.62
P2XP7	-7.14**	-23.53**	-13.68**	-27.09**	-8.38**	-16.1**
P3XP4	31.23**	23.05**	7.73**	-8.86**	9.91**	4.94**
P3XP5	20.83**	17.45**	-13.04**	-19.83**	7.63**	4.53**
P3XP6	17.5**	14.02**	-7.21**	-13.08**	7.89**	4.12
P3XP7	-14.1**	-27.02**	-21.31**	-23.51**	1.08	-3.29
P4XP5	19.52**	15.18**	31.87**	20**	22.22**	20.09**
P4XP6	14.58**	10.6**	16.44**	4.35*	9.62**	8.41**
P4XP7	25.41**	1.09	-9.88**	-25.5**	7.9**	7.66**
P5XP6	34.55**	34.77**	16.46**	14.49**	3.74*	3.06
P5XP7	-3.67**	-20.04**	10.42**	-0.8	10.86**	9.17**
P6XP7	-10.38**	-25.71**	11.35**	1.59	14.29**	13.27**
L.S.D5%	1.52	1.75	3.48	4.02	3.6	4.16
L.S.D1%	2.03	2.34	4.64	5.36	4.81	5.55

For Number of pods/plant ($P_2x P_5$) and (P_5xP_6) had desirable highly positive significant values for the heterosis over mid and better parent. For Seed yield/plant (P_1xP_2) and (P_4xP_5) had desirable highly positive significant values for the heterosis over mid and better parent. For 100 seed wight /plant (P_4xP_5) and (P_6xP_7) had desirable highly positive significant values for the heterosis over mid and better parent. These findings are in accordance with those of Alghamdi *et al.* (2009), Ibrahim. (2010), Mourad *et al.* (2011), Yamani. (2012), Farag and Afiah. (2012), Abdalla *et al*. (2017a).

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تقدير قوة الهجين والقدرة علي التالف في الفول البلدي

حمزه السيد يس ، ابراهيم نجاح عبد الظاهر ، مختار حسن هريدي و طارق عبادي صادق
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اجريت هذه الدراسة حديثا لتقدير القدرة العامة والقدرة الخاصة علي التالف لسبعة اصناف من الفول البلدي وهي: (جيزه 716 ، سخا3 ، نوبارية 3 ، جيزه 2 ، جيزه 402 ، جيزه 843 ، مصر 3) حيث تم تقدير النتائج لتلك الاباء وأجيالهم الاول والثاني عن طريق تحليل جريفنج سنة (1956) بالطريقة الثانية للنموذج الأول ووجدت معنوية مختلفة بين كل صفات تحت الدراسة بذلك يمكن القول ان تلك الصفات يتحكم فيها الفعل الاضافي وغير الاضافي . لقد أظهرت النتائج المقدرة عن التأثيرات الناتجة عن القدرة العامة على الائتلاف للآباء أن : الصنف نوبارية 3 كان عالى المعنوية وموجب لكل من (50% تزهير ، ميعاد النضج ، طول النبات) ، بينما الصنف جيزه 2 كان عالى المعنوية وسالب لصفات (عدد القرون علي النبات ، عدد الفروع على النبات ، محصول النبات ,ووزن 100 بذرة) . كان أفضل أب فى صفة التبكير جيزه 716 و جيزه 2 بينما فى صفة محصول النبات وصفة عدد القرون كان الأب مصر 3 . ولكن الأب جيزة 843 كان أفضل الأصناف فى التفريع .كما أظهرت النتائج أن القدرة الخاصة على الائتلاف كانت أفضل الهجن فى الجيلين الأول والثانى فى الهجن (نوبارية 3 × جيزه 2) لصفة عدد الأيام حتى 50% تزهير وصفة عدد القرون, والهجين (نوبارية 3 × جيزه 843) بالنسبة لصفة عدد الافرع فى النبات والهجين (سخا 2 × جيزة 402) بالنسبة لصفة الطول, والهجين (جيزه 843 × مصر3) بالنسبة لصفة ميعاد النضج وصفة محصول وصفة وزن 100 بذره.