RESULTS & DISCUSSION

4. RESULTS AND DISCUSSION

4.1. First cross (line 18 x line 103):

4.1.1. F_3 generation:

The mean squares associated with F_3 families was found to be highly significant for the five traits under study (Table, 2).

The mean performances of F_3-families as well as two parent lines 103 and line 18 for the five traits are presented in Table (3).

For maturity date all families except no. 3 and 9 behaved as the earliest than the early parent line 103. The families no. 1, 2, 3 and 13 significantly surpassed the better origin parent L-18. While, the other families showed lower number of pods/plant relative to L-18. All F_3 families surpassed significantly the heavier parent of 100-seed weight. F_3 families no. 10 and 17 gave the highest significant mean number of seeds/pod than the better parent (L-103).

With respect of seed yield/plant, F_3 families no. 1, 2, 3, 7, 13 and 17 significant out yielded the better parent.

The genetic components of variation Table (3) showed the estimates of Δg, $\Delta g\%$ and GCV.

The high estimates of heritability in broad-sense were detected for all the studied traits. The same results had been reported by El-Hosary (1982) for days to maturity, Leleji *et al.* (1972), Habeeb (1998), Leroy *et al.* (1991) and Darwish (1993) in soybean for no. of pods/plant, no. of seeds/pod, 100 seed weight

Table (2): Mean squares of the F_3 families for the five studied traits.

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replication	2	5.40	12.76**	0.94	0.09	84.51**
F_3 families	17	95.83**	828.51**	596.63**	0.86**	1381.13**
Error	34	3.09	1.43	0.71	0.04	19.96

** Significant at 0.01 level of probability, Table (3): Mean performance of the selected F_3-families and the genetic parameters (heritability in broad sense, genetic coefficient of variation and genetic advance).

F_3-Family	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
1	142.67	53.00	87.56	2.47	118.54
2	147.33	59.00	71.60	1.90	78.94
3	157.33	58.00	74.08	2.34	100.69
4	153.00	35.33	60.42	2.47	57.54
5	153.33	21.00	68.52	2.26	39.79
6	154.00	31.33	85.59	2.44	66.69
7	142.33	36.00	112.55	2.54	104.55
8	145.00	29.00	75.38	2.61	57.44
9	158.33	41.00	81.15	1.92	56.49
10	153.33	23.00	88.61	3.51	64.50
11	150.00	36.67	70.59	2.49	67.54
12	151.33	32.00	82.39	2.80	68.53
13	153.33	44.00	75.84	2.58	95.33
14	142.67	27.33	71.44	3.07	73.72
15	145.00	15.00	114.38	2.79	46.79
16	142.33	24.00	90.95	2.74	60.93
17	143.00	23.00	75.92	4.13	71.93
18	142.00	16.07	89.24	3.27	46.92
Line 103	160.00	32.60	60.70	3.10	61.25
Line 18	165.00	41.90	50.02	2.70	60.90
X	148.70	33.59	82.01	2.67	70.94
L.S.D. at 0.01	3.91	2.66	1.89	0.46	9.92
Heritability %	90.91	99.19	99.62	86.35	95.79
Δg	9.28	23.10	24.61	0.85	36.48
Δg %	6.24	68.77	30.01	31.76	51.42
G.C.V. %	3.74	39.46	17.18	19.53	30.03

and seed yield/plant and El-Hosary *et al*. (2001) for no. of pods/plant.

Genetic gain was rather higher for number of pods/plant and seed yield/plant. Moderate gain was found for 100-seed weight and number of seeds/pod. While, low gain .was detected for days to maturity. Also, the same trend was obtained for G.C.V.%. The same results had been reported by El-Hosary (1982) for days to maturity, El-Hosary *et al.* (1997) in soybean for 100-seed weight and no. of seeds/pod and El-Hosary *et al.* (2001) for no. of pods/plant.

4.1.2. F_4 generation:

Mean squares due to F_4 families were found to be significant for all the studied traits (Table, 4) indicating that the mean performances of 68 F_4 families as well as two parents for the five traits under study are presented in Table (5).

For maturity date the range of the selected families varied from 142.33 to 158 days with an average of 151.37 days. Thirty nine families showed significant for desirable maturity date. The best families were no. 2, 3, 6, 8, 12, 17 and 31 for maturity date (Table, 5).

For number of pods/plant, the range of selected families varied from 85.00 to 7.00 pods. Fourty four families had significant superiority than the best parent. The family no. 52 gave the highest number of pods/plant. However, the family no. 47 gave the lowest one (7.00 pods).

With the exception of families no. 13, 23, 61 and 64 the all families surpassed significantly the best parent for 100-seed.

Table (5): Cont.

Family	Trait				
	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
41	156.67	10.00	67.87	4.14	28.44
42	149.00	15.00	84.29	2.27	30.16
43	149.67	13.33	71.20	1.06	10.25
44	152.33	19.00	75.68	2.84	40.56
45	153.00	20.00	78.61	1.64	21.02
46	156.00	23.00	76.08	2.63	45.96
47	157.00	7.00	80.77	3.24	18.97
48	148.67	15.00	99.53	6.37	61.19
49	147.00	70.67	80.16	2.54	133.18
50	155.67	52.67	75.18	2.45	128.08
51	153.00	43.00	100.63	2.38	85.05
52	153.67	85.00	84.94	2.41	156.53
53	148.33	37.33	112.19	2.47	89.77
54	147.33	33.00	90.99	2.89	77.49
55	152.67	12.00	69.09	2.70	38.32
56	153.33	63.00	86.43	2.42	130.04
57	152.33	37.33	87.97	4.04	103.67
58	152.00	66.33	80.68	2.47	145.23
59	155.33	56.33	87.47	2.75	125.18
60	152.67	57.00	66.52	2.49	115.71
61	151.33	16.00	61.89	3.05	30.07
62	146.33	18.67	74.99	2.74	37.75
63	153.00	10.67	86.29	2.51	23.33
64	148.00	21.00	59.06	2.36	28.93
65	157.33	21.00	85.15	4.00	42.47
66	158.00	11.00	70.39	2.43	19.25
67	155.00	11.00	64.97	2.40	16.90
68	157.00	15.00	66.64	2.46	15.69
Line 18	160.00	25.50	63.00	2.96	50.01
Line 103	158.00	26.30	63.81	2.90	48.33
XG	151.37	38.98	82.24	2.88	88.59
L.S.D at 0.01	6.54	4.11	1.19	0.79	14.69
Heritability %	67.38	99.02	99.79	83.33	97.85
Δg	6.45	34.38	22.08	1.34	81.88
Δg %	4.26	89.34	26.85	46.53	92.43
G.C.V. %	2.97	51.31	15.36	29.05	53.39

The mean values of selected families ranged from 125.77 (Family no. 19) to 56.00 (family no. 23) with average of 82.24 g.

For number of seeds/pod, the range of selected families varied from 6.37 (family no. 48) to 1.06 (family 43) with an average of 2.88.

All selected families surpassed significantly the better parent for seed yield/plant except families no. 6, 23, 39, 40, 41, 42, 43, 44, 45, 46, 47, 55, 61, 62, 63, 64, 65, 66, 67 and 68. The range of selected families varied from 183.14 (family no. 27) to 10.25 (family no. 43). The best families were no. 27, 37 and 32. The percentage of superior selected families having higher seed yield than better parent and the population mean were 66.18% and 55.88%, respectively.

The thirty one families gave two or three times much of seed yield than the better parent (Table, 5).

From the previous mentioned data it is observed that the pedigree method was more effective for selected superior families. The same results had been reported by Shalaby *et al.* (2001) for bulk method.

Heritability in broad sense in the F_4-families for the five traits under study was estimated and the obtained values are presented in (Table, 5). High heritability values were detected for all traits indicating the effectiveness of selection in this materials.

The values for expected genetic advance (ΔG) and $\Delta G\%$ reported in (Table, 5) show the possible gain from selection as percent increase in the F_5 over the F_4 plants. Genetic gain was rather higher for number of pods/plant, number of seeds/pod and seed yield/plant. Moderate gain was found for 100-seed weight.

However, low gain was found for maturity date. These results are in general agreement with those obtained by El-Hosary *et al.* (1997) in soybean for days to maturity and no. of pods/plant, Habeeb *et al.* (1998) in soybean for days to maturity and El-Hosary *et al.* (2001) in soybean for no. of pods/plant.

Table (5) shows high genetic coefficient of variation for number of pods/plant, number of seeds/pod and seed yield/plant and moderate GC.V. for 100-seed weight and low G.C.V. value for maturity date.

Using the genetic coefficient of variation alone, however, is impossible to estimate the magnitude of heritable vatiation. The heritable portion of the variation could be found out with the help of heritability estimates and genetic gain under selection (Swarup and Chaugle, 1962).

Johanson *et al.* (1955) reported that heritability estimates a long with genetic gain upon selection were more valuable than the former alone in predicting the effect of selection. On the other hand, Dixit *et al.* (1970) reported that high genetic coefficient of variation G.C.V. and high heritability were not always associated with high genetic advance for a trait. But to make effective selection, high heritability should be associated with high genetic advance.

Quantitative characters having high heritability values may be of great help for selection on the basis of phenotypic performance. In the present work number of pods/plant, number of seeds/pod and seed yield/plant, showed that high genetic gain was found to be associated with rather high heritability and G.C.V. estimates. Therefore, selection for these traits should be effective and satisfactory for successful breeding purposes. High heritability values associated with moderate gain from selection were obtained for 100-seed weight. Hence it could be concluded that selection for this trait will be effective but probably of less success than in the former three traits.

Relatively low genetic gain was associated with moderate heritability value for maturity date. Hence selection for this trait may be less effective.

4.1.3. F_5-generation:

4.1.3.1. Comparison between three breeding methods:

Mean square due to breeding methods were significant for all the five traits under study (Table, 6). This result indicated that the pedigree method gave earliness plants but without superiorty than bulk method for maturity date (Table, 7). While, the bulk method had the highest number of pods/plant followed by pedigree method and then single pod descent (SPD). However, the pedigree method had significant high 100 seed weight, number of seeds/pod and seed yield/plant followed by bulk method and then SPD (Table, 7).

Working on self pollinated crops, breeders applied one or more different breeding methods in order to investigate or compare their efficiency in selecting high seed yield. Among those Torrie (1958), Voigt and Weber (1960), Shutz *et al.* (1968), Allard and Adams (1969), Omer (1989) on barley, wheat, soybean and faba bean using two or more methods of breeding.

Table (6): Mean squares of method of plant breeding selection and lines/methods in the selected F_5 lines.

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Lines	38	17.39	30.55	159.33	0.83	192.87
Methods	2	13.77	69.22**	376.58**	0.86**	101.97**
Lines/methods	36	17.59**	28.40**	147.26**	0.82**	197.92**
Error	78	6.88	0.54	0.94	0.01	2.44

** Significant at 0.01 level of probability, Table (7): Mean values of the three breeding methods in the first cross.

Trait / Breeding method	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Pedigree method	156.05	14.13	82.80	2.57	29.56
Bulk method	156.15	16.36	76.67	2.28	28.71
Single pod descent	157.13	13.98	80.62	2.42	26.43
Average (XG)	156.44	14.82	80.03	2.42	28.23
L.S.D. at 0.01	0.91	0.25	0.274	0.035	0.54

Table (8): **Mean performance of the selected F_5-lines for the three breeding methods**

Regarding to 100-seed weight, twelve, ten and nine lines showed significant higher than heavier parent in seed index for pedigree, SPD and bulk method, respectively. The heavier line was no. 11 (94.52) in pedigree method, followed by lines no. 7 (91.91) and no. 1 (89.33) in SPD.

For number of seeds/pod, six, five and three lines gave significant higher than the best parent in pedigree SPD and bulk methods, respectively. The line no. 6 and 11 in pedigree method gave the highest number of seeds/pod.

4.1.3.2. Direct and indirect selection:

Selection for yield and yield components deserves considerable interest. A crop breeding programme aimed at increasing plant productivity requires consideration interest not only of yield but also of its components which have a direct or indirect bearing on yield. Present work was under taken to compare the efficiency of indirect selection for yield via yield components with direct selection for seed yield/plant.

Mean squares due to five selection criteria; number of pods/plant, 100-seed weight, number of seeds per pod, low and high seed yields/plant were significant (Table, 9). Significant differences between the five selection criteria in maturity date number of pods/plant, 100-seed weight, number of seeds/pod and seed yield/plant were detected revealing that the selection criteria differed among them.

Table (10) shows the effect of selection criteria on five traits under study.

Table (9): Mean squares for the five selection criteria and lines/selection criteria in the first cross (F_5-lines).

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Lines	44	20.28	60.42	209.53	0.91	463.42
Methods	4	19.00*	245.56**	112.82**	1.64**	1032.26**
Lines/methods	46	20.40**	41.91**	219.20**	0.83**	406.56**
Error	90	7.28	1.34	1.04	0.02	12.31

* and ** significant at 0.05 and 0.01 level of probability, respectively.

Table (10): Mean values of the five selection criteria in the first cross.

Trait / Selection criteria	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
No. of pods/plant	157.60	20.79	79.13	2.72	42.61
100-seed weight	157.17	15.76	82.58	2.27	29.26
No. of seeds/pod	156.10	15.53	82.23	2.31	35.04
Seed yield/plant (H)	156.03	14.95	80.97	2.38	28.58
Seed yield/plant (L)	77.73	5.93	42.69	1.44	14.49
L.S.D. at 0.01	0.87	0.37	0.33	0.05	1.14

For maturity date, the selection for low seed yield/plant gave the earliest plant (77.73 days) followed by high seed yield/plant and number of seeds/pod and then by selection of 100-seed weight and number of pods/plant. The selected low seed yield/plant gave the earliest of maturity date which is logically expected. Whereas, the low seed yield was correlated with early maturity.

Concerning the differences between selection criteria in number of pods/plant, it is clear that selection criteria significantly affected number of pods/plant. The highest number of pods/plant was recorded from selection for number of pods followed by 100-seed weight. However, the selection of low seed yield gave the lowest one.

With respect to the effect of selection criteria on 100-seed weight, the results revealed that selection for 100-seed weight gave significant heavier seed index followed by selection high number of seeds/pod and then by selection high number of pods/plant. However, the lowest values was detected by selection of low seed yield/plant.

Concerning the effect of selection methods on number of seeds/pod, the selection of high number of pods/plant gave significant highest number of seeds/pod followed by selection plants with heavier seed index and then by selection with high number of seeds/pod. However the lowest value was detected when selected plants with low seed yield/plant.

For seed yield/plant, the selection method of high number of pods/plant exhibited significant higher value of this trait, followed by selected plants with high number of seeds/pod and then by selected plants with heavier seed index and selection high seed yield/plant.

Generally, the selection of high number of pods/plant gave the highest mean values for number of pods/plant, number of seeds/pod and seed yield/plant. Also, it ranks the fourth for seed index. As early as 1964 Grafius suggested that improvement of complex characters like yield may be accomplished through components breeding. Subsequently, many workers (Takeda and Frey, 1976; Mc Neal *et al.*, 1978; Johnson *et al.*, 1983; Bahi and Vinod, 1991 and Kumar and Bahi, 1992) suggested that selection for component traits can help to increase productivity. The present investigation expressed that the selection for high number of pods/plant was more efficient as indirect selection for yield via direct selection for seed yield/plant. Also, the selection for high number of seeds/pod and heavier 100-seed gave more effectiveness of seed yield/plant compared with selection of seed yield *per se* in faba bean. The results indicate that selection for pod number, seeds/pod and seed index was more efficient in breeding forward superior yielding F_5 lines. It could be concluded that selection for number of pods/plant, number of seeds/pod and seed index for three successive generations was successful in improving the mean seed yield of F_5 lines.

The mean values of selected F_5-lines for maturity date, number of pods/plant, number of seeds/pod, 100-seed weight and seed yield/plant were affected by selection criteria (indirect selection high no. of pods/plant, high no. of seeds/pod, heavier seed index and direct selection high seed yield/plant and low seed yield/plant) (Table, 11).

For maturity date, line no. 6 derived from selection of high seed yield/plant had significantly the earliest than the over all mean. However none of the other lines gave significant earliest differences than the population mean. This result is logically expected whereas the selection for earliness was not.

For number of pods per plant, seven, two, two, two and zero lines gave significantly higher than population mean, when selected plants with high number of pods/plant, heavier seed index, high number of seeds/pod, high seed yield/plant and low seed yield/plant, respectively. This result is logically expected. The lines beared high number of pods obtained from lines derived from selection gave plant with high number of pods (Table, 11).

For seed index, one, five, three, three and four lines surpassed significantly heavier population mean for selection high number of pods/plant, seed index number of seeds/pod, high and low seed yield/plant, respectively.

Regarding seed yield/plant, the range of selected lines ranged from 35.95 to 55.98, 21.69 to 38.99; 12.69 to 78.67; 17.15 to 48.20 and 20.03 to 38.70 when selected plants with high number of pods, heavier seed, no. of seeds/pod, high and low seed yields/plant, respectively. Also, six, zero, one, one and zero lines surpassed significantly higher seed yield/plant than population mean in the same order.

It could be concluded that indirect selection for yield via pod number is more efficient than direct selection for yield.

Table (11): Mean performance of the F_5-selected F_5 by the five selection criteria in the first cross.

Selection criteria	Line	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
No. of pods/plant	1	155.33	15.40	101.21	2.36	36.52
	2	159.00	16.30	89.86	2.79	40.73
	3	158.00	26.40	79.69	2.69	55.98
	4	159.33	22.30	68.63	2.24	34.28
	5	160.00	23.20	80.35	1.93	35.95
	6	154.33	23.73	76.44	2.31	41.42
	7	158.00	21.00	69.06	3.15	45.42
	8	159.00	19.00	79.67	2.78	42.77
	9	153.33	12.53	74.68	4.18	38.28
	10	159.67	28.10	71.66	2.73	54.76
100-seed weight	1	155.33	16.00	88.82	2.15	30.29
	2	157.00	17.10	90.16	2.31	34.86
	3	158.33	11.97	80.49	2.75	26.13
	4	159.33	16.40	74.93	2.18	30.35
	5	158.00	13.63	78.99	2.67	28.69
	6	156.00	15.30	88.04	2.25	30.07
	7	157.33	12.97	88.13	2.46	28.00
	8	159.33	18.50	86.87	2.46	38.99
	9	158.67	18.40	77.91	1.52	21.69
	10	152.33	17.30	71.48	1.91	23.49
No. of seeds/pod	1	157.00	15.53	101.54	1.26	78.67
	2	159.33	26.20	80.09	2.33	57.99
	3	152.67	11.63	70.93	2.23	18.21
	4	153.00	17.20	76.94	3.35	44.70
	5	160.00	18.87	77.82	2.13	30.55
	6	153.00	13.40	78.24	1.68	12.69
	7	157.00	11.60	75.16	2.50	20.97
	8	156.33	15.53	93.75	2.44	35.36
	9	159.67	9.63	92.73	3.23	28.83
	10	153.00	15.73	75.09	1.89	22.46

Table (11): Cont.

Selection criteria	Line	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
High seed yield/plant	1	154.00	20.63	75.84	1.90	29.22
	2	157.00	14.77	75.18	2.09	23.40
	3	159.00	14.33	79.78	2.82	33.29
	4	154.00	17.00	80.51	2.31	31.33
	5	152.33	14.30	75.53	1.68	18.08
	6	151.67	11.53	83.28	3.38	25.50
	7	157.00	13.63	82.28	2.13	23.52
	8	158.68	18.20	97.36	2.73	48.20
	9	159.33	14.40	89.33	2.51	36.09
	10	157.33	10.73	70.63	2.26	17.15
Low seed yield/plant	1	157.67	8.73	76.07	3.07	20.03
	2	152.67	13.43	86.49	2.53	28.81
	3	155.67	12.53	94.52	3.27	38.70
	4	153.00	11.97	84.78	3.07	31.13
	5	158.33	12.63	85.12	2.43	26.25
X		156.59	16.22	81.69	2.47	33.33
L.S.D. at 0.01		5.79	2.49	2.19	0.34	7.54

The comparison revealed the efficiency of selection for number of pods/plant, followed by number of seeds/pod and then seed index in improving mean yield of F_5 lines and also extracting a higher number of high yielding lines (selection for high no. of pods/plant). It also appeared that indirect selection for yield via number of pods per plant was more efficient than direct selection for yield. Similar observations have been reported by other workers. Bisen *et al.* (1985) reported that indirect selection for seed size was the best method for improving seed yield in chickpea. Rahman and Bahi (1985) reported that the random bulk method was inferior to other breeding methods. Khorgade *et al.* (1985) observed that seed weight selection was more efficient in increasing yield than selection for seed yield alone. Bahi and Vinod (1991) reported that selection for number of pods/plant was more effective in extracting maximum number of high yielding F_5 lines than other methods studied.

It is interesting to examine the combining ability with regard to seed yield of the parents involved in the crosses which yielded a relatively high proportion of lines which excelled the check significantly in terms of seed yield. This information was available from the previous study.

4.2. Second cross:

4.2.1. F_3-generation:

The results indicated that F_3-families mean squares were highly significant for all the five studied traits, indicating wide differences between the F_3-families (Table, 12).

Table (12): Mean squares of the F_3 families for the five studied traits.

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replication	2	5.36	3.36	0.92*	0.014	7.69
F_3 families	14	73.41**	383.71**	378.62**	0.77**	2543.28**
Error	28	11.52	1.83	0.19	0.01	11.52

* and ** significant at 0.05 and 0.01 level of probability, respectively.

Mean performances of F_3-families as well as the two parents G.B. and G.429 for the five traits are presented in Table (13). For maturity date the families no. 1, 11 and 15 showed the earliest than the early parent G.429 at five of percent of significant. The families no. 1 and 10 significantly surpassed the better parent G.429 for no. of pods/plant. However, the other families showed lower number of pods/plant relative to variety G.B.

Ten families surpassed significantly the heavier parent of 100-seed weight. The family no. 15 followed by no. 6 gave the highest values of 100-seed weight. For number of seeds per pod, the F_3-families no. 6, 7, 12, 13 and 14 gave significant higher values of this trait than the better parent (G.B). With respect of seed yield/plant, all F_3-families except both families no. 4 and 12, surpassed significant higher than the best parent (G.429). These results indicated the importance of selection in this material.

The genetic components of variation G.C.V. (Table 13) showed the high estimates of Δg, $\Delta g\%$ and G.C.V. for number of pods/plant and seed yield/plant. However, moderate values were detected for number of seeds/pod and 100-seed weight. Low values of these parameter were obtained for maturity date. The high heritability values in broad sense were detected for yield and its components. However, moderate values for these parameter were detected for maturity date. The same trend was previously reported by El-Hosary (1982) for maturity date, Bastwisy *et al.* (1997) in soybean for seed yield/plant and no. of pods/plant, El-Hosary *et al.* (1997) in soybean for no. of pods/plant and El-Hosary *et al.* (2001) in soybean for seed yield/plant, no. of seeds/plant and no. of pods/plant.

Table (13): Mean performance of the selected F_3-families and the parents parameters (heritability, genetic coefficient of variation and genetic advance) for the five traits in the second cross.

Family	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
1	154.33	45.00	81.06	1.95	65.10
2	156.00	21.00	79.34	3.20	51.19
3	161.33	27.33	66.47	2.89	52.38
4	162.33	16.33	71.70	3.18	37.48
5	162.33	22.00	90.31	3.19	62.99
6	158.33	19.33	95.34	3.82	73.20
7	163.00	27.00	96.29	3.44	89.31
8	162.33	20.00	88.01	2.97	52.13
9	161.33	24.00	90.70	3.18	68.95
10	156.00	54.33	94.45	2.82	144.71
11	148.00	32.67	81.93	2.27	60.48
12	161.00	10.33	86.73	3.39	30.35
13	161.00	37.00	86.74	3.57	114.60
14	161.00	24.00	89.39	3.76	79.71
15	148.33	24.00	113.36	2.84	76.96
R.B.	165.00	16.30	82.12	3.22	40.11
G.429	155.00	26.30	63.10	2.10	44.04
X	158.44	26.96	87.27	3.04	70.64
L.S.D. at 0.01	7.65	3.05	0.99	0.21	7.65
Heritability %	64.17	98.58	99.84	96.60	98.65
Δg	6.37	19.60	19.64	0.87	50.49
Δg %	4.02	72.70	22.50	28.62	71.48
G.C.V. %	2.87	41.85	12.87	16.64	41.12

4.2.2. F_4-generation:

Mean squares due to F_4 selected families were found to be significant for all the studied traits (Table, 14) indicating that the sixty F_4 selected families behaved some what differently from each to other. For maturity date, the range of the selected families ranged from 151.33 to 168.77 with an average of 161.11 days. The three families no. 10.11 and 27 had earlier compared with average of all genotypes. However, non of selected families were significantly earlier in maturity than those best parent.

As for no. of pods/plant the range of selected families varied from 7.00 to 81 pods. With the exception of selected families no. 3, 15, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 55, 56, 57, 58, 59 and 60 all selected families had significant superiority than the best parent. The families 11 and 27 followed by no. 4 gave the highest number of pods/plant. However the family no. 38 gave the lowest one.

Regarding 100-seed weight none of the selected families surpassed significantly the best parent. The mean values of selected families ranged from 106.09 (families no. 8 and 25) to 53.47 (family no. 33).

Concerning number of seeds/pod, the range of selected families varied from 5.03 (family no. 44) to 1.57 (family no. 2) with average 3.32. The selected families no. 9, 26, 32, 43, 44 and 52 showed significant superiority than the best parent.

With regard to seed yield/plant 33 selected families surpassed significant than the better parent. The range of selected families varied from 281.41 (family no. 51) to 20.31 (family 35). The best families were no. 51, 27, 11, 13, 23, 29, 43 and 54. The

Table (14): Mean squares of the selected F_4 families in the second cross.

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replication	2	14.11	2.67	2.39**	0.02	207.37**
F_4 families	59	48.06**	1178.00**	407.98**	1.28**	9708.51**
Error	118	15.17	3.16	0.311	0.04	42.97

** Significant at 0.01 level of probability.

percentage of superior selected families having higher seed yield than better parent and population mean were 61.66% and 45%, respectively.

From the previous mentioned data, it is observed that the pedigree method was more effective for selected superior families or lines.

The estimates of genetic coefficient of variation, genetic gain, genetic gain% and heritability in broad sense are presented in Table (15).

Heritability in broad sense in the F_4-families for the five traits under study was estimated and the obtained values are presented in Table (15). High heritability values were detected for yield and its components (no. of pods/plant, 100 seed weight, no. of seeds/pod and seed yield/plant) indicating the effectiveness of selection in this materials for these traits. However, low hertibility value was obtained for maturity date. The values of expected genetic advance (ΔG) and $\Delta G\%$ reported in Table (15) show the possible gain from selection as percent increase in the F_5 over the F_4 are selected.

Genetic gain was rather higher for number of pods/plant and seed yield/plant. Moderate gain was found for 100-seed weight and number of seeds/pod. However, low gain was found for maturity date. These results are in general agreement with those obtained by El-Hosary (1982) for maturity date, El-Hosary *et al.* (1997) in soybean for maturity date, 100-seed weight and no. of seeds/pod and El-Hosary *et al.* (2001) in soybean for maturity date.

Table (15): Mean performance of the selected F_4-families, heritability, genetic coefficient of variation and genetic gain% of selection in the second cross.

Line \ Trait	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
1	156.00	28.00	95.81	3.25	87.38
2	156.33	45.00	82.28	1.75	66.60
3	163.33	15.00	84.74	3.56	45.02
4	156.00	78.00	72.31	3.34	186.46
5	162.33	36.33	82.09	3.40	101.12
6	156.33	47.00	80.64	2.36	89.14
7	156.00	24.00	77.89	3.29	61.61
8	159.33	26.00	106.09	4.13	114.17
9	156.00	33.00	86.01	4.51	127.59
10	151.33	27.00	94.44	3.28	83.65
11	153.67	81.00	79.71	3.17	208.60
12	166.00	32.33	79.78	3.42	88.03
13	168.67	65.00	81.11	2.89	152.73
14	167.33	38.00	71.38	2.48	65.96
15	157.67	21.00	100.71	3.34	70.49
16	164.00	42.33	95.91	3.51	142.19
17	166.00	26.00	98.13	3.73	95.39
18	158.67	32.33	74.00	2.81	67.47
19	158.33	38.33	74.41	2.57	73.51
20	164.00	46.00	56.44	2.50	64.87
21	165.33	28.00	86.17	2.57	62.19
22	164.33	33.67	84.11	3.92	128.19
23	156.00	78.00	72.31	3.34	186.46
24	162.33	36.33	82.06	3.40	101.12
25	159.33	26.00	106.09	4.13	114.17
26	156.00	33.00	86.01	4.51	127.59
27	153.67	81.00	81.12	3.17	208.60
28	166.00	32.33	79.77	3.42	88.03
29	168.67	65.00	81.11	2.89	152.73
30	164.00	42.33	95.91	3.75	142.19
31	166.00	26.00	98.13	3.73	95.39
32	164.33	33.67	84.11	4.53	128.19
33	161.00	16.67	53.47	2.47	21.81
34	163.00	11.33	98.13	3.39	37.62
35	164.00	8.00	81.16	3.25	20.31

Table (15): Cont.

Trait / Line	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
36	160.00	7.67	94.32	3.08	22.09
37	162.67	19.00	78.00	2.42	35.59
38	162.00	7.00	100.43	4.13	28.27
39	163.33	15.00	82.05	2.54	31.09
40	164.00	13.33	94.71	3.44	43.06
41	163.00	11.33	104.85	3.53	39.61
42	161.00	9.33	76.44	3.45	24.58
43	161.33	44.00	94.08	4.56	188.72
44	156.67	22.00	102.81	5.03	113.80
45	159.67	35.33	86.24	3.21	98.04
46	158.67	37.67	80.78	3.31	100.39
47	158.00	45.00	70.55	3.50	111.09
48	164.00	56.33	81.17	3.57	162.63
49	158.33	22.00	101.34	3.43	76.65
50	168.00	34.33	102.63	2.57	90.39
51	161.33	79.00	97.63	3.64	281.41
52	162.33	26.00	101.43	4.25	111.97
53	162.00	36.33	95.02	2.36	81.11
54	164.00	53.00	90.80	3.67	177.92
55	164.00	10.33	90.73	2.55	23.91
56	163.00	9.33	75.08	3.11	21.96
57	159.00	12.00	80.83	2.51	24.63
58	159.00	11.33	103.94	3.69	43.51
59	162.67	16.00	81.11	2.74	35.75
60	157.00	15.00	92.71	3.20	44.49
R.B.	165.00	17.90	109.90	3.80	73.02
G.429	156.00	14.90	80.70	2.26	26.83
X	161.11	33.01	86.72	3.32	93.66
L.S.D at 0.01	8.17	3.73	1.17	0.43	13.75
Heritability %	41.95	99.20	99.80	90.90	98.70
Δg	3.75	39.49	20.38	1.07	98.69
Δg %	2.33	104.48	23.50	32.23	105.37
G.C.V. %	2.06	59.95	13.44	19.30	60.60

Table (15) shows high genetic coefficient of variation (G.C.V.) for number of pods and seed yield/plant. Moderate G.C.V. for 100-seed weight and number of seeds/pod and low G.C.V. value for maturity date were detected using the genetic coefficient of variation alone. However, it is impossible to estimate the magnitude of heritabile variation. The heritable portion of the variation could be found out to estimate heritability and genetic gain under selection (Swarup and Chaugle, 1962).

Johnson *et al.* (1955) reported that heritability estimates along with genetic gain upon selection were more valuable than the former alone in predicting the effect of selection. On the other hand, Dixit *et al.* (1970) reported that high genetic coefficient of variation (G.C.V.) and high heritability were not always associated with high genetic advance for a trait. But to make effective selection high heritability should be associated with high genetic advance. Quantitative characters having high heritability values may be of greet help for selection on the basis of phenotypic variance. In the present work for number of pods/plant and seed yield/plant, high genetic gain was found to be associated with rather high heritability and G.C.v. estimates. Therefore, selection for both traits should be effective and satisfactory for successful breeding purposes. High heritability values associated with moderate gain from selection were obtained for 100-seed weight and number of seeds/pod. Hence it could be concluded that selection for both traits will be effective but probably of less success than in the former two traits.

Low genetic gain was associated with low heritability value for maturity date. Hence selection for this trait may be less effective. As it is well know that expected improvement of selection is directly proportional to the heritability value. Also, the expected response to selection, varies with the phenotypic standard deviation of population means. This is measure of the total variability in the trait and therefore reflects the total response that could be realized breeding techniques.

4.2.3. F_5-generation:

4.2.3.1. Comparison between three selection methods:

Mean squares due to breeding methods were significant for yield and its components only (Table, 16). This result indicated the differences between breeding methods.

The bulk methods gave the highest values for number of pods/plant, number of seeds/pod and seed yield/plant. While the SPD exhibited significantly heaving 100-seed weight. It could be concluded that bulk method considered the best breeding method for seed yield/plant, number of seeds/pod and number of pods/plant, than those pedigree and SPD in this cross. This result attributed to working on self pollinated crops, breeders applied one or more different breeding methods efficiency in selecting high seed yield. Among those Torrie (1958), Voigt and Weber (1960), Schutz *et al.* (1968), Allard and Adams (1969), Omer (1989), Shalaby *et al.* (2001) on barley, wheat, soybean and faba bean using two or more methods of breeding.

Whan *et al.* (1982) found that the effect of selection using the means of lines form the F_3 and F_4 rather than the individual F_2 or F_3 derived lines, can be assessed by the yields

Table (16): Mean squares of method of plant breeding and lines/methods in the selected F_5 lines.

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Lines	38	14.88	42.53	260.28	0.97	230.41
Methods	2	13.56	75.17**	788.88**	1.36**	504.58**
Lines/methods	36	14.96**	40.72**	230.92**	0.95**	214.90**
Error	78	5.01	0.58	35.62	0.01	1.99

** Significant at 0.01 level of probability.

Table (17): Mean values of the three breeding methods in the second cross.

Trait / Method selection	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Pedigree method	156.72	14.69	78.62	2.39	27.35
Bulk method	157.90	15.03	83.46	2.72	33.50
Single pod descent	157.31	12.47	87.60	2.69	27.14
Average	157.30	14.06	83.23	2.60	29.33
L.S.D. at 0.01	0.77	0.26	2.06	0.04	0.49

obtained in the following generations. The improvement obtained in the F_5 by selecting F_2 derived lines was much greater in the first cross. When selection is carried out in an early generation e.g. among F_2 derived lines, the important consideration is the response to this selection in a late generation, *e.g.* the F_5 when lines are approaching homozygosity. In the simulated schemes considered here, the available data enabled each selected line to be continued with one random line only. This caused a less of variation for yield and the gain from selection was often reduced in the generations following selection.

Also, the efficiency of the breeding methods in the present study was evaluated based on the number of superior lines having higher values of seed yield/plant than the best parent. Data presented in Table (18) show that the bulk method produced consistently more superior lines compared the best parent or the average population with 11 and 9; 9 and 7; 7 and 4 for bulk, pedigree and SPD, respectively. The best lines were no. 10 (49.58 g), no. 6 (44.32) and no. 8 (43.02 g) in bulk method and no. 4 (43.62 g) in SPD.

For number of pods/plant the results indicated the pedigree method produced more superior lines followed by bulk and then by SPD compared the best parent or average over lines with eight, six and five lines, respectively.

Regarding to 100-seed weight, six, five and two lines showed significant higher than average over lines for SPD, bulk and pedigree methods, respectively. The heavier line was no. 1

Table (18): Mean performance of the selected F_5-lines for the three breeding methods.

Breeding method	Line	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
Pedigree	1	153.33	21.30	49.79	2.50	37.63
	2	158.67	8.63	79.62	2.27	14.79
	3	159.33	13.97	70.94	3.16	31.12
	4	159.00	17.53	82.07	2.06	29.35
	5	159.67	14.77	75.13	1.40	15.17
	6	158.33	16.63	77.41	2.73 .	34.47
	7	156.67	11.63	81.04	1.83	16.81
	8	154.67	15.20	94.87	1.10	15.72
	9	158.33	13.00	95.52	2.62	32.18
	10	153.00	13.87	71.67	3.23	31.32
	11	156.33	16.00	80.59	2.68	34.44
	12	155.33	12.53	80.77	2.89	29.23
	13	154.67	15.97	82.59	2.53	33.26
Bulk	1	158.00	9.67	98.18	3.23	30.63
	2	157.67	17.53	88.02	2.40	37.55
	3	158.33	11.10	78.52	2.73	23.79
	4	159.33	17.63	82.09	1.87	26.49
	5	159.67	15.73	87.43	2.73	37.53
	6	158.00	12.97	92.01	3.70	44.32
	7	159.00	17.97	83.86	2.33	34.54
	8	158.67	18.00	75.79	3.17	43.02
	9	158.33	17.00	88.07	2.17	32.46
	10	158.00	21.20	83.29	2.83	49.58
	11	151.67	11.63	76.78	2.40	21.27
	12	159.00	12.30	84.22	3.07	31.51
	13	157.00	12.63	66.74	2.77	22.81
Single pod descent	1	156.00	15.63	97.98	2.57	39.49
	2	154.67	6.63	82.89	3.30	18.05
	3	158.33	8.97	93.02	2.67	22.49
	4	159.33	16.63	84.09	3.04	43.62
	5	160.33	10.97	78.22	3.47	29.72
	6	159.33	7.30	95.43	3.03	20.74
	7	153.00	21.20	94.84	1.60	32.71
	8	158.00	13.63	88.49	2.80	33.41
	9	159.67	11.30	85.02	2.70	20.90
	10	157.67	12.97	85.13	2.67	25.47
	11	157.00	6.73	90.42	2.43	26.76
	12	158.00	15.07	80.40	3.02	18.15
	13	153.67	15.13	82.90	1.73	21.28
R.B.		165.00	6.80	107.51	3.10	22.99
G.429		152.00	13.60	79.27	1.25	13.54
L.S.D. at 0.01		4.34	1.47	11.57	0.21	2.73

(98.18) in bulk method followed by line no. 9 (95.52) and line no. 8 (94.87) in pedigree method and then by line no. 1 (97.98) in SPD (Table, 18).

For number of seeds/pod, nine and two; eight and two; and five and two lines showed significant higher seed number than the average of all lines and best parent for SPD, bulk and pedigree breeding methods, respectively. The line no. 6 in bulk breeding method and line no. 5 in SPD gave the highest number of seeds/pod.

4.2.3.2. Direct and indirect selection:

Selection for yield and yield components deserves considerable interest. A crop breeding program aimed at increasing plant productivity, requires consideration interest not only of yield but also of its components which have a direct and indirect bearing on yield. The present part was under taken to compare the efficiency of indirect selection for yield via yield components with direct selection for seed yield/plant.

Mean squares due to five selection criteria *i.e.* number of pods/plant, 100-seed weight, number of seeds per pod (indirect selection), low and high seed yield/plant (direct selection) were significant (Table, 19). Significant differences between the five selection criteria in maturity date, number of pods/plant, 100 weight, number of that recorded by selected plants heavier seed index. However, the selection plants with low seed yield gave the lowest one.

Generally, the selection of high number of pods/plant, gave the highest seed yield/plant, number of pods/plant and the second for seed index and number of seeds/plant. As early as

Table (19): Mean squares for the five selection criteria and lines/selection criteria in the second cross (F_5-lines).

Source of variation	d.f.	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Lines	44	20.58	50.74	160.84	1.07	197.92
Methods	4	16.21**	142.30**	246.99**	1.04**	697.48**
Lines/methods	40	21.02**	41.58**	152.23**	1.08**	147.97**
Error	90	4.14	0.62	0.75	0.05	6.64

** Significant at 0.05 level of probability.

1964, Grafius suggested that improvement of complex characters like yield may be accomplished through components breeding subsequently, many workers (Takeda and Frey, 1976; Mc Neal *et al.*, 1978; Johanson *et al.*, 1983; Bahi and Vinod, 1991 and Kumar and Bahi, 1992) suggested that selection for component traits can help to increase productivity. The present investigation expressed the selection for high number of pods/plant was more efficiency as indirect selection for yield gave the lowest one.

With respect to the effect of selection criteria on 100-seed weight, the results revealed that selection for 100-seed weight gave significant heavier seed index followed by selection high number of pods/plant. However, to selection of low yield/plant gave the lowest one.

For the selection methods on number of seeds/pod the selection of high number of seeds/pod gave significant highest values followed by selection plants with high number of pods. However, the selection plants with low seed yield gave the lowest one.

Concerning seed yield/plant, the selection method of high number of pods/plant exhibited significantly higher value of this trait but without superiority over seeds/pod and seed yield/plant were detected revealing that the selection criteria differed among them.

Table (20) shows the effect of selection criteria on five traits under study.

For maturity date, the selection for low seed yield/plant gave the earliest plants than other selection criteria. The selection for low seed yield/plant gave the earliest of maturity date which

Table (20): Mean values of the five selection criteria in the second cross.

Trait / Selection criteria	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
No. of pods/plant	155.97	16.84	82.38	2.63	32.91
100-seed weight	156.87	15.36	86.76	2.29	32.13
No. of seeds/pod	156.90	10.81	79.57	2.66	22.15
Seed yield/plant (H)	155.67	13.87	79.94	2.38	24.74
Seed yield/plant (L)	77.43	7.14	41.35	1.39	15.97
L.S.D. at 0.01	0.65	0.25	0.28	0.07	0.83

is logically expected. Whereas the lowest yield was correlated with early maturity.

Concerning the differences between selection criteria in number of pods/plant, it is clear that selection criteria significantly affected number of pods/plant. The highest number of pods/plant was recorded from selection for number of pods/plant followed by selection of 100-seed weight. However, the selection of low seed yield/plant via direct selection for seed yield/plant. Also, the selection for heavier 100-seed and number of seeds/pod gave more effectiveness of seed yield/plant compared with selection of seed yield *per se* in faba bean and chickpea. The results indicated that selection for pod number, and 100-seed weight were more efficient in breeding for word superior yielding F_5 lines.

It could be concluded that selection for number of pods/plant and 100-seed weight for the three successive generations was successful in improving the mean seed yield in the F_5 lines.

The mean values of selected F_5 lines for maturity date number of pods/plant, 100-seed weight, number of seeds/pod and seed yield/plant were affected by selection criteria indirect selection i.e. (high number of pods/plant, high number of seeds/pod and heavier seed index) and direct selection (high and low seed yield/plant) are presented in Table (21).

For maturity date, five, three, four, four and three lines in the F_5 generation had significantly the earliest than the over all mean when selected plants with high number of pods/plant heavier seed index, high number of seeds/pod, high seed yield/plant

Table (21): Mean performance of the F_5-selected F_5 by the five selection criteria in the second cross.

Selection criteria	Trait	Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
No. of pods/plant	1	159.33	15.40	84.74	3.69	47.22
	2	158.33	21.00	74.72	3.09	48.22
	3	153.33	17.30	91.97	1.72	27.36
	4	153.67	14.63	75.93	2.54	27.94
	5	152.37	21.00	79.59	2.17	36.15
	6	156.00	9.63	81.22	3.29	25.61
	7	159.33	18.00	75.13	1.77	32.54
	8	159.67	18.53	87.73	2.19	35.73
	9	154.33	10.83	81.75	3.24	19.07
	10	153.33	12.10	91.03	2.56	29.30
100-seed weight	1	154.33	17.30	78.67	2.56	35.07
	2	158.00	14.63	82.99	2.39	28.62
	3	159.33	13.47	97.05	2.55	32.73
	4	159.67	17.50	87.34	2.21	33.83
	5	159.33	16.53	76.26	2.31	29.02
	6	154.67	13.07	88.57	2.17	25.33
	7	156.00	15.63	98.39	2.52	38.79
	8	155.00	26.03	83.96	1.96	40.59
	9	154.33	12.10	93.48	2.17	26.76
	10	158.00	18.30	80.85	2.09	30.65
No. of seeds/pod	1	159.33	17.30	85.08	2.33	34.57
	2	159.67	10.07	65.78	3.63	23.82
	3	154.33	10.97	81.27	2.27	19.89
	4	153.33	16.07	86.56	1.87	25.85
	5	158.33	9.63	71.62	2.67	18.53
	6	153.33	12.80	84.37	2.15	22.11
	7	159.67	10.10	73.71	3.23	23.83
	8	154.33	6.10	82.47	2.11	13.48
	9	157.33	7.53	79.11	2.83	16.69
	10	159.33	7.50	85.73	3.50	22.78

Table (21): Cont.

Selection criteria \ Trait		Days to maturity	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/ plant (g)
High seed yield/plant	1	152.67	21.30	71.38	2.50	37.63
	2	155.00	8.63	80.14	2.15	14.79
	3	157.33	13.97	72.10	3.16	31.12
	4	154.33	17.53	83.19	2.06	29.35
	5	152.00	14.77	75.10	1.40	15.17
	6	152.00	16.63	77.41	2.73	34.47
	7	158.00	11.63	81.04	1.83	16.90
	8	158.67	15.20	94.49	1.10	15.68
	9	159.33	7.77	87.33	3.67	24.81
	10	157.33	11.30	77.23	3.17	27.47
Low seed yield/plant	1	156.33	13.00	94.83	2.62	32.18
	2	153.00	13.87	72.66	3.23	31.32
	3	153.33	16.00	80.58	2.66	33.73
	4	158.00	12.53	81.73	2.89	29.17
	5	153.67	15.97	83.69	2.53	33.28
X		156.19	14.23	82.22	2.52	28.43
L.S.D. at 0.01		4.37	1.69	1.89	0.48	5.50

and low seed yield/plant, respectively. However none of the selected lines gave significantly earlier differences than the best parent. This result is logically expected whereas the selection for earliness do not done.

For number of pods/plant, six and seven; six and seven; two and two; five and six; and two and two lines were significantly higher than population mean and best parent when selected plants with high number of pods/plant, heavier seed index, high number of seeds/pod, high seed yield/plant and low seed yield/plant, respectively. This result is logically expected. The best lines were no. 8 when selected plants with heavier seed index and no. 2 and 5 when selected plants with high number of pods and no. 1 when selected high yield/plant.

For seed index, three, seven, four, three and two lines surpassed significantly heavier than population mean over all lines for selection high number of pods/plant, seed index, number of seeds/pod, high and low seeds/plant, respectively. None of the lines in the F_5 surpassed the best parent.

For number of seeds/pod, four and three, five and three, four and three and three and one lines exhibited significant higher seeds than over all grand mean and best parent when selected plants with high number of pods/plant, number of seeds/pod, high and low yields/plant, respectively. None of the lines surpassed the grand mean or best parent when selecting plants with heavier seed index.

Regarding seed yield/plant the range of selected lines ranged from 19.07 to 48.22 g; 25.33 to 40.59; 13.48 to 34.57; 14.79 to 37.63; and 29.17 to 33.73 when selecting plants with high number of pods, heavier seed, no. of seeds/pod, high and low seed yield/plant, respectively. Also, five and nine; six and ten, one and four; four and six; and four and five lines surpassed significantly higher seed yield/plant than grand mean and best parent, respectively, in the same order. In addition, the best three lines were no. 1 and 2 when selecting plants with high number of pods and no. 8 when selecting plants with heavier seed index.

It could be concluded that indirect selection for yield via pod number and heavier seed index are more efficient than direct selection for yield.

The comparison revealed the efficiency of selection for number of pods/plant followed by heavier seed index in improving mean yield of F_5 lines in this cross and also extracting a higher number of high yielding lines (selection for high no. of pods/plant and heavier seed index). It also appeared that indirect selection for yield via number of pods/plant and seed weight was more efficient than direct effects of selection for yield. Similar observations have been reported by other workers in faba been. Bisen *et al.* (1985) reported that indirect selection for seed size was the best method for improving seed yield in chickpea and Khorgade *et al.* (1985) observed that seed weight selection was more efficient in increasing yield than selection for seed yield alone. Bahi and Vinod (1991) reported that selection for number of pods per plant was more effective in extracting maximum number of high yielding F_5 lines than other methods studied.

It is interesting to examine the combining ability with regard to seed yield of the parents involved the crosses which yielded a relatively high proportion of lines which excelled the check significant in terms of seed yield. This information was available from two crosses studied (El-Hosary *et al.*, 1998).

The cross L18 x L103 gave the lowest SCA effects for seed yield/plant and its parents were pors combiners. However, this cross gave significant positive SCA for number of seeds and 100-seed weight and the parent L103 was good combiner for the both traits.

The cross G.B. x G.429 gave significant SCA effects for seed yield and both parents G.B. and G.429 gave significant positive g_i effects for 100-seed weight and seed yield/plant. Also, RB showed significant g_i effects for number of seeds/pod and number of pods/plant. Apparently, the cross with H x H or H x L general combining ability effects responded to selection pressure for number of pods/plant and 100-seed weight (the second cross). However, the first cross with L x L general combining ability status responded to selection pressure for number of pods per plant. It seems that sufficient additive genetic variation for seed weight was present in the base material leading to fixation of transgressive segregants.