IV. RESULTS AND DISCUSSION

The success of any breeding program depends upon the genetic studies which lead us to effective selection. There are many mating designs to estimate of the type of genetic behavior. In this study for instance, the design of male by female method was used. Estimation of type of gene action in the breeding programs is very useful in improving genetic characters as well as in choosing the most efficient breeding program.

The cross method using male x female was used to provide an estimate of general combining ability for lines being tested. Male x Female analysis is used by (**Kemphorne, 1957**). This design provides information for both general and specific combining ability in addition to its usefulness in estimating various types of gene effects.

A. Inheritance of determinate growth in faba bean :

Crosses between the four indeterminate varieties as females with the five determinate males produced 20 F_1 hybrids with indeterminate habit indicating complete dominance of indeterminate over determinate growth type. Table (7) shows the inheritance of determinate growth.

The F_2 plants segregated into the monohybrid ratio of three indeterminate to one determinate and X^2 ranged from 0.54 in the cross Giza 843 x D_5 to 2.21 in cross Sakha 1 x D_7 and all values of X^2 were non significant. Therefore, determinate growth habit is considered as simple recessive trait. The results were agreement with those reported by **Sjodin (1971) and El-Shawaf *et al.* (1999).**

B.1. Mean performance of F_1 generation :

Mean performance of all studied traits i.e. days to flowering, days to maturity, plant height, first pod height, number of branches/plant, number of

Table (7). Growth habit of F_1 and F_2 in the crosses studied of faba bean *Vicia faba* L.

Crosses	Growth habit F1 Ind.	F1 Det.	F2 Ind.	F2 Det.	Total	Ratio	X^2
Giza 461 x Determinate 5	40	-	95	25	120	3:1	0.90
" x " 6	38	-	96	24'	120	3:1	1.34
" x " 7	39	-	94	24	118	3:1	1.14
" x " 8	38	-	93	23	116	3:1	1.48
" x " 9	40	-	93	24	117	3:1	1.08
Giza 843 x Determinate 5	39	-	94	26	120	3:1	0.54
" x " 6	38	-	95	25	120	3:1	0.90
" x " 7	38	-	94	24	118	3:1	1.14
" x " 8	39	-	93	24	117	3:1	1.08
" x " 9	40	-	95	25	120	3:1	0.90
Sakha 1 x Determinate 5	38	-	94	26	120	3:1	0.54
" x " 6	38	-	95	25	120	3:1	0.90
" x " 7	37	-	96	22	118	3:1	2.21
" x " 8	39	-	95	24	119	3:1	1.23
" x " 9	40	-	94	25	119	3:1	0.81
Nubaria x Determinate 5	37	-	95	25	120	3:1	0.90
" x " 6	40	-	94	24	118	3:1	1.14
" x " 7	39	-	94	25	119	3:1	0.81
" x " 8	39	-	97	23	120	3:1	1.88
" x " 9	40	-	96	24	120	3:1	1.34

X^2, 0.05 = 3.841
Ind. = Indeterminate growth
Det. = Determinate growth

pods/plant, number of seeds/plant, number of seeds/pod, seed yield/plant and 100-seed weight for four females parental varieties, five males and 20 F_1's are presented in Table (8).

Days to flowering :

With regard to 50% flowering, the mean values of the females were (61.83). The highest value was (76.38) for variety Nubaria 1 followed by 75.16 for Giza 461, while the earliest one was for variety Sakha 1 (47.50). However the mean values of males were (81.71). The highest value was (96.16) for male D_5 followed by (92.04) for male D_6, the lowest value was (63.64) for male D_8, indicated the wide variability between males and females. On the other hand, the mean values for F_1 crosses were (75.27). The highest value was (94.18) for cross Nubaria 1 x D_6 followed by crosses, Nubaria 1 x D_5 (88.17), Giza 461 x D_6 (86.68), Giza 461 x D_5 (88.97) and Nubaria 1 x D_9 (83.58), respectively.

The lowest value was for cross Giza 843 x D_8 (54.94) followed by cross Sakha 1 x D_8 (57.11), cross Giza 843 x D_9 (60.54) and cross Sakha 1 x D_9 (62.52).

Days to maturity :

Females ranged from the highest (161.50) for female Giza 461 and Nubaria 1 to the lowest (146.00) for female Sakha 101. The mean values for females were (155.69). While the mean values for males were (160.15), the highest estimate was (163.75) for tester D_5 and the lowest value was (153.50) for male D_9. On the other hand, the mean performance for F_1 crosses was (157.88). Those values ranged from the highest crosses Nubaria 1 x D_8 and Nubaria 1 x D_5 (162.50) followed by crosses Nubaria 1 x D_9, Giza 461 x D_5 (162.00), for cross Nubaria 1 x D_6 (160.50), Giza 461 x D_6 (159.50) to the lowest value by cross Giza 843 x D_7 (153.75), followed by cross Sakha 1 x D_8 (154.00), Sakha 1 x D_6 (154.25) and cross Giza 843 x D_9 (154.75).

Table (8). Mean performance of all studied traits for parental genotypes and their F_1 generations

	Entries	Days to flower.	Days to mat.	Plant height (cm)	First pod height (cm)	No. of bran./ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
	Females :										
1	Giza 461	75.16	161.50	177.32	61.07	4.48	18.68	53.92	2.92	53.30	94.32
2	Giza 843	48.27	153.75	135.98	15.16	5.34	19.81	54.65	2.78	36.89	69.42
3	Sakha 1	47.50	146.00	128.70	21.40	5.09	22.19	64.46	2.90	52.17	79.08
4	Nubaria 1	76.38	161.50	151.33	45.09	5.56	12.64	52.50	4.07	57.26	109.20
	Females mean	*61.83*	*155.69*	*148.34*	*35.69*	*5.12*	*18.32*	*56.38*	*3.17*	*49.91*	*88.00*
	Males :										
1	D_5	96.16	163.75	108.39	72.43	5.96	19.97	66.64	3.36	48.56	72.78
2	D_6	92.04	166.25	117.63	70.37	7.52	29.64	78.66	2.67	69.24	88.17
3	D_7	85.45	160.00	95.16	54.31	7.50	10.41	36.23	3.49	25.28	71.27
4	D_8	63.64	154.75	84.42	43.64	10.91	9.58	24.17	2.56	19.32	80.07
5	D_9	71.25	153.50	91.89	44.91	9.88	15.09	38.44	2.56	27.99	72.61
	Males mean	*81.71*	*160.15*	*99.50*	*57.13*	*8.35*	*16.94*	*48.83*	*2.93*	*38.08*	*76.99*
	Crosses :										
1x1	G. 461 x D_5	85.97	162.00	162.43	70.27	5.26	32.83	111.50	3.40	107.37	96.66
1x2	x D_6	86.68	159.50	177.28	72.14	5.33	34.17	96.57	2.83	91.77	93.78
1x3	x D_7	85.84	159.25	181.08	76.74	5.30	28.17	94.82	3.38	84.64	88.46
1x4	x D_8	71.72	158.75	176.97	58.83	6.64	28.37	91.76	3.34	82.20	89.59
1x5	x D_9	79.22	157.25	172.16	66.53	6.78	26.98	80.53	3.00	79.98	94.75
2x1	G. 843 x D_5	73.49	158.00	140.28	45.23	5.23	33.79	111.94	3.35	95.39	83.19
2x2	x D_6	71.94	157.75	152.50	40.21	5.92	43.29	135.21	3.14	93.32	68.90
2x3	x D_7	67.35	153.75	156.72	43.29	4.57	24.60	91.57	3.71	75.13	82.22
2x4	x D_8	54.94	156 00	155.63	32.44	5.64	28.27	96.09	3.40	72.84	76.32
2x5	x D_9	60.54	154.75	154.35	38.85	5.70	37.63	117.18	3.11	72.20	61.21
3x1	Sakha 1 x D_5	73.26	156 50	154.99	46.97	5.36	33.96	123.43	3.66	123.57	96.97
3x2	x D_6	74.47	154.25	158.11	57.30	5.29	27.26	91.30	3.36	87.86	93.34
3x3	x D_7	71.82	155.00	157.79	43.96	5.92	34.47	135.94	3.94	105.77	78.08
3x4	x D_8	57.11	154.00	149.87	33.94	5.84	25.12	92.00	3.68	88.77	95.72
3x5	x D_9	62.53	152.00	148.53	46.21	6.02	37.88	113.66	3.01	92.55	83.49
4x1	Nubaria 1 x D_5	88.71	162.50	161.98	75.75	6.83	18.68	64.63	3.53	78.12	120.20
4x2	x D_6	94.18	160.50	169.80	75.59	6.99	25.08	83.99	3.37	80.50	96.13
4x3	x D_7	84.92	162.00	169.79	80.06	6.28	20.26	90.46	4.45	79.99	88.59
4x4	x D_8	77.03	162.50	160.61	53.07	7.48	19.39	68.67	3.55	78.90	119.60
4x5	x D_9	83.58	162.00	151.57	49.80	6.75	19.42	65.37	3.37	67.04	102.35
	Crosses mean	*75.27*	*157.88*	*160.62*	*55.36*	*5.96*	*28.98*	*97.82*	*3.43*	*86.90*	*90.48*
	LSD 0.05	**3.56**	**2.50**	**6.50**	**4.03**	**0.51**	**2.66**	**8.33**	**0.37**	**4.35**	**6.64**
	LSD 0.01	**4.66**	**3.29**	**8.55**	**5.31**	**0.67**	**3.50**	**10.93**	**0.49**	**5.72**	**9.50**

D = Determinate growth
Days to mat. = Days to maturity
No. of bran./plant = No. of branches/plant
Days to flower. = Days to flowering

Plant height (cm) :

The mean values of plant height for females were (148.34 cm). The tallest genotype was Giza 461 with highest mean value (177.32). While the shortest female was Sakha 1 (128.70). The mean values of plant height for males were (99.50) ranged from (117.63-84.42) for the two males D_6 and D_8, respectively. On the other hand (160.62) was obtained for F_1 mean values of plant height ranging from the shorter F_1 cross Giza 843 x D_5 (140.28) to the tallest one (181.08) for the cross Giza 461 x D_7 (Table 8).

First pod height (cm) :

This character recorded different estimates for female and males and between mean values of females and males. The mean values for females ranged from (15.16-61.07) with mean values (35.69). Meanwhile the mean values of males were (57.13) ranging from (44.91-72.43). The mean values of F_1 crosses gave (55.36) to the first pod height ranging from lowest value (32.44) to the highest one (80.06) for the crosses 2x4 and 4x3, respectively.

Number of branches/plant :

The determinate lines had the higher mean values of number of branches (8.35) than indeterminate genotypes (5.12). The highest mean number of branches was obtained for L.D_8 (10.91) followed by L.D_9 (9.88) and the lowest mean values of number of branches/plant was (5.96) for L.D_5 indicated the wide variability in parental genotypes. With regard to maternal genotypes, Nubaria 1 had the highest mean number of branches (5.56). In addition, Giza 461 recorded the lowest value (4.46). With respect to F_1, the highest number of branches resulted from the highest number of branches to maternal and parental genotypes (Nubaria 1 x L.D_8), Table (8).

Number of pods/plant :

With regard to no. of pods/plant, the variety Sakha 1 had the highest mean values (22.19) followed by Giza 843 (19.81). For maternal genotypes, the mean pods/plant ranged from (12.64-22.19) and the general mean was (18.32). While he mean values for parental genotypes was (16.94) and the genotype D_6 had highest mean values (29.64) genotype. D_8 recorded the lowest mean values (9.58). These estimates confirmed the diversity between all parents, males and females. On the other hand the mean values of pods/plant for crosses were (28.98). The pods/plant ranged from the highest cross. The highest cross Giza 843 x D_6 (43.29) followed crosses Sakha 1 x D_9 (37.88), Giza 843 x D_9 (37.63) and Sakha 1 x D_7 (34.47), respectively. The crosses Nubaria 1 x D_5, Nubaria 1 x D_8, Nubaria 1 x D_9 and Nubaria 1 x D_7 recorded the lowest values (18.68, 19.39, 19.42 and 20.26), respectively.

Number of seeds/plant :

With respect to number of seeds/plant, the mean values of female genotypes was (56.38). In the same time, the highest (64.46) and lowest (52.50) genotypes were obtained for Sakha 1 and Nubaria 1, respectively. Meanwhile the mean values for male genotypes was (48.83). L.D_5 (78.66 had the highest mean value and D_7 (24.17) was the lowest one. The mean values for F_1 was (97.82) with a wide range from (64.63) to (135.94) for the two crosses (4x1) and (3x3), respectively.

Number of seeds/pod :

The female genotype Nubaria 1 had the highest mean values (4.07) followed by Giza 461. The lowest value was obtained from Giza 843 (2.78) and the mean value was (3.17). While the mean values of male genotypes (2.93), the highest value was obtained from L.D_7 (3.49) and the lowest values were obtained from lines D_8 and D_9 (2.56). The mean values of crosses were (3.43) and the mean of no. of seeds/pod were slightly differed from cross to other. The highest values were obtained from crosses; Nubaria 1 x D_7, Sakha 1 x D_7, Sakha 1 x D_8, Nubaria 1 x D_7 and Nubaria 1 x D_5 had values (4.55, 3.94, 3.68, 4.45 and 3.53), respectively. The lowest value was obtained from cross Giza 461 x D_6 had value (2.83).

Seed yield/plant (g) :

The highest female mean values was obtained from Nubaria 1 (57.26) followed by Giza 461 (53.3), Sakha 1 (52.17) and the lowest value by Giza 843 (63.89). While the mean values for males was (49.91 g). However, the highest value was obtained from D_6 (69.24) followed by D_5 (48.45), D_9 (27.99) and D_8 (19.32 g), respectively. But the mean values was (38.08 g). On the other hand the mean performance for crosses gave (86.9 g), while the highest cross was Sakha 1 x D_5 had (123.57) and the lowest cross Nubaria 1 x D_9 had value (67.04).

100-seed weight (g) :

The highest female mean values was obtained from Nubaria 1 (109.20 g) followed by Giza 461 (94.32), Sakha 1 (79.08) and the lowest value by Giza 843 (69.42 g). While the mean values for males was (76.99). However the highest value was obtained from D_6 (88.17) followed by D_8 (80.07), D_5 (72.78), D_9 (72.61) and D_7 (71.27 g), but the mean values was (76.99 g). On the other hand the mean performance for F_1 crosses gave (90.48 g), while the highest cross was Nubaria 1 x D_5 (120.20) followed by cross Nubaria 1 x D_8 (1196) and the lowest cross was Giza 843 x D_9 had value (61.21 g).

B.2. <u>Mean performance of F_2 generation</u> :

Mean performance of studied traits for four female varieties, five male lines and their 20 F_2's generation are presented in Table (9).

Days to flowering :

For No. of days to flowering, the earliest genotype was Sakha 1 (47.5) followed by Giza 843 (48.27), the late one was obtained by genotype Nubaria 1 (76.38) and the mean values of female genotypes was (61.83). While the mean values of male lines was (81.71), the lowest value was obtained by $L.D_8$ (63.64) and the highest value was obtained by $L.D_5$ (95.16). On the other hand mean

Table (9). Mean performance of all studied traits for parental genotypes and their F_2 generation

	Entries	Days to flower.	Days to mat.	Plant height (cm)	First pod height (cm)	No. of bran./ plant	No. of pods/plant	No. of seeds/plant	No. of seeds/ pod	Seed yield/plant (g)	100-seed weight (g)
	Females :										
1	Giza 461	75.16	161.50	177.32	61.07	4.78	18.63	53.92	2.93	53.30	94.32
2	Giza 843	48.27	153.75	135.98	15.17	5.34	19.81	54.65	2.78	36.89	69.42
3	Sakha 1	47.50	146.00	128.70	21.40	5.09	22.19	64.46	2.89	52.17	79.08
4	Nubaria 1	76.38	161.50	151.33	45.10	5.56	12.64	52.50	4.08	57.26	109.20
	Females mean	*61.83*	*155.69*	*148.34*	*35.69*	*5.19*	*18.32*	*56.38*	*3.17*	*49.91*	*88.00*
	Males :										
1	D_5	96.16	166.25	108.39	72.43	5.96	19.97	66.64	3.36	48.56	72.78
2	D_6	92.04	166.25	117.63	70.37	7.66	29.64	78.66	2.67	69.24	88.17
3	D_7	85.45	160.00	95.16	54.31	7.58	10.41	36.23	3.49	25.28	71.27
4	D_8	63.64	154.75	84.43	43.64	10.91	9.58	24.17	2.56	19.32	80.07
5	D_9	71.25	153.50	91.90	44.91	9.88	15.09	38.44	2.56	27.99	72.61
	Males mean	*81.71*	*160.15*	*99.50*	*57.13*	*8.40*	*16.94*	*48.83*	*2.93*	*38.08*	*76.99*
	Crosses :										
1x1	G. 461 x D_5	79.40	160.25	150.67	57.59	6.23	26.76	80.47	3.02	67.89	84.36
1x2	x D_6	79.73	161.75	158.61	62.03	6.28	30.60	83.47	2.75	68.24	78.75
1x3	x D_7	79.54	160.25	141.58	57.95	7.03	21.89	79.43	3.63	68.80	86.61
1x4	x D_8	55.59	158.00	144.27	40.36	5.99	26.84	86.91	3.23	70.39	85.41
1x5	x D_9	61.31	156.75	156.63	54.94	5.99	23.97	77.00	3.21	62.30	80.89
2x1	G. 843 x D_5	73.50	160.00	140.61	53.51	6.34	25.84	73.41	2.85	64.13	87.66
2x2	x D_6	67.66	158.00	133.89	60.36	6.55	26.68	75.20	2.80	59.96	79.62
2x3	x D_7	63.68	162.25	135.13	41.51	7.60	27.97	85.20	2.95	66.88	83.50
2x4	x D_8	51.26	158.50	139.41	38.62	6.38	25.65	69.31	2.88	59.67	84.45
2x5	x D_9	60.40	156.75	145.39	42.43	5.57	28.60	82.61	3.03	64.55	78.27
3x1	Sakha 1 x D_5	66.87	158.50	133.31	44.74	5.48	23.41	69.12	2.97	60.65	87.95
3x2	x D_6	59.66	154.00	148.89	39.62	5.64	22.95	70.00	2.82	58.41	83.40
3x3	x D_7	67.72	158.25	133.32	47.48	6.40	22.83	73.20	3.21	59.70	81.69
3x4	x D_8	47.63	156.00	117.94	32.53	7.20	21.69	62.33	2.86	57.20	91.72
3x5	x D_9	55.57	156.00	141.17	44.39	5.72	25.77	73.90	2.97	55.98	86.92
4x1	Nubaria 1 x D_5	84.49	162.50	152.03	58.97	5.92	21.01	86.00	4.09	78.99	91.79
4x2	x D_6	86.67	162.25	158.38	60.92	7.44	25.31	88.00	3.47	82.24	93.35
4x3	x D_7	73.46	159.75	144.95	57.79	7.15	23.95	86.80	3.78	79.54	91.80
4x4	x D_8	64.53	158.50	134.56	46.93	7.26	18.28	62.32	3.43	63.19	100.34
4x5	x D_9	79.53	156.50	152.99	57.01	6.16	25.26	74.40	3.01	71.62	96.06
	Crosses mean	*68.41*	*158.74*	*143.19*	*49.98*	*6.42*	*24.76*	*76.95*	*3.15*	*66.02*	*86.73*
	LSD 0.05	**3.10**	**2.34**	**5.82**	**4.51**	**0.44**	**2.48**	**5.77**	**0.34**	**5.06**	**7.40**
	LSD 0.01	**4.09**	**3.08**	**7.64**	**5.93**	**0.57**	**3.26**	**7.59**	**0.45**	**6.63**	**9.74**

D = Determinate growth
Days to mat. = Days to maturity
No. of bran./plant = No. of branches/plant
Days to flower. = Days to flowering

values of F_2 crosses was (68.41). However, the highest value was obtained by cross Nubaria 1 x D_6 (86.67) as a late flowering followed by crosses Nubaria 1 x D_5, Nubaria 1 x D_7, Giza 461 x D_6, Giza 461 x D_7 and Nubaria 1 x D_9. While the earliest cross was obtained by the two early female and male genotypes by Sakha 1 x D_8 (47.63).

Days to maturity :

With respect to days to maturity, the female genotypes ranged from (153.75 to 161.5) for Giza 843 and Nubaria 1, respectively. The mean values of females was (155.69). While days to maturity for males ranged from L.D_9 (153.5) to L.D 5 (166.25) and the mean values was (160.15). On the other hand, the mean values of F_2 crosses for days to maturity was (158.74) and the late cross was Nubaria 1 x L.D_6 had value of (162.5). The more early F_2 crosses were obtained from the earlier female genotype Sakha 1 and the five male parents (Table 9).

Plant height (cm) :

The mean values of female parents was (148.34 cm), the tallest genotype was obtained by Giza 461 (177.32), and Sakha 1 (128.7) was the shorter one. While the mean values of male parents was (99.5 cm), the highest value was obtained by L.D_6 (117.63) and lowest value was obtained by L.D_8 (84.43). On the other hand, the mean values of F_2 crosses was (143.19 cm), the highest value was (158.61 cm) for the tallest cross Giza 461 x D_6 followed by crosses Nubaria 1 x D_6, Giza 461 x D_9, Nubaria 1 x D_9 and Giza 461 x D_5, respectively. While the lowest value was (117.94) for the shorter cross Sakha 1 x D_8.

First pod height :

The mean values of female genotypes for first pod was (35.19), ranged from (15.17-61.07) for the two varieties Giza 843 and Giza 461, respectively. While the mean values of first pod height males was (57.13 cm), L.D_5 recorded the highest pod height (72.43) and L.D_9 recorded the lowest one (44.91). On the other hand, the mean values of F_2 crosses for first pod was (49.98 cm), the highest value was for cross Giza 461 x L.D_6 (62.03 cm). While the lowest value was (32.53 cm) was obtained by Sakha 1 x D_8.

Number of branches/plant :

The mean values of female for No. of branches was (5.19), the highest value (5.56) was obtained by variety Nubaria 1 and Giza 461 had the lowest value (4.78). While, the mean values was obtained by L.D_8 (10.91) and the lowest value was (5.96) for L.D_5. On the other hand, the mean values of F_2 crosses was (6.42), the crosses 1x3, 2x3, 3x4, 4x2, 4x3 and 4x4 had the highest mean values of number of branches (Table 9).

Number of pods/plant :

The mean values of maternal genotypes for No. of pods was (18.32), the highest value was obtained by variety Sakha 1 (22.19), the lowest value was (12.64) for Nubaria 1. While the mean values of parental genotypes for No. of pods was (16.94). On the other hand, the mean values of F_2 crosses was (24.76), the highest value was (30.6) was obtained by cross Giza 461 x D_6. While the lowest value (18.28) was obtained by Nubaria 1 x D_8 (Table 9).

Number of seeds/plant :

The mean values of females for No. of seeds/plant was (56.38), the highest value was (64.46) for Sakha 1 and the lowest value was (52.5) for Nubaria 1. While the mean values of males was (48.83). The highest (78.66) and the lowest (24.17) mean values were obtained by L.D_6 and L.D_8, respectively. On the other hand, the mean values of F_2 crosses for No. of seeds/plant was (76.95). The cross (4x2) had the highest value (88.00) and cross (4x4) gave the lowest number of seeds/plant (62.32), (Table 9).

Number of seeds/pod :

Regarding number of seeds/pod, the mean values of females and males were (4.08 and 2.93), respectively. While, the crosses (4x1) and (1x2) showed the highest and the lowest mean values of no. of seeds/pod, respectively (Table 9).

Seed yield/plant :

The mean values of females for seed yield/plant was (49.91 g), the mean values of males was (38.08 g). On the other hand, the mean values for seed yield of crosses ranged from (55.98 to 82.24) for the crosses (3x5) and (4x2), respectively with mean value of (66.02).

100-seed weight (g) :

The mean values of females for 100-seed was (88 g), the highest value (109.2) was obtained by Nubaria 1 and Giza 843 gave the lowest mean values (69.93). While, the mean values of males was (76.99 g), ranged from (80.07 to 71.27) for D_8 and D_9, respectively. With respect to F_2, the crosses (4x4) and (4x5) gave the highest mean values of 100-seed weight. It could be concluded that the above mentioned parents and crosses would be interesting and prospective for the future in faba bean breeding for improving seed yield and yield components.

The mean performance (x), experimental error variance (σ^2e) and coefficient of variability (C.V. %) for F_1 and F_2 generations of all studied traits are presented in Table (10). The values of mean performance (x) for all studied traits in the F_1 generation are found to be more than their corresponding values in the F_2 generation except for days to maturity and No. of branches/plant, while all studied traits in the F_1 generation showed the highest values of (σ^2e) more than their corresponding values in the F_2 generation except for first pod height, seed yield/plant and 100-seed weight. The highest value of (σ^2e) in the F_1 generation was (47.67) for No. of seeds/plant, the lowest value was (0.10) for

Table (10). Mean performance (x), experimental error variance (σ^2e) and coefficient of variability (C.V. %) for all studied traits on the F_1 and F_2 generations

Traits		X	σ^2e	C.V. %
Days to flowering	F_1	74.50	8.71	3.96
	F_2	68.03	6.62	3.78
Days to maturity	F_1	157.91	4.30	1.30
	F_2	158.60	3.77	1.22
Plant height (cm)	F_1	148.40	29.04	3.63
	F_2	136.40	23.26	3.54
First pod height (cm)	F_1	52.95	11.18	6.30
	F_2	49.20	13.99	7.60
No. of branches/plant	F_1	6.26	0.18	6.78
	F_2	6.60	0.13	5.46
No. of pods/plant	F_1	25.43	4.86	8.67
	F_2	22.50	4.23	9.14
No. of seeds/plant	F_1	83.66	47.67	8.25
	F_2	69.30	22.86	6.89
No. of seeds/pod	F_1	3.31	0.10	9.55
	F_2	3.11	0.08	9.09
Seed yield/plant (g)	F_1	73.38	12.98	4.91
	F_2	58.98	17.61	7.12
100-seed weight (g)	F_1	87.81	30.27	6.27
	F_2	85.20	37.60	7.19

No. of seeds/pod. While the highest value of ($\sigma^2 e$) in the F_2 generation was (37.6) for 100-seed weight, the lowest value was (0.08) for No. of seeds/pod. On the other hand, all studied traits in the F_1 generation showed the highest values of (C.V. %) more than their corresponding values in the F_2 generation except for first pod height, No. of pods/plant, seed yield/plant and 100-seed weight. The highest value of (C.V. %) in the F_1 generation was (9.55) for No. of seeds/pod, the lowest value was (1.3) for days to maturity while, the highest value of (C.V. %) in the F_2 generation was (9.14) for No. of pods/plant, the lowest value was (1.22) for days to maturity.

C.1. Analysis of variance :

F_1 generation :

The ordinary analysis of variance for all studied traits for F_1 generation are presented in Table (11). Significant F_1 mean squares were detected for all studied traits. Replication mean squares were found to be significant for only trait of days to maturity. Genotypes, parents and their resultant crosses mean squares were found to be highly significant for all studied traits, indicating significant of all differences among these publications.

Parent vs. crosses mean squares, as an indication of average heterosis overall crosses, were found to be highly significant for all studied traits except days to maturity was insignificant. This may indicate that the average heterosis could be pronounced for all studied traits.

Partitioning of crosses mean squares to its three components, i.e., varieties (females), lines (males) and females x males showed significant differences for all studied traits. Therefore, mean squares of females were found to be highly significant for all studied traits except No. of seeds/pod. While mean squares of male lines were highly significant for

Table (11). Mean square estimates of ordinary analysis and combining ability analysis for all studied traits on the F_1 generation

S.O.V.	d.f	Days to flowering	Days to maturing	Plant height	First pod height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
Replications	3	20.04	14.95*	18.37	19.88	0.01	7.65	51.35	0.02	15.18	48.71
Entries	28	680.15**	75.99**	2752.43**	1156.46**	7.91**	290.98**	3351.77**	0.789**	2510.30**	821.60**
Parents	8	1211.00**	161.19**	3699.07**	1534.60**	19.27**	162.24**	1149.03**	1.045**	1124.68**	694.12**
P. vs. C.	1	142.20**	0.01	38587.15**	1494.91**	24.48**	3241.16**	51729.42**	3.993**	47112.20**	1835.77**
Crosses (C)	19	484.95**	44.11**	467.80**	966.79**	61.41**	189.92**	1733.05**	0.514**	746.27**	821.99**
Females (F)	3	1999.18**	227.51**	2036.72**	4301.46**	8.05**	668.27**	5897.04**	0.760	1968.48**	3247.08**
Males (M)	4	757.91**	22.24**	382.55**	906.07**	2.42*	132.27	789.95	1.450**	1293.14**	679.09*
Females x Males (FxM)	12	15.41	5.55	103.99**	153.37**	0.78**	89.55**	1006.49**	0.138	258.42**	263.36**
Error	84	8.71	4.30	29.04	11.80	0.18	4.86	47.67	0.096	12.98	30.27

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

all studied traits except both No. of branches/plant, 100-seed weight were significant. In the same time, No. of pods/plant and No. of seeds/plant were insignificant. Mean squares of females x males were found to be highly significant for all studied traits except days to flowering, days to maturity and No. of seeds/pod were insignificant. Similar results were obtained by **Dawwam (1991), Mohamed (1997) and Yamani (1998), Abdalla *et al.* (1999), El-Harty (1999) and El-Hifny *et al.* (2001)**.

C.2. Analysis of variance for F_2 generation :

Mean squares for all studied traits for F_2 generation are presented in Table (12).

Mean squares for replications were found to be highly significant for days to maturity, plant height and No. of pods/plant. Genotypes, parents and crosses mean squares were highly significant for all studied traits.

Parents vs. crosses mean squares were significant for no. of seeds/pod and highly significant for all studied traits except days to maturity. Partitioning of crosses mean squares to its three components, i.e., (females), (males) and females x males have significant differences for most studied traits. Therefore, mean squares of females were found to be highly significant for all studied traits except it was insignificant for No. of branches/plant and significant for No. of pods/plant with respect to mean squares of males were found to be highly significant for all studied traits except No. of pods/plant; No. of seeds/pod and seed yield/plant were insignificant.

Regarding lines x testers (females x males) mean squares found to be highly significant for all studied traits except 100-seed weight was insignificant. Similar results were obtained **by Hendawy *et al.* (1994), Kabeel (1994), Kaul and Vaid (1996), Attia (1998), Darwish *et al.* (1999) and Rabia (2001)**.

Table (12). Mean square estimates of ordinary analysis and combining ability analysis for all studied traits on the F_2 generation

S.O.V.	d.f	Days to flowering	Days to maturing	Plant height	First pod height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
Replications	3	2.71	19.82**	146.05**	12.52	0.05	21.17**	26.31	0.10	5.51	89.17
Entries	28	739.08**	66.60**	1772.10**	674.66**	6.97**	115.12**	1044.06**	0.67**	936.10**	315.11**
Parents	8	1211.00**	178.63**	3699.43**	1564.38**	19.39**	162.19**	1149.03**	1.04**	1122.52**	693.30**
P. vs. C.	1	494.15**	8.09	11996.17**	140.98**	7.66**	1291.88**	15231.00**	0.32*	12768.18**	581.24**
Crosses (C)	19	553.27**	22.51**	422.49**	328.13**	1.70**	33.37**	253.15**	0.53**	229.60**	141.86**
Females (F)	3	1608.49**	44.71**	1114.60**	908.46**	1.74	82.55*	528.59**	1.74**	1013.10**	612.11**
Males (M)	4	1259.88**	41.83**	736.64**	624.06**	3.87**	29.05	525.50**	0.45	119.34	105.35**
Females x Males (FxM)	12	53.93**	10.53**	144.74**	84.40**	0.97**	22.52**	93.51**	0.25**	70.49**	36.47
Error	84	6.62	3.77	23.26	13.99	0.13	4.23	22.86	0.08	17.61	37.61

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

D. <u>Heterotic effect and inbreeding depression</u> :

It is known fact that the phenomena of heterosis (hybrid vigor) is of common occurrence in both out-crossed and self pollinated crops. Faba bean, which is often a self fertilized crop, also, shows hybrid vigor when hybridization takes place between homozygous varieties. It should be noted that positive significant values of heterosis are indicating favorable value for studied traits except for earliness where the negative values would be beneficial.

Values of mid and better parent heterosis and inbreeding depression for each of the traits under study are presented in Table (13) as follows :

Days to flowering :

Nine crosses (Giza 461 x D_7, Giza 461 x D_9, Sakha 1 x D_6, Sakha 1 x D_7, Sakha 1 x D_9, Nubaria 1 x D_6, Nubaria 1 x D_7, Nubaria 1 x D_8 and Nubaria 1 x D_9) showed highly significant positive heterotic effect relative to mid parent, ranged from 4.94% (Nubaria 1 x D_7) to 13.24% (Nubaria 1 x D_9), but only one cross (Giza 461 x D_6) showed significant positive heterotic effect relative to mid parent (3.68 %). On the other hand, all crosses showed highly significant positive effect relative to better parent, ranged from 11.18 % (Nubaria 1 x D_7) to 56.48% (Sakha 1 x D_6). The results are agreement with those reported by **El-Hosary (1992), El-Hady *et al.* (1997) and El-Refaey (1999).**

Regarding to inbreeding depression values, highly significant positive values were obtained from all crosses except four crosses, three of them showed insignificant, the other cross showed significant positive. These results agreed with those obtained by **Havbetinek *et al.* (1985) and Abaas (2001).**

Days to maturity :

Only two crosses (Nubaria 1 x D_8, and Nubaria 1 x D_9) showed significant positive heterotic effect relative to mid parent (2.78% and 2.86%), but one cross (Giza 461 x D_6) showed significant negative effect relative to mid parent (-2.68 %). On the other hand, seven crosses (Sakha 1 x D_5, Sakha 1 x

Table (13). **Percentage of heterosis relative to mid-parent (MP), better-parent (BP) and inbreeding depression (ID %) for all studied traits on the F_1 generation**

Crosses		Days to flowering			Days to maturity			Plant height			First pod height			No. of branches/plant		
		MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID
G. 461	x D_5	-0.37	14.38**	7.6**	-0.37	0.81	1.0*	13.67**	-8.39*	7.2**	5.27*	-2.98	18.0**	-2.05**	-11.70**	-18.5*
	x D_6	3.68*	15.33**	8.0**	-2.68*	-1.23	-1.4	32.26**	0.05	10.5**	6.77**	2.52	14.0*	-14.31**	-30.40**	-17.8*
	x D_7	6.89	14.20**	7.3**	-0.93	-0.44	-0.6	32.95**	2.13	21.8**	32.83**	25.50**	24.5*	-14.24**	-30.80**	-32.6*
	x D_8	3.34	12.70**	22.5**	0.44	2.58	0.5	35.19**	-0.19	18.5**	12.36**	-3.67	31.4**	-15.41**	-39.10**	9.8
	x D_9	8.22**	11.20**	22.6**	-0.43	2.48	0.3	27.90**	-2.90	9.0**	25.55**	8.94**	17.4**	-7.50**	-31.40**	11.7*
G. 843	x D_5	1.76	52.25**	-0.0	-0.50	2.73	-1.3*	14.80**	3.15	-0.2	3.26	-37.60**	-18.3**	-3.53**	-8.40**	-21.2**
	x D_6	2.54	49.04**	5.9**	-1.38	2.40	-0.2	20.30**	12.13**	12.2**	-5.99**	-42.90**	-50.1**	-8.92**	-22.70**	-10.6
	x D_7	0.73	39.53**	5.4**	-1.98	0.00	-5.5**	35.60**	15.24**	13.8**	24.61**	-20.30**	4.1	-29.30**	-39.70**	-66.3**
	x D_8	-1.82	13.82**	6.7	1.10	1.43	-1.6	41.23**	14.43**	10.4**	10.34**	-25.70**	-21.5	-30.63**	-48.30**	-13.1**
	x D_9	1.46	25.42**	0.2	0.78	0.85	-1.3*	35.50**	13.49**	5.8*	29.32**	-13.50**	-9.2	-25.10**	-42.30**	2.3
Sakha 1	x D_5	1.99	54.23**	8.7**	1.03	7.19**	-1.3	30.80**	20.43**	14.0**	0.11	-35.20**	4.7	-2.72**	-10.07**	-2.2
	x D_6	6.74**	56.76**	19.9**	-1.15	5.68**	0.2	28.34**	22.85**	5.8*	24.86**	-18.60**	30.9**	-17.08**	-30.90**	-6.6
	x D_7	8.05**	51.22**	5.7**	1.30	6.16**	-2.0	41.00**	22.60**	15.5**	16.11**	-19.02**	-8.0**	-6.62**	-21.90**	-8.1
	x D_8	2.77	20.23**	16.6**	2.39	5.48**	-1.3	40.60**	16.45**	21.3**	4.37*	-22.23**	4.1	-27.00**	-46.50**	-23.3
	x D_9	5.32**	31.64**	11.1**	1.47	4.10**	-1.4*	34.66**	15.40**	4.9	39.35**	2.89	3.9	-19.60**	-39.07**	4.9
Nubaria 1	x D_5	2.83	16.14**	4.8*	-0.06	0.62	0.0	27.70**	7.06	6.1*	28.89**	4.58	2.1**	18.60**	14.60**	13.3
	x D_6	11.84**	23.30**	8.0**	-1.47	-0.62	-1.0	26.25**	12.23**	6.7	30.92**	7.42**	19.4	5.75**	-8.75**	-6.4
	x D_7	4.34**	11.18**	13.5**	0.45	1.25	1.4*	37.70**	12.22**	14.6**	61.05**	47.40**	27.8**	-4.41**	-17.15**	-13.9
	x D_8	10.03**	21.04**	16.2**	2.78*	4.97**	2.5**	36.23**	6.15	16.2**	19.61**	17.70**	11.6*	-9.22**	-31.44**	2.9
	x D_9	13.24**	17.32**	5.1*	2.86*	5.54**	3.4**	24.65**	0.18	-0.9*	10.64**	10.40**	-14.5	-12.60**	-31.70**	8.7*
LSD 0.05		**3.56**	**4.11**		**2.50**	**2.89**		**6.50**	**7.51**		**4.03**	**4.66**		**0.51**	**0.59**	
LSD 0.01		**4.66**	**5.41**		**3.29**	**3.81**		**8.55**	**9.87**		**5.31**	**6.11**		**0.67**	**0.78**	

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.
D = Determinate growth

Table (13). Continue

Crosses	No. of pods/plant			No. of seeds/plant			No. of seeds/pod			Seed yield/plant (g)			100-seed weight (g)		
	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID
G. 461 x D_5	70.10**	64.40**	18.5*	84.90**	67.32**	27.8**	7.94**	1.19**	0.7	116.04**	111.20**	36.8**	15.60**	2.48	12.7**
x D_6	41.20**	15.28**	10.4	45.70**	22.77**	13.6	1.07**	-3.40**	2.8	55.80**	32.50**	25.6*	2.83	-0.57	16.0**
x D_7	94.88**	50.80**	22.3*	110.24**	75.85**	16.2	5.30**	-3.15**	-7.4	122.40**	66.50**	18.7*	6.84*	-6.21	2.0
x D_8	100.78**	51.90**	5.4	134.98**	70.20**	5.3	25.50**	17.70**	3.3	134.30**	61.70**	14.4	2.70	-5.30	4.7*
x D_9	59.64**	44.43**	11.2	74.30**	49.40**	4.4	9.09**	2.39**	-7.0	102.90**	57.30**	22.1*	13.50**	0.46	14.6**
G. 843 x D_5	69.80**	69.20**	23.5*	85.13**	68.40**	34.4**	9.12**	-0.29	14.9*	123.40**	96.40**	32.8*	21.20**	18.28**	-5.4
x D_6	75.26**	46.10**	38.4*	103.09**	72.20**	44.4**	15.02**	12.95**	10.8**	75.80**	34.80**	35.7*	-12.60**	-20.90**	-15.6**
x D_7	62.80**	24.20**	-13.7	101.70**	67.60**	6.9	18.79**	6.88**	20.5	141.70**	103.70**	11.0	16.90**	15.36**	-1.6
x D_8	92.31**	42.70**	9.3	143.90**	75.80**	27.9**	27.34**	22.30**	15.3**	194.70**	124.60**	18.0	2.10	-4.70	-10.6**
x D_9	115.03**	89.95**	24.0**	120.70**	114.40**	29.5**	16.80**	11.90**	2.0	122.60**	95.70**	10.6	-13.80**	-15.70**	-27.9**
Sakha 1 x D_5	61.10**	53.40**	31.0**	88.20**	85.22**	44.0**	16.93**	8.93**	18.9**	149.10**	143.90**	50.9**	27.60**	22.10**	9.3**
x D_6	5.25**	-8.03**	15.8	27.50**	16.70**	23.3*	20.43**	15.90**	16.0**	46.50**	26.90**	33.5**	11.70**	5.86	10.6**
x D_7	111.50**	55.34**	16.6**	169.90**	110.89**	46.1**	23.13**	12.90**	18.5**	178.50**	108.70**	43.0**	3.90	-1.26	-4.6
x D_8	52.99**	13.20**	13.7	107.70**	42.72**	32.2**	34.80**	26.90**	22.3**	153.60**	75.20**	35.6**	20.30**	19.60**	4.2
x D_9	103.70**	70.70**	32.0**	120.70**	76.30**	35.0**	10.26**	3.79**	1.3	135.30**	82.70**	39.5**	10.07**	5.58	-4.1
Nubaria 1 x D_5	14.60**	-6.46**	-12.5	8.44*	-3.02	-33.0*	-5.38**	-13.70**	-15.9	47.70**	36.40**	-1.1	32.30**	-10.07*	23.6**
x D_6	18.64**	-15.40**	-0.9	28.03**	6.78	-4.8	-0.30	-17.40**	-3.0	27.20**	16.30**	-2.2	-2.60	-11.90**	4.5
x D_7	76.20**	60.30**	-18.2	103.70**	72.30**	4.0	17.40**	9.09**	15.0**	93.70**	39.70**	0.6	-1.80	-18.90**	-3.6
x D_8	74.50**	53.40**	5.7	79.40**	30.80**	9.2	6.93**	-12.99**	3.4	106.00**	37.80**	20.0	26.40**	9.52*	16.1**
x D_9	39.70**	28.70**	-30.0	43.70**	24.50**	-13.8*	1.50**	-14.40**	10.7	57.30**	17.08**	-6.8	1.24	-6.30	6.1
LSD 0.05	**2.66**	**3.07**		**8.33**	**9.62**		**0.37**	**0.43**		**4.35**	**5.02**		**6.64**	**7.66**	
LSD 0.01	**3.50**	**4.04**		**10.93**	**12.64**		**0.49**	**0.57**		**4.72**	**6.60**		**9.50**	**10.08**	

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.
D = Determinate growth

D_6, Sakha 1 x D_7, Sakha 1 x D_8, Sakha 1 x D_9, Nubaria 1 x D_8 and Nubaria 1 x D_9) showed highly significant positive heterotic effect relative to better parent, ranged from 4.94% (Nubaria 1 x D_8) to 7.19% (Sakha 1 x D_5). These results are agreement with those reported by **Abul Naas *et al.* (1991), El-Hosary *et al.* (1992), El-Galaly (1997) and El-Hosary (1998 b).**

Concerning to inbreeding depression, crosses (Giza 461 x D_5, Nubaria 1 x D_7, Nubaria 1 x D_8 and Nubaria 1 x D_9) showed highly significant and significant positive values, while crosses (Giza 843 x D_5, Giza 843 x D_7, Giza 843 x D_9 and Sakha 1 x D_9) showed significant and highly significant negative values of inbreeding depression. The rest of crosses were insignificant. These results agreed with those reported by **Steuckardt and Dietrich (1986) and Scheybal (1988).**

Plant height :

All crosses showed highly significant positive heterotic effect relative to mid parent ranged from 13.67% (cross Giza 461 x D_5) to 40.6% (cross Sakha 1 x D_8). On the other hand, eleven crosses showed highly significant positive heterotic effect relative to better parent, ranged from 12.13% (cross Giza 843 x D_6) to 22.85% (cross Sakha 1 x D_6), while only one cross (Giza 461 x D_5) showed significant negative heterotic effect relative to better parent. These results are agreement with those reported by **Bargale and Billore (1990), Abul Naas *et al.* (1991), El-Hosary *et al.* (1992), Kabeel (1994), El-Hady *et al.* (1998 b), Abdalla (1999) and El-Refaey (1999).**

Inbreeding depression values were highly significant positive in the thirteen crosses, three crosses were significant positive. On the other hand, only one cross Nubria 1 x D_9 was significant negative. While three crosses were insignificant. Similar results were also reported by **Abul Naas *et al.* (1991) and El-Refaey (1999).**

First pod height :

All crosses showed highly significant positive heterotic effect relative to mid parent except five crosses. The highest estimate was 61.05% for cross (Nubaria 1 x D_7) followed by 39.35%, 32.83% and 30.92% for the three crosses (Sakha 1 x D_9, Giza 461 x D_7 and Nubaria 1 x D_6), respectively. While the lowest value was 6.77% for cross (Giza 461 x D_7). Also, two crosses showed significant positive heterotic effect relative to mid parent, had values of 4.37% for cross (Sakha 1 x D_8) and 5.27% for cross (Giza 461 x D_5). However, only one cross (Giza 843 x D_6) 5.99% showed highly significant negative heterotic effect relative to mid parent. On the other hand, crosses (Giza 461 x D_7, Giza 461 x D_9, Nubaria 1 x D_6, Nubaria 1 x D_7, Nubaria 1 x D_8 and Nubaria 1 x D_9) showed highly significant positive heterotic effect relative to better parent, had values, 25.5%, 8.94%, 7.42%, 47.4%, 17.7% and 10.4%, respectively. While crosses (Giza 843 x D_5, Giza 843 x D_6, Giza 843 x D_7, Giza 843 x D_8, Giza 843 x D_9, Sakha 1 x D_5, Sakha 1 x D_6, Sakha 1 x D_7 and Sakha 1 x D_8) showed highly significant negative heterotic effect relative to better parent, had values –37.6%, -42.9%, -20.3%, -25.7%, -13.5%, -35.2%, -18.6%, -19.02% and –22.23%, respectively. The results are agreement with those reported by **Omar *et al.* (1992), Kabeel (1994), El-Hady *et al.* (1998 b), and El-Refaey (1999).**

Regarding to inbreeding depression of first pod height, six crosses showed highly significant positive values, three crosses showed significant positive values, while three crosses showed highly significant negative values of inbreeding depression. The results are agreement with those reported by **Filippetti and Riccardi (1988) and El-Refaey (1999).**

Number of branches/plant :

All crosses except two showed highly significant negative heterotic effect relative to mid parent ranged from –30.63% by cross Giza 843 x D_8 (lowest cross) to –2.05% by cross Giza 461 x D_5 (highest cross). The highest values followed –29.3%, -27.0%, -25.1% and –19.6% for the crosses Giza 843 x D_7, Sakha 1 x D_8, Giza 843 x D_9 and Sakha 1 x D_9, respectively. However, the Nubaria 1 x D_6 and Nubaria 1 x D_5 showed highly significant positive increase relative to mid parent, had values of 5.75% and 18.6%. On the other hand, all crosses except one cross showed highly significant negative heterotic effect relative to better parent, ranged from –48.3% by cross Giza 843 x D_8 (lowest cross) to –8.4% by cross Giza 843 x D_5 (highest cross), while, only cross Nubaria 1 x D_5 showed highly significant positive heterotic effect, had value 14.6% relative to better parent. Negative significant values of inbreeding depression were detected for crosses Giza 461 x D_5, Giza 461 x D_6 and Giza 461 x D_8. While crosses Giza 843 x D_5, Giza 843 x D_7 and Giza 843 x D_8 showed highly significant negative values. On the other hand, two crosses, Giza 461 x D_9 and Nubaria 1 x D_9 showed significant positive values. The results are agreement with those reported by **El-Refaey (1999).**

Number of pods/plant :

All crosses showed highly significant positive increase relative to mid parent, had value ranged from 5.25% by cross Sakha 1 x D_5 (lowest cross) to 115.03% by cross Giza 843 x D_9 (highest cross), while all crosses except three crosses showed highly significant positive heterotic effect relative to better parent, had values ranged from 13.2% by cross Sakha 1 x D_8 (lowest cross) to 89.95% by cross Giza 843 x D_9 (highest cross), however, crosses, Sakha 1 x D_6, Nubaria 1 x D_5 and Nubaria 1 x D_6 showed highly significant negative decrease relative to better parent, had values –8.03%, -6.46% and –15.4%. These results were in accordance by **Ebmeyer (1988), Omar *et al.* (1992), Abo El-Zahab *et al.* (1994 a), El-Galaly (1997), Helal (1997) and El-Refaey *et al.* (1999).**

Regarding to inbreeding depression in F_2 plants five crosses; Giza 843 x D_6, Giza 843 x D_9, Sakha 1 x D_5, Sakha 1 x D_7 and Sakha 1 x D_9 showed highly significant positive values, while three crosses; Giza 461 x D_5, Giza 461 x D_7 and Giza 843 x D_5 showed significant positive values.

Number of seeds/plant :

All crosses except only one cross showed highly significant positive heterotic effect relative to mid parent, had values ranged from 27.5% by cross Sakha 1 x D_6 (lowest cross) to 134.98% by cross Giza 461 x D_8 (highest cross), in addition, one cross (Nubaria 1 x D_5) showed significant positive heterotic effect, had value 8.44%. On the other hand, all crosses except two crosses showed highly significant positive increase relative to better parent, ranged from 16.7% by cross Sakha 1 x D_6 to 114.4% by cross Giza 843 x D_9. Two crosses Nubaria 1 x D_5 and Nubaria 1 x D_6 showed insignificant negative and positive increase relative to better parent. The results are agreement with those reported by **Ebmeyer (1988), El-Hady *et al.* (1991 a, 1997 and 1998 b), Omar *et al.* (1992), Abo El-Zahab *et al.* (1994 a) and El-Refaey (1999).**

The inbreeding depression of F_2 plants detected for twelve crosses. Nine crosses showed highly significant positive values, while only one cross (Sakha 1 x D_6) showed significant positive. On the other hand, two crosses; Nubaria 1 x D_5 and Nubaria 1 x D_9 showed significant negative values. The results are agreement with those reported by **Habetinek (1985) and Scheybal (1988).**

Number of seeds/pod :

All crosses except two crosses showed highly significant positive heterotic effect relative to mid parent ranged from 1.07% by cross Giza 461 x D_6 (lowest cross) to 34.8% by cross Sakha 1 x D_8 (highest cross). On the other hand, cross Nubaria 1 x D_5 showed highly significant negative heterotic effect, gave –5.38% only one cross (Nubaria 1 x D_6) had insignificant decrease relative to mid parent. On the other hand, thirteen crosses showed highly significant positive increase relative to better parent, ranged from 1.19% by cross Giza 461 x D_5 (lowest cross) to 26.9% by cross Sakha 1 x D_8 (highest cross). While crosses (Giza 461 x D_6, Giza 461 x D_7, Nubaria 1 x D_5, Nubaria 1 x D_6, Nubaria 1 x D_8 and Nubaria 1 x D_9) showed highly significant negative decrease, had values –3.4%, -3.15%, -13.7%, -17.4%, -12.99% and

−14.4%, respectively. Only cross (Giza 843 x D_5) showed insignificant decrease relative to better parent as shown in Table (13). These results are agreement with those reported by **Ebmeyer (1988), Bargale and Billore (1990), El-Hosary (1998 b) and Abou Zeid (1999).**

In the F_2 plant, seven crosses showed highly significant positive values of inbreeding depression, while only one cross (Giza 843 x D_5) showed significant positive value. The results are agreement with those reported by **Scheybal (1988) and Abaas (2001).**

Seed yield/plant :

All crosses showed highly significant positive heterotic effect relative to mid parent, ranged from 27.2% to 194.7%. The highest crosses (Giza 843 x D_8) gave 194.7% followed by crosses Sakha 1 x D_7 (178.5%), Sakha 1 x D_8 (153.6%), Sakha 1 x D_5 (149.1%), Giza 843 x D_7 (141.7%) and Sakha 1 x D_9 (135.3%). While the lowest crosses were Nubaria 1 x D_9 (57.3%), Giza 461 x D_6 (55.8%), Nubaria 1 x D_5 (47.7%), Sakha 1 x D_6 (46.5%) and Nubaria 1 x D_6 (27.2%). On the other hand, all crosses showed highly significant positive increase relative to better parent, the highest cross was Sakha 1 x D_5 (143.9%) followed by Giza 843 x D_8 had value 124.6%, 116.04% by cross Giza 461 x D_5. While cross Nubaria 1 x D_6 gave the lowest value (16.3%) relative to better parent. Similar results were obtained by **Ebmeyer (1988), Abul Naas *et al.* (1991), Kabeel (1998), El-Galaly (1997) and Abou Zeid (1999).**

Regarding to inbreeding depression in F_2 plants, seven crosses; Giza 461 x D_5, Giza 461 x D_6, Giza 461 x D_9, Sakha 1 x D_5, Sakha 1 x D_6, Nubaria 1 x D_5 and Nubaria 1 x D_8 showed highly significant positive values, while only one cross Giza 461 x D_8 showed significant positive. On the other hand, three crosses; Giza 843 x D_6, Giza 843 x D_8 and Giza 843 x D_9 showed highly significant negative values. The results are agreement with those reported by **El-Refaey (1999) and Abaas (2001).**

Generally, when the values of F_1 hybrids exceeded the better parent, the heterosis would be of economical value. The result of this study revealed the presence of heterosis over mid parent values for most studied traits. The presence of useful heterosis from the better parent was found for some traits especially for yield traits, number of pods and seeds/plant. Therefore, the expected selection program in these materials in the advanced segregating populations would not be limited to the superior specific hybrids, and the expected improvement would be fruitful. These results are in agreement with those reported by many of investigators.

100-seed weight :

Ten crosses showed highly significant positive heterotic effect relative to mid parent, ranged from 6.84% by cross (Giza 461 x D_7) to 32.3% by cross (Nubaria 1 x D_5), followed by (Sakha 1 x D_5, Nubaria 1 x D_8 and Giza 843 x D_5) had values 27.6%, 26.4% and 21.2%, respectively. While, cross (Giza 461 x D_7) showed significant increase, had value 6.84%. However, crosses (Giza 843 x D_6) and (Giza 843 x D_9) showed highly significant negative decrease relative to mid parent, had values –12.6% and –13.8%. On the other hand, four crosses (Giza 843 x D_5, Giza 843 x D_7, Sakha 1 x D_5 and Sakha 1 x D_8) showed highly significant heterotic effect relative to better parent and cross (Nubaria 1 x D_8) exhibited significant positive increase. While crosses (Giza 843 x D_6, Giza 843 x D_9, Nubaria 1 x D_6 and Nubaria 1 x D_7) showed highly significant negative heterotic effect and cross (Nubaria 1 x D_5) showed significant negative heterotic effect relative to better parent, had value –10.07%. Similar results were noted by **Ebmeyer (1988) and El-Refaey (1999).**

The crosses (Giza 461 x D_5, Giza 461 x D_6, Sakha 1 x D_5, Sakha 1 x D_6, Sakha 1 x D_7, Sakha 1 x D_8 and Sakha 1 x D_9 showed highly significant positive of inbreeding depression, while three crosses; Giza 461 x D_9, Giza 843 x D_5 and Giza 843 x D_6) showed significant positive values. The results are noted **by Steuckardt and Dietrich (1986) and El-Refaey (1999).**

E. <u>Combining ability effects</u> :

The variance of the crosses was partitioned into: **a**) main effects of lines and testers as indicators for general combining ability (GCA) and **b**) interaction of lines x testers as indicators for specific combining ability (SCA) **(Bond, 1967).**

Estimation of general combining ability effects of a parent is not an absolute value. It actually depends upon the group of parents to which this particular parent was crossed in the crossing system. If the parent has exactly the same average in its combination as the general average performance of the parents in their combinations, the expected estimate would be zero. Significant departure from zero, wherever the direction would indicate that the parent is much better or much poorer than the overall average of the parents involved in the test. On the other sides, specific combining ability effects of a genotype in any particular cross can be defined as the magnitude of the direction exhibited by the genotype in the cross from the performance expected of it on the basis of its GCA effect. A significant departure from zero in any one cross would indicate specially higher low SCA according to the sign whether plus or minus. Positive SCA values of any cross, means that F_1 or F_2 generation of this cross would produce higher yield relative to the performance of its parents and the magnitude values of this heterosis would depend on the value of the specific combining ability effect. On the same trend; the negative value of SCA effect of any cross indicates that the cross between two varieties would produce less yield than the mid parent performance.

From these points of view, the obtained results of all studied traits could be discussed as follows :

E.1. General combining ability effects :

F_1 generation :

Estimation of general combining ability effect were found to be significantly differed from zero in most cases. The GCA effects of females and males for all studied characters are presented in Table (14).

For days to flowering : as expected, the two early varieties Giza 843 and Sakha 1 had negative and highly significant gca effects, while the other late varieties Giza 461 and Nubaria 1 exhibited undesirable positive gca estimates for earliness. Concerning the male genotypes, D_8 and D_9 had negative and highly significant gca effect, while, the late genotypes D_5, D_6 and D_7 showed highly significant positive values of GCA effects.

For days to maturity : as expected, the early female genotypes Giza 843 and Sakha 1 showed highly significant and positive value of GCA effect. However, the late varieties Giza 461 and Nubaria 1 showed undesirable positive estimates and highly significant GCA effect. Concerning the parental lines D_9 exhibited highly significant negative value of GCA effect, while, the parental line D_5 showed highly significant positive value of GCA effects.

For plant height : The female genotype Giza 461 showed highly significant and positive value of GCA effect, while, Giza 843 and Sakha 1 exhibited highly significant negative values of GCA effects. On the other hand, the male genotypes D_5 and D_9 showed highly significant negative estimates of GCA effects, while, the parental lines D_6 and D_7 showed highly significant and had positive values of GCA effects.

Table (14). **Estimates of general combining ability effects of parental varieties for all studied traits on the F_1 generation**

Entries		Days to flowering	Days to maturing	Plant height	First pod height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
Females :											
Giza 461		6.62**	1.44**	13.38**	13.54**	-0.098	1.12*	-2.80	-0.220**	2.30**	2.16
Giza 843		-9.61**	-1.86**	-8.73**	-15.36**	-0.551**	4.54**	12.56**	-0.090	-5.12**	-16.11**
Sakha 1		-7.42**	-3.56**	-6.77**	-9.68**	-0.276**	2.46**	13.43**	0.096	12.81**	-0.96
Mubaria 1		+10.42**	3.99**	2.12	11.50**	0.905**	-8.41**	-23.20**	0.218**	-9.99**	14.99**
LSD (g-i)	0.05	1.30	0.91	2.40	1.47	0.186	0.97	3.04	0.140	1.59	2.42
	0.01	1.70	1.20	3.12	1.94	0.240	1.28	3.99	0.180	2.09	3.19
LSD (g_i-g_j)	0.05	1.84	1.29	3.40	2.08	0.260	1.37	4.30	0.190	2.24	3.43
	0.01	2.42	1.70	4.40	2.74	0.340	1.81	5.65	0.250	2.95	4.51
Males :											
Determinate	5	5.09**	1.84**	-5.70**	4.20**	-0.292**	0.83	5.04**	0.050	14.22**	8.77**
"	6	6.55**	0.09	3.82**	5.95**	-0.048	3.47**	3.93*	-0.260**	1.47	-2.44
"	7	2.22**	-0.41	5.72**	5.65**	-0.444**	-2.11**	5.36**	0.440**	-0.51	-6.14**
"	8	-10.07**	-0.10	0.14	-10.79**	0.438**	-3.70**	-10.70**	0.084	-6.29**	4.82**
"	9	-3.79**	-1.41**	-3.97**	-5.01**	0.352**	1.50**	-3.65*	-0.310**	-8.95**	-5.03**
LSD (g-i)	0.05	1.46	1.02	2.65	1.65	0.210	1.09	3.40	0.150	1.77	2.72
	0.01	1.91	1.34	3.50	2.16	0.270	1.43	4.47	0.200	2.33	3.57
LSD (g_i-g_j)	0.05	2.06	1.44	3.75	2.33	0.290	1.54	4.81	0.220	2.51	3.84
	0.01	2.70	1.90	4.93	3.06	0.390	2.02	6.32	0.280	3.30	5.05

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

For first pod height : The two female varieties Giza 461 and Nubaria 1 showed highly significant positive values of GCA effects. While, Giza 843 and Sakha 1 had highly significant negative values of GCA effects. Concerning the parental lines D_5, D_6 and D_7 showed highly significant positive values of GCA effects, while, D_8 and D_9 gave highly significant negative values of GCA effects.

For No. of branches/plant : The female genotype Nubaria 1 showed highly significant positive value of GCA effect, in addition the parental lines D_8 and D_9 gave highly significant positive values of GCA effects.

For No. of pods/plant : The female cultivar Giza 461, Giza 843 and Sakha 1 showed significant and highly significant positive values of GCA effect, while Nubaria 1 showed highly significant negative value of GCA effects. On the other hand, the male genotypes D_7 and D_9 showed highly significant positive values of GCA effects, while D_7 and D_8 exhibited highly significant negative values of GCA effects.

For No. of seeds/plant : The female genotypes Giza 843 and Sakha 1 showed highly significant positive values of GCA effect. Nubaria 1 showed highly significant negative estimates of GCA effects. Concerning the parental genotypes D_5, D_6 and D_7 showed significant and highly significant positive values of GCA effects, while, D_9 exhibited highly significant negative value of GCA effects.

For No. of seeds/pod : The female genotypes Giza 461 and Nubaria 1 showed highly significant negative and positive values of GCA effect, respectively. While the parental genotypes D_6 and D_9 exhibited highly significant negative values of GCA effect. However, the D_7 showed highly significant positive value of GCA effects.

For Seed yield/plant : For seed yield/plant the two female genotypes Giza 461 and Sakha 1 gave highly significant positive effects for GCA while both Giza 843 and Nubaria 1 exhibited highly significant negative effects of GCA. In the same time, the male genotype D_5 had a positive highly significant effect of GCA. However, D_8 and D_9 exhibited highly significant negative effects.

For 100-seed weight : The female genotypes Giza 843 and Nubaria 1 showed highly significant negative and positive GCA effects, respectively. While the two male genotypes D_5 and D_8 showed highly significant positive values of GCA effects. However both parental genotype D_9 showed highly significant negative values of GCA effects. These results were in accordance with those reported by **Abo El-Zahab *et al.* (1994 a), Hendawy *et al.* (1994), El-Galaly (1997) and El-Hady *et al.* (1998 b).**

Generally, the late variety Giza 461 was a good combiner for some traits such as No. of pods/plant and seed yield/plant, also, the late variety Nubaria 1 was a good combiner for number of branches/plant, No. of seeds/pod and seed yield/plant. While Giza 843 was a good combiner for earliness (flowering date and maturity times), plant height, first pod height, No. of pods/plant and number of seeds/plant Also the earlier variety Sakha 1 was a good combiner for earliness, plant height, first pod height, No. of pods/plant, No. of seeds/plant and seed yield/plant. On the other side, the late male genotype D_5 was a good combiner for plant height, No. of seeds/plant, seed yield and 100-seed weight. But D_6 was a good combiner for No. of pods/plant and No. of seeds/plant, and D_7 was a good combiner for traits, No. of seeds/plant and No. of seeds/pod. While the early maturing D_8 was a good combiner for earliness (flowering and maturity date), first pod height, No. of branches/plant and 100-seed weight. However, the earlier male genotype D_9 was a good combiner for earliness (flowering and maturity date), plant height, first pod height, No. of branches/ plant and No. of pods/plant.

F_2 generation :

The GCA effects for the parental varieties of all studied traits are presented in Table (15).

For days to flowering : The varieties Giza 843 and Sakha 1 showed highly significant negative values of GCA effects, while Giza 461 and Nubaria 1 showed highly significant positive values of GCA effects. Concerning the parental genotypes, D_5, D_6 and D_7 showed highly significant positive effects of GCA. However, D_8 and D_9 showed highly significant negative values of GCA effects.

For days to maturity : Both the two varieties Sakha 1 and Nubaria 1 showed highly significant negative and positive values of GCA effect, respectively. On the other hand, D_5 and D_6 showed highly significant positive value of GCA effect. While D_8 and D_9 had highly significant negative values of GCA effect.

For plant height : Both the female varieties Giza 461 and Nubaria 1 showed highly significant positive values of GCA effect, while, Giza 843 and Sakha 1 showed highly significant negative values. On the other hand, the male genotypes D_6 and D_9 exhibited highly significant positive values of GCA effects, in addition, D_7 and D_8 showed highly significant negative values of GCA effects.

For first pod height : The two varieties Giza 461 and Nubaria 1 showed highly significant positive values of GCA effects. While, Giza 843 and Sakha 1 had highly significant negative values of GCA effects. On the other side, the male genotypes D_5 and D_6 exhibited highly significant positive values, while, the male genotypes D_8 showed highly significant and negative value of GCA effects.

Table (15). Estimates of general combining ability effects of parental varieties for all studied traits on the F_2 generation

Entries	Days to flowering	Days to maturing	Plant height	First pod height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
Females :										
Giza 461	2.70**	0.66	7.17**	4.59**	-0.112	1.25**	4.51	0.019	1.503	-3.52*
Giza 843	-5.11**	0.36	-4.30**	-2.70**	0.072	2.18**	0.20	-0.244**	-2.978**	-4.03**
Sakha 1	-8.92**	-2.19**	-8.26**	-8.23**	-0.330**	-1.43**	-7.24*	-0.185**	-7.622**	-0.39
Nubaria 1	11.33**	1.16**	5.40**	6.34**	0.370**	-1.99**	2.55	0.407**	9.097**	7.94**
LSD (g-i) 0.05	1.13	0.85	2.12	1.65	0.160	0.91	5.50	0.125	1.850	2.70
0.01	1.49	1.12	2.79	2.17	0.210	1.19	7.24	0.165	2.430	3.55
LSD (g_i-g_j) 0.05	1.60	1.20	3.00	2.33	0.230	1.28	7.79	0.180	2.620	3.82
0.01	2.11	1.59	3.95	3.06	0.300	1.68	10.24	0.230	3.440	5.02
Males :										
Determinate 5	7.65**	1.58**	0.97	3.72**	-0.423**	-0.51	0.30	0.081	1.897	1.21
" 6	5.02**	0.26	6.76**	5.75**	0.059	1.62**	2.22	-0.188**	1.196	-2.95
" 7	5.19**	1.39**	-4.44**	1.20	0.630**	-0.61	4.21	0.243**	2.722**	-0.83
" 8	-13.66**	-0.99	-9.14**	-10.38**	0.291**	-1.65**	-6.73**	-0.051	-3.406**	3.75*
" 9	-4.21**	-2.24**	5.86**	-0.29	-0.554**	1.14*	-0.03	-0.096	-2.408*	-1.19
LSD (g-i) 0.05	1.27	0.96	2.38	1.84	0.180	1.01	6.15	0.140	2.070	3.02
0.01	1.67	1.26	3.12	2.42	0.230	1.33	8.09	0.180	2.720	3.97
LSD (g_i-g_j) 0.05	1.79	1.35	3.36	2.61	0.250	1.43	8.70	0.198	2.920	4.27
0.01	2.36	1.78	4.42	3.43	0.330	1.88	11.44	0.260	3.830	5.62

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

For No. of branches/plant : Both the two varieties Sakha 1 and Nubaria 1 showed highly significant negative and positive values of GCA effect, respectively. On the other side, the parental genotypes D_5 and D_9 showed highly significant negative values, while both D_7 and D_8 showed highly significant positive values of GCA effects.

For No. of pods/plant : Both the two varieties Giza 461 and Giza 843 showed highly significant positive values, while both Sakha 1 and Nubaria 1 exhibited highly significant negative values of GCA effects. Concerning the parental genotypes D_8 and D_9 had highly significant negative values, while D_6 showed highly significant positive values of GCA effects.

For No. of seeds/plant : Only the maternal variety Sakha 1 showed significant negative value of GCA effect, in the same time, the male genotype D_8 exhibited highly significant negative value of GCA effects.

For No. of seeds/pod : The two varieties Giza 843 and Sakha 1 showed highly significant negative values of GCA effect. While the variety Nubaria 1 showed highly significant positive value of GCA effects. Regarding to the parental line D_6 had highly significant negative values of GCA effects, while, the parental line D_7 exhibited highly significant positive value of GCA effects.

For Seed yield/plant : Both the maternal varieties Giza 843 and Sakha 1 showed highly significant negative values of GCA effects, while the variety Nubaria 1 showed highly significant positive value of GCA effects. Regarding to the parental line D_7 showed highly significant positive value of GCA effect. However, the parental lines D_8 and D_9 had highly significant negative values of GCA effects.

For 100-seed weight : Both the maternal varieties Giza 461 and Giza 843 showed highly significant negative values of GCA effects, while Nubaria 1 showed highly significant positive value of GCA effects. Regarding to the parental line Only D_8 showed significant positive value.

Generally, the late variety Giza 461 was a good combiner for some traits such as No. of pods/plant. However, the late variety Nubaria 1 was a good combiner for number of branches/plant, No. of seeds/pod, 100-seed weight and seed yield/plant. While both the early maturing varieties Giza 843 and Sakha 1 were a good combiners for earliness (flowering date and maturity times) and some other traits such as plant height and first pod height. On the other hand, the late genotypes D_5 and D_6 were a good combiner for No. of pods/plant, while D_7 was a good combiner for plant height, No. of branches/plant, No. of seeds/plant and seed yield/plant. Moreover, D_9 was a good combiner for earliness (flowering and maturity date), first pod height, No. of pods/plant, also the earlier male D_8 was a good combiner for earliness, plant height, first pod height and 100-seed weight. The results were agreement with those reported by **Hendawy *et al.* (1988), Dawwam (1991), El-Badawy (1994), Kabeel (1994), Kaul and Vaid (1996), El-Galaly (1997), Attia (1998) and Abdalla *et al.* (1999).**

It is of interest for plant breeders to know whether the GCA for a parent agrees with its own performance or that some parents are more patent when crossed than would be expected from their own performance. The results obtained herein proved an excellent agreement between the parental performance and its GCA effects for most studied traits. Such agreement might add another proof about the preponderance of additive genetic variance in the inheritance of these traits, coinciding with the findings reached in the analysis of variance that mentioned before.

E.2. <u>Specific combining ability effects (SCA)</u> :

Positive SCA value of any cross means the F_1 or F_2 generation of this cross would produce higher yield relative to the average performance of its parents and the magnitude of this heterosis would depend on the value of the specific combining ability effect. On the same trend, the negative value of SCA effect of any cross indicates that its F_1 or F_2 would produce lower yield than the mid parent performance.

F_1 generation :

Values of SCA effects for all studied traits of F_1 generation are presented in Table (16).

For days to flowering : Negative values of SCA effects is favourable and means that crosses tend towards earliness.

In this study, negative but insignificant values of SCA effects were obtained by most of crosses except the cross Nubaria 1 x D_7 had significant negative value of SCA effect. This cross was also found to show highly significant value of heterotic effects relative to mid parent.

For days to maturity : Most of crosses showed insignificant negative values of SCA effect. In the same time, only cross Giza 461 x D_6 had significant negative value of heterotic effect relative to mid parent. Generally, also negative and significant estimates of SCA effects are desirable for selecting genetic sources characterized by short duration and it can be utilized in different intercropping systems.

For plant height : In faba bean the negative values of SCA effect are desirable for plant breeders to avoid lodging. In this study most of crosses non-significant but had negative values of SCA effects except a few cases.

The crosses; Giza 461 x D_5, Giza 843 x D_5 and Nubaria 1 x D_9 gave significant negative values of SCA effects. While crosses Giza 843 x D_9 and Sakha 1 x D_5 showed significant positive values of SCA effects.

Table (16). Estimates of specific combining ability effect (S_{ij}) for all studied traits on the F_1 generation

Entries		Days to flowering	Days to maturing	Plant height	First pod height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
Giza 461 x Determinate 5		-1.01	0.81	-5.87*	-2.83	-0.31	1.89	11.42**	0.140	3.96*	-4.86
" x " 6		-1.76	0.06	-0.44	-2.71	-0.45*	0.60	-2.40	-0.120	1.11	3.58
" x " 7		1.74	0.31	1.36	2.19	-0.12	0.17	-5.58	-0.270	-4.04*	1.96
" x " 8		-0.10	-0.50	2.82	0.72	0.34	1.96	7.42*	0.150	-0.77	-7.88**
" x " 9		1.13	-0.69	2.13	2.64	0.57**	-4.62**	-10.86**	0.100	-0.26	7.14**
Giza 843 x Determinate 5		2.75	0.11	-5.91*	1.03	0.11	-0.56	-3.50	-0.040	-0.61	0.05
" x " 6		-0.27	1.61	-3.22	-5.75**	0.59**	6.31**	20.88**	0.060	10.08**	-3.02
" x " 7		-0.52	-1.89	-0.89	-2.37	-0.41*	-6.80**	-24.19**	-0.070	-6.14**	13.99**
" x " 8		-0.65	0.05	3.59	3.23	-0.22	-1.56	-3.61	-0.027	-2.72	-2.88
" x " 9		-1.31	0.11	6.43*	3.86*	-0.06	2.62*	10.43**	0.078	-0.62	-8.13**
Sakha 1 x Determinate 5		0.33	0.31	6.84*	-2.91	-0.03	1.39	7.12*	0.078	9.65**	-1.05
" x " 6		0.08	-0.19	0.43	5.67**	-0.31	-7.95**	-23.90**	0.092	-13.31**	6.26*
" x " 7		1.77	1.06	-1.79	-7.37**	0.68**	4.84**	19.31**	-0.026	6.58**	-5.31
" x " 8		-0.66	-0.25	-4.13	-0.95	-0.28	-2.92**	-8.57*	0.065	-4.70**	1.38
" x " 9		-1.51	-0.94	-1.35	5.55**	-0.02	4.64**	6.04	-0.210	1.80	-1.20
Nubaria 1 x Determinate 5		-2.07	-1.24	4.93	4.70**	0.25	-2.72*	-15.04**	-0.170	-13.00**	6.05*
" x " 6		1.95	-1.49	3.23	2.79	0.20	1.04	5.42	-0.030	2.12	-6.81*
" x " 7		-2.98*	0.51	1.32	7.55**	-0.15	1.80	10.47**	0.360*	3.60*	-10.65**
" x " 8		1.41	0.70	-2.28	-2.99	0.17	2.52*	4.76	-0.190	8.21**	9.40
" x " 9		1.69	1.51	-7.20*	-12.04**	-0.47*	-2.64*	-5.61	0.028	-0.91	2.001
LSD (S_{i-j})	0.05	2.91	2.04	5.31	3.29	0.41	2.17	6.80	0.31	3.55	5.42
	0.01	3.82	2.69	6.98	4.33	0.54	2.85	8.94	0.40	4.67	7.12
LSD (S_{ij}-S_{ki})	0.05	4.11	2.89	7.51	4.66	0.59	3.07	9.62	0.43	5.02	7.66
	0.01	5.41	3.79	9.87	6.42	0.77	4.04	12.64	0.57	6.60	10.08

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

For first pod height : Regarding this character, the negative values of SCA, effects are desirable for faba bean improvement. In this study, three crosses; Giza 843 x D_5, Sakha 1 x D_7 and Nubaria 1 x D_5 showed highly significant negative values of SCA effects. However, crosses; Giza 461 x D_5, Giza 461 x D_6, Giza 843 x D_5, Sakha 1 x D_5 and Nubaria 1 x D_8 showed non-significant negative values of SCA effects. Moreover, five crosses; Giza 843 x D_9, Sakha 1 x D_6, Sakha 1 x D_9, Nubaria 1 x D_5 and Nubaria 1 x D_7 showed significant and highly significant positive values of SCA effects.

For No. of branches/plant : Three crosses; Giza 461 x D_9, Giza 843 x D_6 and Sakha 1 x D_7 showed highly significant positive values of SCA effects. While the crosses; Giza 461 x D_6, Giza 843 x D_6 and Sakha 1 x D_9 had significant negative values of SCA effects.

For No. of pods/plant : Five crosses; Giza 843 x D_6, Giza 843 x D_9, Sakha 1 x D_7, Sakha 1 x D_9 and Nubaria 1 x D_8 exhibited significant and highly significant positive values of SCA effects. These crosses were also highly significant positive heterotic effects relative to mid and better parent (Table 13). While the crosses; Giza 461 x D_9, Giza 843 x D_7, Sakha 1 x D_6, Sakha 1 x D_8, Nubaria 1 x D_5 and Nubaria 1 x D_9 had significant and highly significant negative values of SCA effects.

No. of seeds/plant : Seven crosses; Giza 461 x D_5, Giza 461 x D_8, Giza 843 x D_6, Giza 843 x D_9, Sakha 1 x D_5, Sakha 1 x D_7 and Nubaria 1 x D_7 showed significant and highly significant positive values of SCA effects, while the crosses; Giza 461 x D_9, Giza 843 x D_7, Sakha 1 x D_6, Sakha 1 x D_8 and Nubaria 1 x D_5 showed significant and highly significant negative values of SCA effects.

For No. of seeds/pod : All crosses showed non-significant negative and positive values of SCA effects except only one cross Nubaria 1 x D_7 showed desirable significant positive value of SCA effects.

For seed yield/plant : Six crosses; Giza 461 x D_5, Giza 843 x D_6, Sakha 1 x D_5, Sakha 1 x D_7, Nubaria 1 x D_7 and Nubaria 1 x D_8 exhibited desirable significant and highly significant positive value of SCA effect, while crosses; Giza 461 x D_7, Giza 843 x D_7, Sakha 1 x D_6, Sakha 1 x D_8, and Nubaria 1 x D_5 showed significant and highly significant negative values of SCA effects.

For 100-seed weight : Only four crosses; Giza 461 x D_9, Giza 843 x D_7, Sakha 1 x D_7 and Nubaria 1 x D_5 showed significant and highly significant positive values of SCA effects. However, four crosses; Giza 461 x D_8, Giza 843 x D_9, Nubaria 1 x D_6 and Nubaria 1 x D_7 showed significant and highly significant negative values of SCA effects.

Based on the obtained data in Table (16) the cross Nubaria 1 x D_7 had desirable value of SCA effect for earliness, No. of seeds/plant, seed yield and No. of seeds/pod. While crosses; Giza 461 x D_5, Giza 843 x D_5 and Nubaria 1 x D_9 had desirable values of SCA for plant height. However, crosses; Giza 843 x D_6, Sakha 1 x D_7 and Nubaria 1 x D_9 exhibited highly significant negative values of SCA effects for first pod height, while crosses; Giza 461 x D_9, Giza 843 x D_6 and Sakha 1 x D_7 had highly positive SCA effects for No. of branches. On the other hand, crosses Giza 843 x D_6, Giza 843 x D_9, Sakha 1 x D_7 and Sakha 1 x D_9 had desirable values of SCA effects for No. of pods/plant. However, crosses; Giza 461 x D_5, Giza 461 x D_8, Giza 843 x D_6, Giza 843 x D_9, Sakha 1 x D_5, Sakha 1 x D_7 and Nubaria 1 x D_7 had desirable values of SCA effects for No. of seeds/plant. Moreover, crosses; Giza 461 x D_5, Giza 843 x D_6, Sakha 1 x D_5, Sakha 1 x D_7, Nubaria 1 x D_7 and Nubaria 1 x D_8 had desirable values of SCA effects for seed yield/plant. On the other side, crosses; Giza 461 x D_9, Giza 843 x D_7, Sakha 1 x D_6, and Nubaria 1 x D_5 had desirable values of SCA effects for 100-seed weight. Only cross Nubaria 1 x D_7 had desirable values of SCA effect for No. of seeds/pod. These results were previously found by **Abo El-Zahab *et al.* (1994 a), Hendawy *et al.* (1994), El-Lithy (1996), El-Galaly (1997) and El-Hady *et al.* (1998 b).**

F_2 generation :

The SCA effects (S_{ij}) of all studied traits in the F_2 generation are presented in Table (17).

Significant differences for SCA were detected for all studied traits. This would indicate the importance of non-additive genetic variance in determining the performance of these traits.

For days to flowering : Negative values of SCA effects is desirable and means that crosses tend towards earliness. The crosses Giza 461 x D_9, Giza 843 x D_7, Sakha 1 x D_6 and Nubaria 1 x D_5 showed desirable highly significant negative values of SCA effects. The best cross for earliness was Sakha 1 x D_6 followed by cross Giza 843 x D_7, while the crosses Giza 461 x D_6, Giza 461 x D_7, Giza 843 x D_5, Sakha 1 x D_7 and Nubaria 1 x D_9 showed significant and highly significant positive values of GCA effects, other four crosses showed non-significant negative values of SCA effects.

For days to maturity : The best cross was Sakha 1 x D_6 and it is the same for flowering. This cross showed highly significant negative value of SCA effects. While, insignificant negative values were obtained by other ten crosses. On the other hand, crosses; Giza 461 x D_6 and Nubaria 1 x D_6 showed significant positive values of SCA effects. These crosses are considered as a late crosses.

For plant height : The three crosses; Giza 843 x D_6, Sakha 1 x D_8 and Nubaria 1 x D_8 are the best crosses because it showed significant and highly significant negative values of SCA effects. While crosses; Giza 843 x D_8 and Sakha 1 x D_6 showed highly significant positive values of SCA effects. So they are considered undesirable. Most of other crosses had non-significant SCA effects.

Table (17). Estimates of specific combining ability effect (S_{ij}) for all studied traits on the F_2 generation

Entries	Days to flowering	Days to maturing	Plant height	First pod height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
Giza 461 x Determinate 5	0.63	-0.725	-0.649	-0.702	0.350	1.26	-1.29	-0.232	-1.530	-0.057
" x " 6	3.60**	2.088*	1.502	1.711	-0.087	2.97**	-0.21	-0.226	-0.470	-1.508
" x " 7	3.23*	-0.538	-4.330	2.175	0.096	-3.52**	-6.24**	0.220	-1.439	4.230
" x " 8	-1.87	-0.413	3.056	-3.840*	-0.604**	2.47*	12.18**	0.109	6.271**	-1.550
" x " 9	-5.60**	-0.413	0.421	0.657	0.243	-3.18**	-4.49	0.139	-2.829	-1.118
Giza 843 x Determinate 5	2.55*	-0.675	0.753	2.510	0.280	-0.60	-4.04	-0.132	-0.803	3.740
" x " 6	-0.67	-1.362	-11.750**	7.320**	0.002	-1.89	-4.07	0.087	-4.272	-0.133
" x " 7	-4.81**	1.763	0.687	-6.970**	0.485**	1.63	3.84	-0.194	1.115	1.629
" x " 8	1.62	0.388	9.670**	1.710	-0.403*	0.35	-1.11	0.025	0.039	-2.000
" x " 9	1.31	-0.112	0.647	-4.560*	-0.360*	0.52	5.43*	0.225	3.919	-3.240
Sakha 1 x Determinate 5	-0.28	0.375	-2.580	-0.730	-0.182	0.59	-0.89	-0.081	0.353	0.404
" x " 6	-4.85**	-2.813**	7.210**	-7.880**	-0.507**	-2.00	-1.93	0.046	-1.181	0.012
" x " 7	3.04*	0.313	2.840	4.530*	-0.316	0.10	-0.72	0.029	-1.382	-3.821
" x " 8	1.80	0.438	-7.840**	1.160	0.818**	0.01	-0.65	-0.052	-2.208	1.630
" x " 9	0.29	1.688	0.383	2.930	0.186	1.30	4.16	0.096	-0.004	1.780
Nubaria 1 x Determinate 5	-2.90*	1.030	2.480	-1.070	-0.446*	-1.24	6.20**	0.453**	1.975	-4.090
" x " 6	1.91	2.090*	3.040	-1.150	0.593**	0.92	6.28**	0.102	5.926**	1.630
" x " 7	-1.47	-1.540	0.810	0.270	-0.266	1.79	3.09	-0.012	1.705	-2.040
" x " 8	-1.55	-0.410	-4.878*	0.980	0.188	-2.83**	-10.45**	-0.073	-8.519**	1.920
" x " 9	4.001**	-1.160	-1.450	0.980	-0.069	1.36	-5.13*	-0.451**	-1.087	2.580
LSD (S_{i-j}) 0.05	2.53	1.91	4.75	3.68	0.36	2.02	4.71	0.28	4.29	6.04
0.01	3.33	2.51	6.25	4.84	0.47	2.66	6.19	0.37	5.65	7.94
LSD (S_{ij}-S_{ki}) 0.05	3.58	2.70	6.71	5.21	0.50	2.86	6.66	0.39	5.85	8.50
0.01	4.71	3.55	8.83	6.85	0.66	3.76	8.75	0.52	7.69	11.23

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

For first pod height : The four crosses; Giza 461 x D_8, Giza 843 x D_7, Giza 843 x D_9 and Sakha 1 x D_6 showed desirable significant and highly significant negative values of SCA effects. On the other hand, the two crosses Giza 843 x D_6 and Sakha 1 x D_7 showed undesirable significant and highly significant positive values of SCA effects.

For No. of branches/plant : Only three crosses; Giza 843 x D_7, Sakha 1 x D_8 and Nubaria 1 x D_6 showed desirable highly significant positive values of SCA effects. While crosses; Giza 461 x D_8, Giza 843 x D_8, Giza 843 x D_9, Sakha 1 x D_6 and Nubaria 1 x D_6 showed significant and highly significant negative values of SCA effects. The rest of crosses most of them were non-significant.

For No. of pods/plant : Only two crosses; Giza 461 x D_6 and Giza 461 x D_8 showed desirable significant and highly significant positive values of SCA effects. While three crosses showed highly significant negative values of SCA effects for pods/plant. The other crosses were insignificant.

For No. of seeds/plant : Four crosses; Giza 461 x D_7, Giza 843 x D_9, Nubaria 1 x D_5 and Nubaria 1 x D_6 showed desirable significant and highly significant positive values of SCA effects. While three crosses; Giza 461 x D_7, Nubaria 1 x D_8 and Nubaria 1 x D_9 showed significant and highly significant negative values of SCA effects. The most of other crosses had negative values and showed non-significant SCA effects.

For No. of seeds/pod : All crosses gave non-significant negative or positive values of SCA effects except crosses; Giza 461 x D_8 and Nubaria 1 x D_6 showed desirable highly significant positive values. While only one cross showed highly significant negative value of SCA effects.

For 100-seed weight : All crosses gave insignificant and had negative or positive values of SCA effects.

In general, the most desirable crosses which had desirable values of SCA effects were as follows: For flowering and maturity crosses; Giza 461 x D_9, Giza 843 x D_7, Sakha 1 x D_6 and Nubaria 1 x D_5. While, for plant height and first pod height crosses; Giza 461 x D_8, Giza 843 x D_6, Sakha 1 x D_6, Sakha 1 x D_8 and Nubaria 1 x D_8. In addition, for No. of branches cross Sakha 1 x D_6, however for No. of pods crosses; Giza 461 x D_6 and Giza 461 x D_8, while for No. of seeds/plant crosses; Giza 843 x D_8, Nubaria 1 x D_5 and Nubaria 1 x D_6. But for seed yield/plant crosses; Giza 461 x D_8 and Nubaria 1 x D_6.

The results obtained here concerning general and specific combining ability effects could indicate that the excellent hybrid combinations were detected from the possible combinations between the parents of high and low general combining ability effects i.e. high x high, high x low and low x low. Then, it could be concluded that general combining ability effects of the parental varieties were generally unrelated to the specific combining ability effects at their corresponding crosses. From the breeding point of view, parents characterized by good general combining ability for yield and some yield components with heterosis and high estimates of SCA effect are obviously essential for getting good crosses. A great deal of interest has been pointed to select crosses combined good general combining parents or crosses involving at least one good combining parent with high SCA effects as well as high heterosis. This conclusion is in agreement **with Hendawy *et al.* (1988), Dawwam (1991), El-Badawy (1994), Kabeel (1994), Kaul and Vaid (1996), Attia (1998) and Abdalla *et al.* (1999).**

F. Contribution of females, males and females x males in the total genetic variance :

The contribution of females, males and females x males in the total genetic variance for all studied characters in F_1 and F_2 generation are presented in Table (18).

F_1 generation :

In the F_1 generation, the highest contribution values were detected from females relative to both males and females for all studied characters except for No. of seeds/pod was less than males and higher than females x males. This estimates indicated that females had main contribution in the total genetic variance for these traits, while the contribution values of males were higher than females x males for all studied characters except for No. of branches/plant, No. of pods/plant, No. of seeds/plant and 100-seed weight.

F_2 generation :

The highest contribution values were detected from female for all studied characters except for days to flowering, days to maturity, No. of branches and No. of seeds/plant. These values indicated that females had main contribution in the total genetic variance for this traits. While the contribution values of males were higher than males x females for all studied traits except for No. of pods/plant, No. of seeds/ pod, seed yield/plant and 100-seed weight.

G. Gene action and heritability for F_1 generation :

Genetic variance components were calculated for all studied traits and the results are presented in Table (19). It is clear that the additive (σ^2 A) genetic variance was always larger than non-additive genetic variance (σ^2 D) for all studied traits except for No. of seeds/plant. Such results indicated that the additive genetic variance played an important role in the inheritance of these traits. Therefore, selection would be effective in improving these traits. Concerning the other studied trait as No. of seeds/plant, non-additive genetic

Table (18). Contribution of Females (F), Males (M) and Females x Males (FxM) in the total genetic variance

Traits		Lines	Testers	Lines x Testers
Days to flowering	F_1	65.09	32.90	2.01
	F_2	45.90	47.94	6.16
Days to maturity	F_1	81.44	10.61	7.95
	F_2	31.36	39.11	29.53
Plant height	F_1	68.74	17.22	14.04
	F_2	41.66	36.71	21.64
First pod height	F_1	70.25	19.73	10.02
	F_2	43.72	40.04	16.25
No. of branches/plant	F_1	53.12	17.53	29.35
	F_2	16.07	47.81	36.12
No. of pods/plant	F_1	55.56	14.66	29.78
	F_2	39.06	18.30	42.62
No. of seeds/plant	F_1	53.73	9.59	36.68
	F_2	32.97	43.70	23.33
No. of seeds/pod	F_1	23.46	59.55	16.99
	F_2	52.20	18.04	29.76
Seed yield/plant (g)	F_1	41.65	36.48	21.87
	F_2	69.67	10.95	19.38
100-seed weight (g)	F_1	62.37	17.39	20.24
	F_2	68.13	15.63	16.24

Table (19). Estimation of genetic parameters and their standard errors for all studied traits on the F_1 generation

Traits / Parameters	Days to flowering	Days to maturing	Plant height (cm)	First pod height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
σ^2 F = 1/2 σ^2 A	99.19	11.10	96.64	207.4	0.36	28.94	244.53	0.03	85.50	149.19
± S.E	±63.22	±07.2	± 64.4	± 136.05	± 0.25	± 21.2	± 187.4	± 0.02	± 62.44	± 102.8
σ^2 M = 1/2 σ^2 A	46.41	1.04	17.41	47.4	0.10	2.67	-13.55	0.08	64.67	25.98
± S.E	± 27.35	± 0.81	± 14.02	± 32.9	± 0.09	± 5.22	± 37.12	± 0.05	± 47.06	± 25.28
σ^2 A = σ^2 F + σ^2 M	145.60	12.14	114.05	254.8	0.46	31.61	230.98	0.11	150.17	175.17
σ^2 D = σ^2 FM	1.68	0.31	18.74	35.55	0.15	21.17	239.7	0.01	61.36	58.27
± S.E	± 1.49	± 0.55	± 9.9	± 14.5	± 0.07	± 8.46	± 95.12	± 0.01	± 24.4	± 24.9
σ^2 e	8.71	4.3	29.04	11.18	0.18	4.86	47.67	0.10	12.98	30.27
σ^2 G	147.28	12.45	132.49	290.35	0.61	52.78	470.68	0.12	211.53	233.44
σ^2 ph	155.99	16.75	161.83	301.53	0.79	57.64	518.35	0.22	224.51	263.71
D.d = σ^2 D/σ^2 A	0.11	0.16	0.41	0.38	0.57	0.82	1.02	0.30	0.64	0.58
H^2_b %	94.4	74.3	81.9	96.3	77.2	91.6	90.1	54.5	94.2	88.5
± S.E	± 0.078	± 0.211	± 0.071	± 0.057	± 0.989	± 0.126	± 0.042	± 1.57	± 0.065	± 0.088
H^2_n %	93.3	72.5	70.5	84.5	58.2	54.8	44.6	50.0	66.9	66.4
± S.E	± 0.077	± 0.208	± 0.066	± 0.053	± 0.859	± 0.107	± 0.029	± 1.51	± 0.055	± 0.051

variance was more important than additive genetic variance since the estimate of (σ^2 D) was greater than (σ^2 A) for this trait. Consequently, selection would be ineffective and hybridization must be used to produce F_1 hybrids utilizing heterosis. These results are in accordance with those reported by **El-Refaey (1987), Bakheit and El-Mahdy (1988 a), Budvitite (1988), Bakheit** *et al.* **(1991), Bakheit (1992) and Abaas (2001).** The estimation of dominance degree ratio ($\sqrt{\sigma^2 D/\sigma^2 A}$) confirmed the previously finding since the ratios were less than one for all studied traits except for traits namely No. of seeds/plant, this indicating the importance of additive genetic variance for these traits. The dominance degree ratios for the other trait namely No. of seeds/plant was more than one reflecting the importance of non-additive variance in the inheritance of this character indicating an excess of dominant genes in their parents. High values of environmental component were estimated for No. of seeds/plant, 100-seed weight and plant height, while the other estimates for the other traits were normal but different in its magnitude indicating that, these characters were affected by the environmental component with different degrees.

Heritability in both broad and narrows senses were estimated for all studied traits (Table 19). Results indicated that broad sense heritability (h^2_b %) estimates were larger than the corresponding values of narrow sense heritability (h^2_n %) for all studied traits. Heritability in broad sense ranged from 54.5% for No. of seeds/pod to 96.3% for first pod height. Whereas, narrow sense heritability values ranged from 44.6% for No. of seeds/plant to 93.3% for days to flowering indicating that a major part of the total genotypic variance is additive. Accordingly, it is expected that an effective phenotypic selection in these traits can be achieved with a satisfactory degree of accuracy. These genetic materials might be considered as good genetic base suitable to performing of providing different breeding programs in faba bean. Pedigree selection, bulk and back-cross breeding methods may be used in the future to improve parental varieties for yield and other good traits in different directions where the additive genetic variance was the predominant and controlled the inheritance of these traits.

H. Gene action, heritability and genetic advance under selection for F_2 generation :

Genetic variance components were calculated for all studied traits and results are presented in Table (20). The results showed that the additive (σ^2 A) genetic variance was found to be larger than non-additive genetic variance (σ^2 D) for all studied traits. These results indicated that the additive genetic variance played an important role in the inheritance of all studied traits. Therefore, selection would be effective in improving all studied traits. The results were partially confirmed with the previous results obtained in the F_1 data (table 19). The estimates of dominance degree ratios ($^1/_4\sqrt{\sigma^2 \ D / \sigma^2 \ A}$) confirmed that the ratios were less than one for all studied traits, this indicating the importance of additive genetic variance than non-additive for all studied traits. The estimation of environmental component showed that high values was estimated for No. of seeds/plant, 100-seed weight and plant height, while the other estimates for other traits were normal but different in its magnitude indicating that, the trait is affected by the environmental component with different levels. Also, the results obtained from F_1 and F_2 generation (line x tester) were relatively similar.

Heritability in both broad and narrow sense were estimated for all studied traits (Table 20). Results indicated that broad sense heritability (h^2_b %) estimates were larger than he corresponding values of narrow sense heritability (h^2_n %) for all studied traits except for 100-seed weight because in this trait, the non-additive genetic variance had negative value. Heritability in broad sense had values ranged from 46.59% for 100-seed weight to 96.1% for days to flowering. Heritability in broad sense was moderate to high for most of studied traits.

Table (20). Estimation of genetic parameters and their standard errors for all studied traits on the F_2 generation

Traits / Parameters	Days to flowering	Days to maturing	Plant height (cm)	First pod height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed yield/ plant (g)	100-seed weight (g)
$\sigma^2 F = 1/2\ \sigma^2 A$	77.73	1.71	48.49	41.20	0.04	3.0	21.75	0.08	47.13	28.78
± S.E	± 50.87	± 1.43	± 35.35	± 28.77	± 0.06	± 2.6	± 16.8	± 0.06	± 32.06	± 13.37
$\sigma^2 M = 1/2\ \sigma^2 A$	75.37	1.96	36.99	33.73	0.18	0.41	26.99	0.01	3.05	4.3
± S.E	± 45.48	± 1.53	± 26.8	± 22.61	± 0.14	± 1.18	± 19.09	± 0.02	± 4.61	± 3.9
$\sigma^2 A = \sigma^2 F + \sigma^2 M$	153.10	3.67	85.48	74.93	0.22	3.41	48.74	0.09	50.18	33.08
$\sigma^2 D = \sigma^2 FM$	11.83	1.69	30.37	17.6	0.21	4.57	17.66	0.07	13.22	-0.28
± S.E	± 5.1	± 1.0	± 13.71	± 7.99	± 0.09	± 2.14	± 8.88	± 0.02	± 6.69	± 3.73
$\sigma^2 e$	6.62	3.77	23.26	13.99	0.13	4.23	22.86	0.08	17.61	37.6
$\sigma^2 G$	164.93	5.36	115.85	92.53	0.43	7.98	66.4	0.16	63.4	32.8
$\sigma^2 ph$	171.55	913	139.11	106.52	0.56	12.21	89.26	0.24	81.01	70.4
$D.d = \sigma^2 D/\sigma^2 A$	0.07	0.17	0.15	0.12	0.24	0.29	0.15	0.22	0.13	-0.02
H^2_b %	96.1	58.7	83.3	86.9	76.8	65.4	74.4	66.7	78.3	46.59
± S.E	± 0.075	± 0.25	± 0.77	± 0.09	± 1.17	± 0.23	± 0.091	± 1.67	± 0.098	± 0.081
H^2_n %	89.2	40.2	61.4	70.3	39.3	27.9	54.6	37.5	61.9	46.9
± S.E	± 0.072	± 0.21	± 0.66	± 0.08	± 0.84	± 0.15	± 0.078	± 1.25	± 0.087	± 0.082
X	68.03	158.6	136.4	49.2	6.6	22.5	69.3	3.11	58.98	85.2
Ga	25.9	3.7	20.2	18.5	1.2	4.7	14.5	0.67	14.5	8.05
Ga %	38.1	2.3	14.8	37.6	17.9	20.9	20.9	21.6	24.6	9.5

High value of heritability narrow sense was detected for days to flowering revealed that the most of phenotypic variability in this trait was due to additive genetic type. Therefore, a pedigree method of selection program for this trait might be quite promising. Moderate heritability values in narrow sense were obtained for the most other traits. This result indicates that bulk method could be more efficient for obtaining desirable important characters. Low heritability values in narrow sense were obtained for No. of pods/plant and No. of seeds/pod. This result indicating that environmental conditions play major role in determining these traits. This finding supported the previous results obtained for combining ability analysis. Similar results were previously reported **by El-Refaey (1987), Bakheit and El-Mahdy (1988 a), Ghandorah and El-Shawaf (1993), El-Shawaf *et al.* (1999) and Abaas (2001).**

The highest values of genetic advance were detected for days to flowering and first pod height followed by seed yield/plant. This high genetic advance was found in association with high heritability value in broad sense for these traits. Therefore, selection for earliness, first pod height and high seed yield should be effective and satisfactory for successful breeding purposes. The moderate to low values of genetic advance were detected for No. of pods/plant, No. of seeds/plant, No. of seeds/pod, No. of branches/plant and plant height. These values of moderate to low genetic were associated with moderate and low heritability values. Moderate genetic advance associated with moderate of heritability values, selection would be effective in breeding purposes. Moderate genetic advance associated with low heritability values, selection for these traits would be less successful than the other ones. While low genetic advance associated with low heritability values were detected for days to maturity and 100-seed weight. Therefore, selection for these traits would be less successful than for the former cases.

I. <u>Biochemical analysis</u> :

The biochemical analysis of this investigation have provided valuable tools for the genetic studies of *Vicia faba*. Protein content and isozyme variation can serve as a genetic marker and permit early fast assessment of the nature of a variety.

I.a. <u>Protein banding patterns (SDS-PAGE)</u> :

Gel electrophoresis of proteins has become a standard and powerful research tool for application in a multitude of biological disciplines. Sodium dodecyl sulphate, polyacrylamide gel electrophoresis (SDS-PAGE) was used to identify inbred lines, cultivars of *Vicia faba* and differentiate between *Vicia spp.* (**Hussein and Salam, 1985**).

Amino acid changes within a protein, due to mutational events can resulting in altered protein migration rates when the protein are compared on polyacrylamide gels. Therefore, in the present investigation, the protein banding patterns of nine parental genotypes and some of their crosses were analyzed by SDS polyacrylamide gel electrophoresis. The protein profiles of the different parents are presented in Tables (21 & 22) and illustrated in Figure (1). Thirty two different bands were observed for this pattern. The protein zymogram of all parental genotypes (determinate and indeterminate habit) revealed that these bands had molecular weight ranged from 133-19 kd with relative mobility (Rf) ranged from 0.12 to 0.88. The band no. 4 with relative mobility Rf= 0.2, molecular weight 107 kd was absent to faint in all parents. This band is considered as the one molecular marker to differentiate between the indeterminate and determinate habit types of faba bean, whereas, revealed faint density for all indeterminate habit parents, while, was absent to very faint for all determinate habit parents. While, the band no. 8 with Rf= 0.28 and molecular weight 87 Kd was present and revealed faint density for all parents, while, the band no. 16 with mobility Rf= 0.50, Mw. 50 kd was observed for all parents and revealed faint to very dark density. The band no. 17 with mobility Rf= 0.54, molecular weight 46 kd was observed and revealed very faint to faint density for

Table (21). Analysis of protein banding patterns by SDS-PAGE for nine parental genotypes of *Vicia faba*

Entries / Band	Rf	Mw Kd.	Mw st	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1	0.12	133	-	-	-	-	-	-	-	2.3	2.1	1.9
2	0.16	122	-	4.2	2.0	1.7	2.2	2.9	-	1.7	1.8	-
3	0.18	113	-	-	-	3.4	2.4	2.5	2.9	1.9	2.9	4.7
4	0.20	107	-	4.9	5.4	6.8	6.7	-	2.0	-	-	2.8
5	0.23	101	-	-	5.3	-	1.3	6.5	4.0	6.3	6.0	2.5
6	0.24	97	7.6	7.4	-	-	-	-	1.9	-	-	-
7	0.26	92	-	-	2.8	3.1	2.7	3.0	2.6	2.6	2.8	2.3
8	0.28	87	-	2.5	1.7	2.1	2.3	2.7	2.3	2.5	2.3	2.2
9	0.30	84	6.4	-	6.1	6.5	5.5	6.4	5.7	4.9	4.7	4.4
10	0.33	78	-	7.5	-	-	-	-	2.9	2.2	2.7	1.9
11	0.35	73	-	-	-	6.3	3.2	-	-	-	-	4.3
12	0.36	71	-	2.6	3.8	-	3.1	3.5	5.4	5.5	5.7	-
13	0.39	66	-	-	8.1	6.5	4.5	7.6	10.6	5.0	5.6	8.5
14	0.42	61	26.2	10.6	5.8	6.4	4.4	5.3	-	6.0	6.5	4.2
15	0.47	52	29.8	5.9	-	-	3.1	3.9	3.2	1.5	-	-
16	0.50	50	-	10.0	11.6	13.0	7.9	6.5	9.4	9.6	11.3	10.8
17	0.54	46	-	3.6	5.1	2.6	5.3	3.9	5.2	3.7	5.4	7.8
18	0.57	42	-	-	-	-	4.8	3.5	-	5.3	-	-
19	0.59	40	-	4.8	1.9	3.5	-	1.7	2.2	-	3.9	4.3
20	0.62	37	-	-	2.7	3.7	3.6	3.4	3.5	1.9	1.8	-
21	0.64	36	-	3.6	-	-	-	-	-	2.3	-	3.7
22	0.67	33	-	-	-	-	9.3	4.4	4.5	2.8	-	-
23	0.68	32	-	7.7	8.5	8.2	-	4.6	3.9	4.0	10.3	9.2
24	0.71	30	-	-	4.9	3.4	3.6	3.7	3.7	3.7	-	-
25	0.72	29	-	3.4	-	4.1	3.9	-	-	-	2.9	4.7
26	0.73	28	-	4.1	6.6	-	-	4.2	3.9	4.1	4.4	5.0
27	0.76	27	-	-	-	2.2	1.8	2.3	2.6	2.9	-	-
28	0.77	25	-	2.1	4.6	1.2	2.9	3.4	-	2.6	2.7	-
29	0.81	24	13.8	10.8	10.3	8.9	7.4	6.3	14.7	8.1	-	3.5
30	0.82	22	16.2	-	-	4.7	-	-	-	-	7.8	5.5
31	0.84	21	-	4.4	-	-	4.9	4.9	-	3.4	3.9	5.5
32	0.88	19	-	-	2.7	1.5	3.0	2.8	3.0	2.9	2.6	-
Total			6	17	19	21	24	24	22	26	22	21

Table (22). Description of protein banding patterns by SDS-PAGE for nine parental genotypes of *Vicia faba*

Entries / Band	Rf	Mw Kd.	Mw st	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1	0.12	133	-	-	-	-	-	-	-	+	+	+
2	0.16	122	-	++	+	+	+	+	-	+	+	-
3	0.18	113	-	-	-	+	+	+	+	+	+	++
4	0.20	107	-	++	++	++	++	-	+	-	-	+
5	0.23	101	-	-	++	-	+	++	++	++	++	+
6	0.24	97	++	++	-	-	-	-	+	-	-	-
7	0.26	92	-	-	+	+	+	+	+	+	+	+
8	0.28	87	-	+	+	+	+	+	+	+	+	+
9	0.30	84	++	-	++	++	++	++	++	++	++	++
10	0.33	78	-	++	-	-	-	-	+	+	+	+
11	0.35	73	-	-	-	++	+	-	-	-	-	++
12	0.36	71	-	+	+	-	+	+	++	++	++	-
13	0.39	66	-	-	++	++	++	++	++	++	++	++
14	0.42	61	++++	+++	++	++	++	++	-	++	++	++
15	0.47	52	++++	++	-	-	+	+	+	+	-	-
16	0.50	50	-	+++	+++	++++	++	++	+++	+++	+++	+++
17	0.54	46	-	+	++	+	++	+	++	+	++	++
18	0.57	42	-	-	-	-	++	+	-	++	-	-
19	0.59	40	-	++	+	+	-	+	+	-	+	++
20	0.62	37	-	-	+	+	+	+	+	+	+	-
21	0.64	36	-	+	-	-	-	-	-	+	-	+
22	0.67	33	-	-	-	-	++	++	++	+	-	-
23	0.68	32	-	++	+++	+++	-	++	++	++	+++	+++
24	0.71	30	-	-	++	+	+	+	+	+	-	-
25	0.72	29	-	+	-	++	+	-	-	-	+	++
26	0.73	28	-	++	++	-	-	++	+	++	++	++
27	0.76	27	-	-	-	+	+	+	+	+	-	-
28	0.77	25	-	+	++	+	+	+	-	+	+	-
29	0.81	24	+++	+++	+++	+++	++	++	++++	+++	-	+
30	0.82	22	+++	-	-	++	-	-	-	-	++	++
31	0.84	21	-	++	-	-	++	++	-	+	+	++
32	0.88	19	-	-	+	+	+	+	+	+	+	-
Total			**6**	**17**	**19**	**21**	**24**	**24**	**22**	**26**	**22**	**21**

- = Absent   **+ = Very faint**   **++ = Faint**
+++ = Dark   **++++ = Very dark**

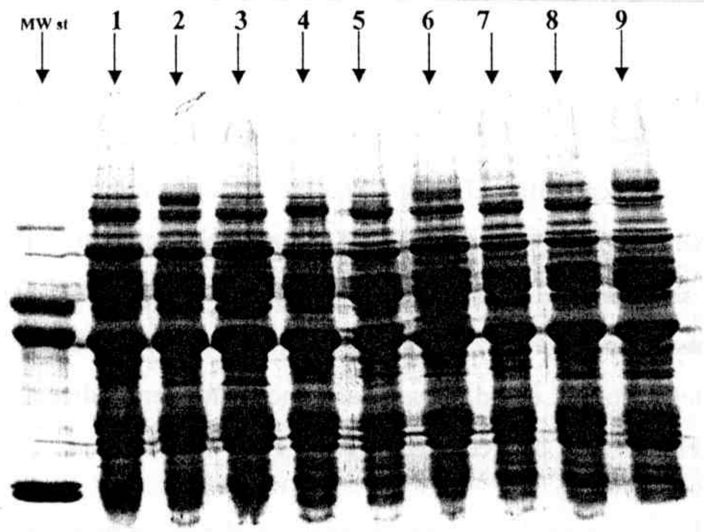


Figure (1). **SDS-PAGE for total soluble protein of *Vicia faba* for nine parental genotypes under study**

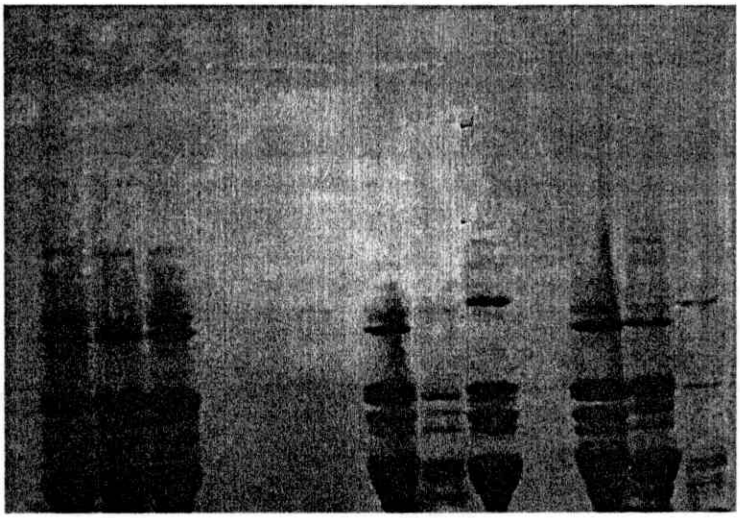
P_1 = Giza 461	P_4 = Nubaria 1	$P_7 = D_7$
P_2 = Giza 843	$P_5 = D_5$	$P_8 = D_8$
P_3 = Sakha 1	$P_6 = D_6$	$P_9 = D_9$

Mw st = Marker

all parents. Moreover, the band no. 7 with mobility Rf= 0.26, Mw. 92 kd was observed for all parent except P_1 (Giza 461) and revealed very faint density, the bands nos. 9 and 13 with mobility Rf= 0.30 and 0.39, Mw= 84 kd and 66 kd were observed for all parents except parent no. 1 (Giza 461) revealed faint density. The band no. 14 with mobility Rf= 0.42, Mw= 61 kd was detected for all parents except parent no. 6 (D_6), revealed faint to dark density, the band no. 23 with mobility Rf= 0.68, Mw= 32 kd was observed for all parents except parent no. 4 (Nubaria 1), revealed faint to dark density, while, the band no. 29 with mobility Rf= 0.81, Mw= 24 kd was observed for all parents except parent no. 8 (D_8), revealed very faint to very dark density.

The results also revealed that the determinate and indeterminate habit types of faba bean differed from each other in their protein profiles and each of them characterized by the presence of some specific protein bands (Tables 21 & 22). In addition, a number of protein band which expressed in all parents were also found to have genetic bases in the respective parents. These results suggest the protein profiles could be used as genetic marker to detect the differences and/or relationships between the different types of faba bean.

Regarding to electrophoresis analysis of protein patterns for six parental genotypes and their 3 F_1 hybrids are illustrated in Fig. (2) and summarized in Tables (23 & 24). We can distinguish fifteen bands (distributed in different groups, slow, medium and fast mobility) were detected in the zymogram for all genotypes. Regarding to cross no. 1 (Giza 461 x D_5) revealed ten bands, while each of the two parents Giza 461 and D_5 revealed four and seven bands, respectively. The bands no. 1, 2, 3 and 15 with mobility Rf= 0.41, 0.46, 0.51 and 0.98 were observed only in the F_1 hybrid 1, while were absent in the two parents, revealed very faint to faint density. The bands nos. 5, 6, 12 and 13 with mobility Rf= 0.57, 0.59, 0.82 and 0.87 were observed for parent (D_5), moved to F_1 hybrid 1, while, the band no. 9 with mobility 0.72 was observed for all genotypes. Regarding to F_1 hybrid no. 8 (Giza 843 x D_7) revealed eight bands,



P8 H14 P3 P7 H8 P2 P5 H1 P1

Figure (2). SDS-PAGE for total soluble protein of *Vicia faba* for six parental genotypes and their three F_1 hybrids

P_1 = Giza 461	H_1 = G. 461 x D_5	$P_5 = D_5$
P_2 = Giza 843	H_8 = G. 843 x D_7	$P_7 = D_7$
P_3 = Sakha 1	H_{14} = Sakha 1 x D_8	$P_8 = D_8$

Table (23). Analysis of protein banding patterns by SDS-PAGE for six parental genotypes and their three F_1 hybrids of *Vicia faba*

Entries / Band	Rf	P_1	H_1	P_5	P_2	H_8	P_7	P_3	H_{14}	P_8
1	0.41	-	4.7	-	5.2	-	-	5.3	7.9	6.7
2	0.46	-	9.2	-	6.4	-	6.3	6.4	-	5.9
3	0.51	-	5.5	-	6.4	-	4.8	9.8	-	-
4	0.54	26.1	-	-	7.8	-	4.0	-	-	-
5	0.57	-	6.1	10.5	7.3	13.2	8.0	7.3	-	12.2
6	0.59	-	8.0	13.6	-	-	10.3	-	6.9	-
7	0.62	-	-	-	-	-	-	8.6	13.8	13.8
8	0.65	-	-	-	9.4	-	-	4.6	-	-
9	0.72	21.0	16.6	11.3	13.9	7.9	4.2	4.6	6.4	-
10	0.76	-	-	9.5	4.7	12.1	13.1	15.7	23.1	7.5
11	0.79	-	8.6	17.5	12.1	9.1	10.5	6.5	-	12.1
12	0.82	-	9.0	9.6	7.7	13.9	6.5	-	10.5	8.8
13	0.87	27.0	-	28.0	-	16.8	-	8.7	10.3	10.2
14	0.93	25.7	24.0	-	19.2	12.4	32.4	-	21.1	23.0
15	0.98	-	8.8	-	-	14.6	-	22.6	-	-
Total	—	**4**	**10**	**7**	**11**	**8**	**10**	**11**	**8**	**9**

P_1 = Giza 461
P_2 = Giza 843
P_3 = Sakha 1

P_5 = D5
P_7 = D_7
P_8 = D_8

H_1 = Giza 461 x D5
H_8 = Giza 843 x D7
H_{14} = Sakha 1 x D_8

Table (24). Description of protein banding patterns by SDS-PAGE for six parental genotypes and their three F_1 hybrids of *Vicia faba*

Entries / Band	Rf	P_1	H_1	P_5	P_2	H_8	P_7	P_3	H_{14}	P_8
1	0.41	-	+	-	+	-	-	+	+	+
2	0.46	-	++	-	+	-	+	+	-	+
3	0.51	-	+	-	+	-	+	+	-	-
4	0.54	++++	-	-	+	-	+	-	-	-
5	0.57	-	+	++	+	++	+	+	-	++
6	0.59	-	+	++	-	-	++	-	+	-
7	0.62	-	-	-	-	-	-	+	++	++
8	0.65	-	-	-	+	-	-	+	-	-
9	0.72	+++	++	++	++	+	+	+	+	-
10	0.76	-	-	++	+	++	++	++	+++	+
11	0.79	-	++	+++	++	++	++	+	-	++
12	0.82	-	++	++	+	++	+	-	++	++
13	0.87	++++	-	++++	-	+++	-	+	++	++
14	0.93	++++	++++	-	+++	++	++++	-	+++	+++
15	0.98	-	+	-	-	++	-	+++	-	-
Total		4	10	7	11	8	10	11	8	9

- = Absent + = very faint ++ = Faint
+++ = Dark ++++ = very dark

while, each of two parents, Giza 843 and D_7 revealed eleven and ten bands. The seven bands nos. 1, 2, 3, 4, 6, 7 and 8 with mobility Rf= 0.41, 0.46, 0.51, 0.54, 0.59, 0.62 and 0.65 were absent in the F_1 hybrid 8, while were observed for each two parents, respectively. The six bands nos. 5, 9, 10, 11, 12 and 14 with mobility Rf= 0.57, 0.72, 0.76, 0.79, 0.82 and 0.93 were observed for all genotypes, revealed very faint to faint density, respectively. In addition the two bands nos. 13 and 15 with mobility Rf= 0.87 and 0.98, were observed only in the F_1 hybrids revealed dark and faint density.

Regarding to F_1 hybrid no. 14 (Sakha 1 x D_8) revealed eight different bands, parent Sakha 1 revealed eleven bands, while parent D_8 revealed nine different bands. The four bands nos. 1, 7, 10 and 13 with mobility Rf= 0.41, 0.62, 0.76 and 0.87 were observed for all genotypes, while the three bands nos. 2, 5 and 11 with mobility Rf= 0.46, 0.57 and 0.79 were observed for two parents and absent for F_1 hybrid 14. The six band nos. 6, 7, 10, 12, 13 and 15 were observed for parent D_8, expressed in the F_1 hybrid 14, revealed very faint to dark density. In general, the results obtained from protein electrophoresis support the conclusion reached from the biometrical and total protein analysis on the importance of heterosis and its usefulness in the improvement of faba bean. This conclusion is in agreement with those reported by **Polignano** ***et al.*** **(1987), Fayed (1989), Youssef (1990), Kamel and El-Mashad (1999) and El-Rodeny (2002)**.

I.b. Isozymes banding patterns :

Electrophoresis technique offer an exceptional opportunity to study the substructure differences in proteins among different genotypes. One form of protein electrophoresis, i.e., isozyme analysis has become a powerful research tool for application in a multitude of biological disciplines, particularly in genetic studies. Because isozymes are proteins, they can directly reflect alterations in the DNA sequence through changes in amino acid composition. Changes in amino acid composition will often alter the charge or less often, the conformation of the enzyme, thereby producing a change in electrophoretic mobility. Despite the redundancy of the genetic code and the possibility of amino acid substitutions not affecting the overall charge on the protein, changes in the electrophoretic mobility of enzymes provide an extremely useful, method of evaluating genetic differences among the two faba bean groups. Therefore, isozyme polymorphisms provide a direct measures of DNA sequence variation within and among genomes (**Abd Rl-Tawab *et al.*, 1989 and El-Rodeny,2002).**

In the present study isozyme analysis was carried out on leaves from three weeks old plants. Two isozyme systems, i.e., peroxidase and esterase were evaluated for each genotype using polyacrylamide gel electrophoresis.

I.b.1. Peroxidase isozyme polymorphism :

Figure (3) shows peroxidase enzyme electrophoresis patterns of the nine parental genotypes under study, while Tables (25 & 26) shows the presence or absence of bands and their activity. The data show that there are ten bands with different mobility and activity which reflect a high degree of variation.

The obtained results in Figure (3) and Tables (25 & 26) show that the peroxidase zymogram of indeterminate habit parents (Giza 461, Giza 843, Sakha 1 and Nubaria 1) revealed (8, 4, 5 and 7) bands, while the determinate habit parents (D_5, D_6, D_7, D_8 and D_9) revealed 5 bands for each parent. The four band with mobility Rf= 0.03, 0.22, 0.33 and 0.69 were present in all parental genotypes, both bands nos. 1 and 5 revealed very faint to faint activity, while, band no. 4 revealed very faint to dark activity, but the band no. 8 revealed faint to very dark activity. The band no. 2 with mobility Rf= 0.05 was absent in each of parents Giza 843, Sakha 1, D_5, D_6, while was detected in each of parents Giza 461, Nubaria 1, D_7, D_8 and D_9, revealed very faint to faint activity. The band no. 3 with mobility Rf= 0.11 was absent in each of parents, P_2, P_4, P_7, P_8 and P_9, while was observed in each of parents, P_1, P_3, P_5 and P_6. The bands no. 6 and 7 with mobility Rf= 0.44 and 0.60 were observed only for parent no. 4

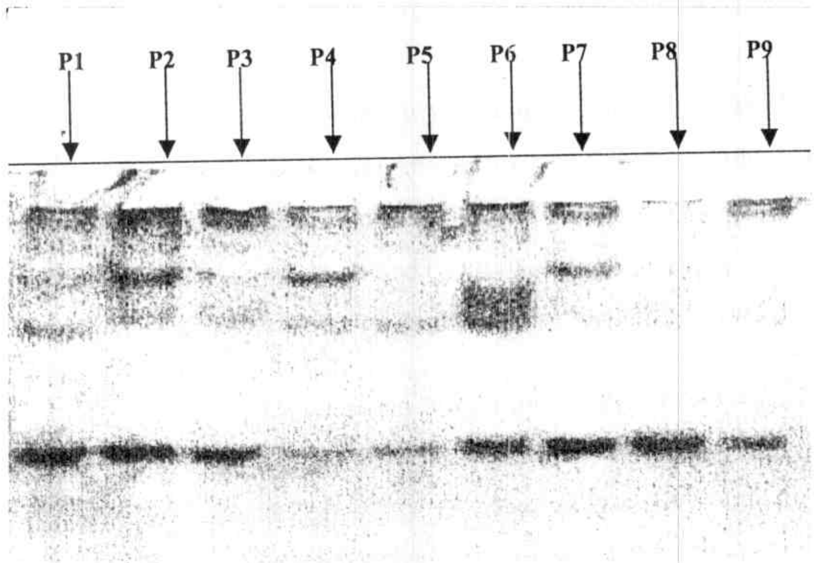


Figure (3). **Electrophoresis banding patterns of peroxidase isozyme of *Vicia faba* for nine parental genotypes under study**

P_1 = Giza 461	P_4 = Nubaria 1	$P_7 = D_7$
P_2 = Giza 843	$P_5 = D_5$	$P_8 = D_8$
P_3 = Sakha 1	$P_6 = D_6$	$P_9 = D_9$

Table (25). Analysis of electrophoresis patterns of peroxidase isozyme for nine parental genotypes of *Vicia faba*

Entries / Band	Rf	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1	0.03	7.8	23.0	21.9	12.0	23.9	13.6	7.8	11.9	17.9
2	0.05	8.7	-	-	10.0	-	-	20.4	8.1	18.3
3	0.11	9.1	-	16.0	-	19.4	11.1	-	-	-
4	0.22	18.8	25.5	14.9	22.6	16.9	28.5	23.1	10.9	9.1
5	0.33	14.2	22.1	22.1	16.3	23.8	23.1	11.2	20.9	12.1
6	0.44	-	-	-	7.9	-	-	-	-	-
7	0.60	-	-	-	7.7	-	-	-	-	-
8	0.69	23.7	29.5	25.1	23.5	16.1	23.6	37.6	48.1	42.9
9	0.83	9.3	-	-	-	-	-	-	-	-
10	0.90	8.4	-	-	-	-	-	-	-	-
Total		**8**	**4**	**5**	**7**	**5**	**5**	**5**	**5**	**5**

Table (26). Description of peroxidase patterns of nine parental genotypes of *Vicia faba*

Entries / Band	Rf	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1	0.03	+	++	++	+	++	+	+	+	++
2	0.05	+	-	-	+	-	-	++	+	++
3	0.11	+	-	++	-	++	+	-	-	-
4	0.22	++	+++	++	++	++	+++	++	+	+
5	0.33	++	++	++	++	++	++	+	++	+
6	0.44	-	-	-	+	-	-	-	-	-
7	0.60	-	-	-	+	-	-	-	-	-
8	0.69	++	+++	+++	++	++	++	++++	++++	++++
9	0.83	+	-	-	-	-	-	-	-	-
10	0.90	+	-	-	-	-	-	-	-	-
Total		**8**	**4**	**5**	**7**	**5**	**5**	**5**	**5**	**5**

- = Absent　　+ = Very faint　　++ = Faint
+++ = Dark　　++++ = Very dark

(Nubaria 1), revealed very faint activity. Moreover, bands no. 9 and 10 with mobility Rf= 0.83 and 0.90 were absent for all genotypes except parent no. 1 (Giza 461), revealed very faint activity. In general these results showed that insignificant differentiate between determinate and indeterminate habit types of faba bean.

I.b.2. Esterase isozyme polymorphism :

Figure (4) shows esterase enzyme electrophoresis patterns of nine parental genotypes under study, while, Tables (27 & 28) show the presence or absence of bands, and their activity. The esterase zymogram of all parents revealed that there are only one band no. 1 with mobility Rf= 0.38, revealed different activity for all genotypes (determinate and indeterminate habit). This band revealed faint activity for each of parents D_6, D_7, while, revealed dark activity for each of parents Giza 461, D_5 and D_9 and revealed very dark activity for each of parents Giza 843, Sakha 1, Nubaria 1 and D_8. These results confirmed the insignificant variations between both determinate and indeterminate habit types of faba bean. Moreover, regarding to esterase isozyme polymorphism for six parental genotypes and their F_1 hybrids illustrated in Figure (5) and summarized in Tables (29 & 30). The results showed that there are only one band no. 1 with mobility Rf= 0.72, revealed different activity for all genotypes. Regarding to cross no. 1 (Giza 461 x D_5), this band revealed dark activity for two parents and faint activity for hybrid 1. Regarding to hybrid no. 8 (Giza 843 x D_7) this band revealed faint activity for each of hybrid 8 and parent D_7, while revealed very dark activity for parent Giza 843. In addition to hybrid no. 14 (Sakha 1 x D_8), this band revealed very dark activity for each of two parents, while revealed dark activity for hybrid. These results confirmed that the activity of band moved from parents to their hybrids. These results were agreement with those reported by **Abd El-Tawab *et al.* (1989), Przybylska *et al.* (1992) and El-Rodeny (2002).**

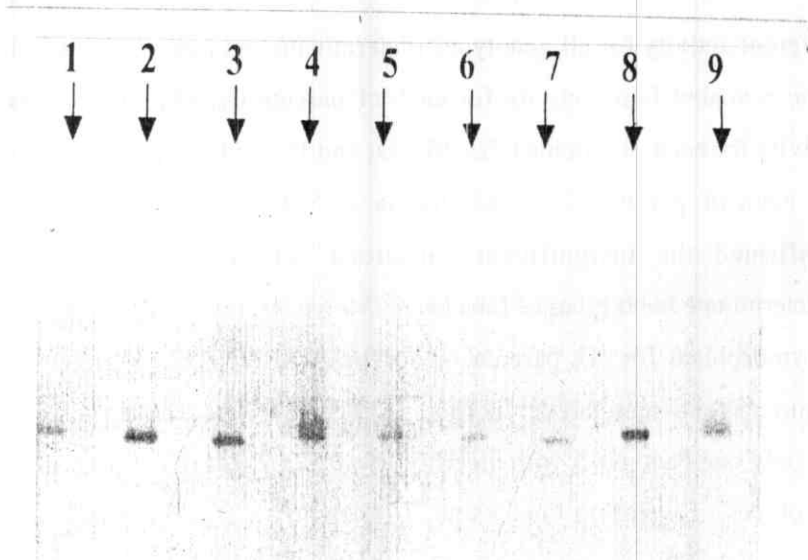


Figure (4). Electrophoresis banding patterns of esterase isozyme of *Vicia faba* for nine parental genotypes under study

P_1 = Giza 461	P_4 = Nubaria 1	$P_7 = D_7$
P_2 = Giza 843	$P_5 = D_5$	$P_8 = D_8$
P_3 = Sakha 1	$P_6 = D_6$	$P_9 = D_9$

Table (27). Analysis of electrophoresis patterns of esterase isozyme for nine parental genotypes of *Vicia faba*

Entries / Band	Rf	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1	0.38	34.8	39.6	46.3	58.1	35.0	20.8	18.9	40.8	37.0

Table (28). Description of esterase patterns for nine parental genotypes of *Vicia faba*

Entries / Band	Rf	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1	0.38	+++	++++	++++	++++	+++	++	++	++++	+++

- = Absent + = Very faint ++ = Faint
+++ = Dark ++++ = Very dark

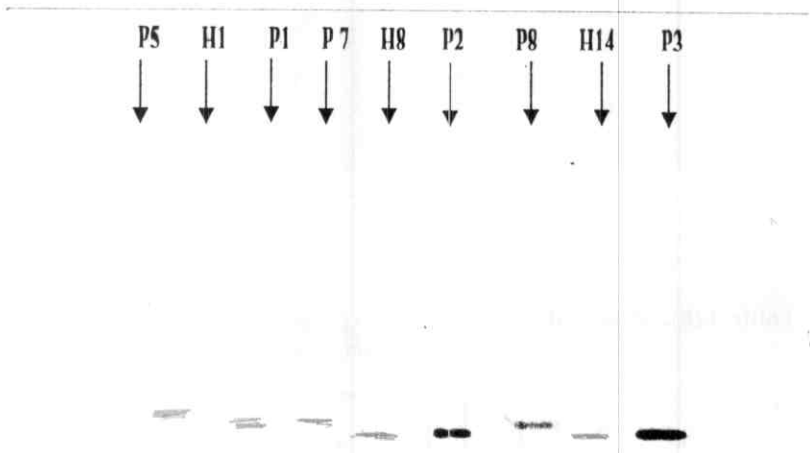


Figure (5).Electrophoresis banding patterns of esterase isozyme of *Vicia faba* for six parental genotypes and their three F_1 hybrids

P_1 = Giza 461	H_1 = G. 461 x D_5	$P_5 = D_5$
P_2 = Giza 843	H_8 = G. 843 x D_7	$P_7 = D_7$
P_3 = Sakha 1	H_{14} = Sakha 1 x D_8	$P_8 = D_8$