RESULTS & DISCUSSION

IV. RESULTS AND DISCUSSION

4.1. First cross (Forrest x H_2L_{20}):

4.1.1. F_3 generation:

The mean squares associated with F_3 families were found to be significant for all studied traits (Table 2).

The mean performance of F_3 families and their parents line Forrest and H_2L_{20} for the five traits are presented in Table (3).

For maturity date, the families' number 10, 19, 26 and 30 showed significant values for earliness than the early parent H_2L_{20}.

On the other hand, the families' number 1, 2, 3, 4, 5, 6, 9, 11, 12, 13, 14, 16, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34 and 35 significantly surpassed the better parent (H_2L_{20}) for number of pods/plant. While, the other families showed lower number of pods/plant relative to better parent (H_2L_{20}). Also, the families' number 2, 5 and 12 exhibited significant higher number of seeds per pod than the better parent, while, the families no. 1, 2, 5, 6, 9, 11, 12, 13, 16, 28 and 29 expressed significant higher no. of seeds/pod relative to grand mean. For 100-seed weight, families no.5, 8, 9, 10, 12, 13, 16, 18, 20, 21, 26, 28 and 30 surpassed significantly the heavier parent. With respect to seed yield/plant the families no. 1, 2, 4, 5, 6, 9, 11, 12, 13, 14, 16, 20, 21, 26, 27, 30, 32, 33 and 35 significantly out yielded the better parent Forrest. The genetic components of

Table (2): Mean squares of the F_3 families for the five studied traits in the first cross (Forrest x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed Weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	1.16	60.60**	4.02**	0.11*	0.57
F_3 families	36	40.39**	1079.20**	3.97**	0.48**	104.34**
Error	72	3.37	4.60	0.22	0.03	6.76

*, ** Significant and highly significant at 0.05 and 0.01 respectively.

Table (3): Mean performances of the selected F_3 families, their parents and genetic parameters (heritability, genetic coefficient. of variation and genetic gain) in the first cross.

F_3 families	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
1	117.67	72.67	12.72	2.83	28.68
2	117.00	73.00	12.87	2.87	32.28
3	117.33	80.67	11.60	2.50	23.89
4	117.33	112.33	12.76	2.05	28.33
5	118.00	81.67	14.08	3.57	28.59
6	117.00	77.33	13.62	2.73	34.12
7	118.00	41.67	12.76	2.04	11.78
8	117.33	63.00	14.68	2.30	23.55
9	118.33	73.67	13.94	2.77	34.28
10	116.00	63.67	15.66	2.30	23.35
11	117.00	81.67	12.94	2.83	30.63
12	119.00	74.33	14.30	3.01	34.68
13	119.00	101.67	16.01	2.80	29.46
14	117.33	121.67	12.65	2.50	32.64
15	116.33	30.33	12.71	2.13	9.04
16	118.00	76.33	13.96	2.77	29.41
17	117.00	57.67	12.33	2.10	17.72
18	119.33	58.33	14.68	1.70	20.79
19	116.00	99.33	12.86	1.83	23.73
20	117.33	67.33	14.73	2.23	27.63
21	117.67	78.00	13.81	2.60	34.16
22	117.00	98.00	12.02	2.10	23.61
23	118.67	65.33	13.37	2.07	17.31
24	119.33	92.33	11.83	1.83	23.32
25	116.33	87.33	12.73	1.70	19.61
26	115.67	84.00	15.04	2.30	27.76
27	118.00	94.67	13.69	2.20	29.24
28	118.67	74.00	14.27	2.73	27.30
29	117.00	72.33	11.92	2.73	24.31
30	115.67	86.67	13.92	2.47	29.46
31	118.00	72.33	12.01	2.47	24.30
32	118.67	82.00	12.52	2.27	27.47
33	118.67	88.33	13.30	2.67	28.50
34	117.00	71.67	11.57	2.23	26.00
35	116.33	101.00	13.62	2.33	32.53
Forrest	130.00	62.33	12.99	2.57	23.10
H_2L_{20}	119.10	68.00	11.30	2.10	22.18
Over mean	118.11	79.37	13.29	2.41	26.28
L.S.D $_{5\%}$	3.00	3.50	0.77	0.29	4.25
L.S.D $_{1\%}$	3.98	4.66	1.03	0.39	5.65
h^2	78.57	98.73	84.80	82.32	82.79
Δg	6.41	38.74	2.12	0.72	10.69
$\Delta g\%$	5.43	48.81	15.95	29.83	40.68
G.C.V.	10.45	451.31	9.39	6.14	123.77

variation (G.C.V %), ΔG, ΔG% and heritability in broad-sense are presented in Table (3). High estimates of heritability in broad-sense in the F_3 families were detected for all studied traits which ranged from 78.57 to 98.73. The same results had been reported by **Natarajan *et al.* (1988)** for coefficient of variation for seed yield, number of pods, and plant height in mung bean; **El-Hosary *et al.* (2001)** and **Gupta and Punetha (2007)** for high heritability for number of seeds per pod, days to maturity and number of pods per plant.

Genetic gain was rather higher for no. of pods/plant, no., of seeds/pod and seed yield/plant. However, low to moderate genetic gain from selection was obtained for maturity date and 100-seed weight (g), respectively. Also, high G.C.V%. was detected for number of pods/plant and seed yield/plant. However, low to moderate G.C.V. was obtained for other traits.

The same results had been reported by **Khorgada (1995); Bangar *et al.* (2003) and Shobha-Immadi; *et al.* (2004)** for seed yield per plant, number of pods, phenotypic coefficient of variation (PCV), genetic coefficient of variation (GCV %), heritability and genetic advance.

4.1.2. F_4 generation:

The mean squares due to F_4 selected families were found to be significant for all studied traits (Table 4), indicating that the forty five F_4 selected families behaved some what differently from each to other.

The mean performance of 45 F_4 families as well as the two parents' for the five traits is presented in Table (5).

Table (4): Mean squares of the F_4 families for the five studied traits in the first cross (Forrest x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	22.50**	234.92**	0.23	0.05	0.89
Lines (L)	46	33.29**	186.65**	0.56**	0.45**	44.50**
Error	92	4.03	6.26	0.16	0.05	8.39

*, ** **Significant and highly significant at 0.05 and 0.01 respectively.**

Table (5): Mean performance of the selected F_4 families, their parents, heritability genetic coefficient of variation and genetic gain in the first cross.

F_4 families	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
1	117.67	82.33	13.04	2.30	28.44
2	117.67	77.00	12.78	2.50	27.44
3	119.00	76.33	12.36	2.37	25.43
4	119.67	80.33	13.01	2.40	25.81
5	117.67	78.00	12.84	2.33	27.43
6	119.67	79.00	12.60	2.60	27.75
7	117.67	80.33	12.40	3.13	29.30
8	117.67	77.00	13.07	3.20	33.54
9	117.67	85.33	12.65	3.53	37.30
10	117.67	86.67	13.22	3.60	38.62
11	117.67	76.00	12.11	3.10	34.19
12	118.00	79.00	12.91	3.40	33.16
13	119.00	76.00	12.69	3.20	35.18
14	119.00	78.67	13.25	3.10	35.87
15	117.67	82.67	12.52	3.40	33.23
16	117.00	68.33	12.92	3.10	31.91
17	117.67	72.00	13.21	2.87	28.52
18	118.67	74.33	12.83	2.93	25.10
19	117.00	76.00	13.01	2.73	27.96
20	117.67	73.67	12.77	2.30	25.26
21	117.67	72.67	12.61	3.07	27.29
22	116.67	75.00	13.08	3.20	29.13
23	117.67	76.00	12.71	2.60	25.12
24	118.67	71.00	13.20	2.70	24.82
25	117.67	73.00	13.20	2.80	26.23
26	117.33	83.33	12.51	2.10	28.11
27	119.33	76.33	13.06	2.50	24.91
28	117.00	82.00	13.05	3.03	35.18
29	117.33	83.00	12.30	3.20	36.23
30	117.67	74.00	12.35	2.40	27.92
31	119.00	77.33	12.71	2.80	32.23
32	118.67	73.67	12.90	2.50	27.39
33	119.33	72.33	12.32	3.10	26.03
34	117.67	77.33	13.02	3.03	27.19
35	116.00	74.00	12.09	3.30	29.35
36	117.33	71.67	13.22	2.50	28.16
37	117.67	74.33	12.38	2.60	26.17
38	117.33	74.00	13.09	2.63	25.12
39	119.67	76.67	13.10	2.80	28.16
40	117.00	73.33	12.80	2.70	24.12
41	117.67	72.33	13.58	2.40	27.36
42	117.67	68.00	12.63	2.50	26.71
43	117.67	63.67	12.99	2.47	24.34
44	117.67	71.67	13.02	2.90	29.15
45	117.67	64.67	13.84	2.30	24.19
Forrest	130.00	68.00	12.21	2.00	22.80
H_2L_{20}	120.00	69.00	12.90	2.10	21.80
Over mean	118.22	75.48	12.83	2.77	28.65
L.S.D $_{5\%}$	3.24	4.04	0.64	0.37	4.68
L.S.D $_{1\%}$	4.29	5.34	0.85	0.49	6.19
H^2	70.79	90.58	45.87	71.94	58.93
Δg	5.41	15.20	0.51	0.64	5.49
$\Delta g\%$	4.57	19.86	3.97	22.94	19.01
G.C.V.	8.24	78.56	1.04	4.81	41.70

For maturity date, the rang of the selected families ranged from 116.00 to 119.67 with an average of 118.22 days. The two families' number 22 and 35 had earlier compared with early parent.

As for number of pods/plant, the range of selected families varied from 63.67 to 86.67 pods. With the exception of selected families number 16, 17, 21, 24, 25, 33, 36, 41, 42, 43, 44 and 45 all selected families' significant superiority than the best parent. The families' number 9 and 10 gave the highest number of pods/plant. However, the family number 43 gave the lowest one.

Regarding 100-seed weight with the exception of families' number 41 and 45 none of the selected families surpassed significantly the best parent. The mean values of selected families ranged from 12.09 (family no. 35) to 13.84 (family no. 45).

Concerning number of seeds/pod, the range of selected families varied from 2.1(family no. 26) to 3.60 (family no. 10). With the exception of families number 1, 3, 4, 5, 20, 26, 30, 41 and 45, all selected families had significant superiority than the best parent. With regard to seed yield/plant 24 selected families surpassed significant than the best parent. The range of selected families varied from 24.12 (family no. 40) to 38.62 (family no. 10). The best families were number 9, 10, 14, 28 and 29.

The percentage of superior selected families having higher seed yield/plant than the better parent and population mean were 100% and 35.56% , 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 components of variation (G.C.V %), genetic gain (ΔG), genetic gain % (ΔG %) and heritability in broad-sense are presented in Table (5).

High heritability values were detected for maturity date, number of pods/plant and number of seeds/pod, indicating the effectiveness of selection in this material for these traits. However, moderate values were obtained for 100-seed weight and seed yield/plant. The values of expected gain (ΔG) and ΔG % reported in table (5) 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, number of seeds/pod and seed yield/plant. However, low gain was found for maturity date and 100-seed weight. These results are in general agreement with those obtained by **El-Hosary *et al.* (1997)** in soybean for 100-seed weight, **Yadav (2007)** for number of pods per plant, and seed yield per plant.

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

Johnson *et al.* (1955) reported that heritability estimate along with genetic gain upon selection were more valuable than the formal 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 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 variances. In the present work number of pods/plant, number of seeds/pod and seed yield/plant, high genetic gain was found to be associated with rather high heritability and G.C.V. estimate.

Therefore, selection for the three traits should be effective and satisfactory for successful breeding purposes. High heritability values and moderate G.C.V. estimate associated with high gain from selection was obtained for number of seeds/pod. Hence could be concluded that selection for this trait will be effective but probably of less success than in the former two traits.

Low genetic gain was associated with high or moderate heritability value for maturity date and 100-seed weight, respectively. Hence selection for both traits may be less effective. As it is well known 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 measure of the total variability in the trait and therefore reflects the total response that could be realized breeding techniques.

4.1.3. F_5 generation:

4.1.3.1. Comparison between three breeding methods:

The mean squares for breeding methods were significant for maturity date, yield and its components (Table 6). These results indicated the differences between breeding methods.

The bulk method gave the highest values for 100-seed weight and seed yield/plant. While the single pod descent (SPD) method exhibited significantly earlier of maturity date and highest number of seeds/pod, While, pedigree method gave the highest value for number of pods/plant (Table 7). It could be concluded bulk method considered the best breeding method for seed yield/plant and 100-seed weight and the second for number of seeds/pod, 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), Omar (1989), Shalaby *et al.* (2001), Arunachalam *et al.* (2002) and Shobha-Immadi *et al.* (2004)** 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, from the F_3 and F_4 rather than the individual F_2 or F_3 derived lines, can be assessed by the yields 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 F2 derived lines, the important

Table (6): Mean squares of the breeding methods for the five studied traits in the first cross (Forrest x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	122.31**	179.70**	0.118	0.673**	1.02
Lines (L)	32	2.38**	508.80**	0.299**	0.21**	18.46**
Methods(M)	2	1.01	5283.16**	2.034**	0.204**	149.73**
L/M	30	2.55**	197.08**	0.190**	0.217**	10.045
Error	64	1.19	6.09	0.071	0.008	7.561

***, ** Significant and highly significant at 0.05 and 0.01 respectively.**

Table (7): Mean performance of the breeding methods of the F_5 lines for the five studied traits in the first cross (Forrest x H_2L_{20}).

Breeding methodology	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant
Pedigree	117.15	70.97	12.68	3.297	26.45
Bulk	116.85	60.55	13.15	3.312	27.53
Single pod	116.85	45.79	13.06	3.482	23.42
L.S.D $_{5\%}$	0.144	0.738	0.0087	0.0115	0.917
L.S.D $_{1\%}$	0.192	0.982	0.0115	0.0153	1.219

Table (9): Mean performance of the selected lines of breeding methods and two parents and check variety in the first cross population.

Breeding methods	No. of line	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
pedigree	1	117.33	54.00	12.35	3.40	27.54
	2	118.00	57.00	12.82	3.13	26.38
	3	116.00	53.00	13.15	3.30	23.49
	4	117.67	82.00	12.38	3.20	25.28
	5	118.00	76.00	12.72	3.20	28.20
	6	116.33	82.33	12.23	3.40	28.18
	7	116.00	83.67	12.98	3.47	30.46
	8	118.00	78.00	12.96	3.03	25.35
	9	117.33	79.00	12.76	3.17	24.50
	10	116.00	64.00	12.33	3.40	26.34
	11	118.00	71.67	12.81	3.57	28.58
bulk	1	116.00	61.00	12.93	3.47	29.31
	2	116.67	55.00	13.36	3.40	27.28
	3	115.33	56.00	12.96	3.73	28.44
	4	118.00	67.00	12.95	3.90	25.14
	5	117.33	64.00	13.10	2.63	27.90
	6	116.00	54.00	13.00	3.00	23.20
	7	118.00	60.00	13.38	3.40	28.44
	8	116.00	64.00	13.43	3.20	29.51
	9	116.67	58.00	13.37	3.30	27.18
	10	118.00	58.00	12.96	2.80	25.18
	11	117.33	69.00	13.18	3.00	28.25
Single pod	1	118.00	36.00	12.99	3.37	22.34
	2	117.33	42.00	13.01	3.33	23.37
	3	117.67	39.00	13.36	3.40	22.49
	4	116.00	48.00	13.13	3.70	24.18
	5	117.33	48.33	13.09	3.40	22.21
	6	116.00	45.00	13.06	3.13	23.58
	7	116.00	53.00	13.19	3.30	23.20
	8	117.67	49.00	12.62	3.23	25.18
	9	117.33	45.00	12.79	3.57	24.30
	10	116.67	49.00	13.07	3.30	22.30
	11	115.33	49.33	13.34	3.77	24.49
Forrest		131.00	67.00	11.21	2.10	22.18
H_2L_{20}		120.00	65.00	12.13	1.50	21.99
G 111		120.00	66.00	12.52	2.50	22.90
Over mean		117.73	59.68	12.88	3.21	25.51
L.S.D $_{5\%}$		2.00	4.04	0.48	0.30	4.32
L.S.D $_{1\%}$		2.69	5.44	0.64	0.40	5.81

significant heavier 100-seed weight (g) than grand mean in bulk methods. The heavier line was number 8 (13.43g).

For number of seeds/pod, all selection lines significant higher seed number than the best parent (in the three methods of breeding). However, three, two and one lines showed significant higher seed number than the grand mean for SPD, bulk and pedigree methods, respectively. The best lines were no. 11 in pedigree method, no. 4 in bulk methods and no. 4, 9 and 11 in SPD method.

4.1.3.2. 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 four selection criteria *i.e.* number of pods/plant, 100-seed weight, number of seeds/pod (indirect selection), and high seed yield/plant (direct selection) were significant (Table 10).

Significant differences between the four traits in maturity date, number of pods/plant, 100-seed weight, number of seed/pod and seed yield/plant.

Table (10): Mean squares for lines four selection criteria and lines/selection criteria in the first cross (F_5-lines).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	70.58**	476.31**	1.027**	1.062**	78.83**
Lines (L)	51	6.14**	293.30**	0.205**	0.149**	25.48**
Methods(M)	3	42.59**	2505.33**	0.815**	0.269**	135.94**
L/M	48	3.86**	155.05**	0.167**	0.141**	18.57**
Error	102	2.06	17.57	0.097	0.062	7.01

*, ** Significant and highly significant at 0.05 and 0.01 respectively.

Generally, the selection of high number of pods/plant, gave the highest seed yield/plant and the second for number of pods/plant, 100-seed weight and number of seeds/plant (Table 11).

In 1964, **Grafius** suggested that improvement of complex characters like yield may be accomplished through component breeding subsequently, many workers (**Takeda and Frey 1976; Johanson *et al.*, 1983; Bahi and Vinod, 1991; Kumar and Bahi 1992; Shobha-Immadi *et al.*, 2004** and **Dev Vart *et al.*, 2005**) 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, selection of high no. of seeds/pod gave the lowest one (Table 11).

For the selection criteria on no. of seeds/pod, the selection of heavier seed index gave significant highest no. of seeds/pod but without superiority of no. of pods/plant. However, the selection of no. of seeds/pod gave the second of seed yield/plant and maturity date and the third of high no. of pods/plant.

Concerning seed yield/plant, the selection method of high number of pods/plant exhibited significantly higher value of this trait followed by high number of seeds/pod and heavier seed index were detected revealing that the selection criteria differed among them (Table 11).

Table (11): Mean values of the four selection criteria in the first cross.

Selection criteria	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Seed yield/plant (g)	117.13	70.41	12.71	3.30	26.50
No. of seeds/pod	117.23	55.03	12.57	3.31	27.83
No. of pods/plant	119.18	62.26	12.81	3.44	30.85
100-seed weight (g)	118.74	52.62	12.91	3.45	27.56
L.S.D $_{5\%}$	0.21	1.79	0.01	0.01	0.72
L.S.D $_{1\%}$	0.28	2.38	0.01	0.01	0.95

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, seed yield/plant via direct selection for seed yield/plant was detected.

Also, the selection for heavier 100-seed and number of pods/plant gave more effectiveness of seed yield/plant compared with selection of seed yield in faba bean and chickpea. **Bahi and Vinod (1991).** The results indicted that selection for pod number, number of seeds/pod 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, number of seeds/pod and 100-seed weight for (indirect selection) 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, heavier seed index and high number of seeds/pod) and direct selection (high seed yield/plant) are presented in Table (12).

For maturity date, nine, nine; two and zero lines in the F_5 generation had significantly the earliest than the best parent when selected plants with high seed yield/plant, high number of seeds/pod, high number of pods/plant and heavier seed index, respectively.

Table (12): Mean performance of the F_5 selected lines from direct and indirect selection two parents and check variety in the first cross for the studied characters.

Selection criteria	No. of line	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Seed yield/plant (g)	1	117.33	54.00	12.35	3.40	27.54
	2	118.00	57.00	12.82	3.13	26.38
	3	116.00	53.00	13.15	3.30	23.49
	4	117.67	72.00	12.38	3.20	25.28
	5	118.00	76.00	12.72	3.20	28.22
	6	116.33	79.00	12.23	3.40	28.18
	7	116.00	83.67	12.83	3.47	27.15
	8	118.00	78.00	12.96	3.03	25.35
	9	117.33	79.00	12.76	3.17	24.50
	10	116.00	64.00	12.33	3.40	26.34
	11	117.33	71.67	12.81	3.57	28.58
	12	117.33	72.00	13.15	3.20	28.18
	13	117.33	76.00	12.76	3.40	25.28
No. of seeds/pod	1	116.67	66.33	12.24	3.23	25.57
	2	116.00	54.00	12.41	3.10	25.78
	3	117.67	55.67	12.88	3.23	27.18
	4	116.33	54.00	12.34	3.43	25.29
	5	117.67	55.67	12.73	3.37	28.29
	6	119.33	62.00	12.44	3.60	31.11
	7	117.33	58.00	12.87	3.77	28.48
	8	118.67	54.00	12.24	2.60	27.12
	9	117.00	44.00	12.80	3.50	28.09
	10	116.33	46.00	12.35	3.40	28.25
	11	117.00	56.00	12.43	3.20	30.24
	12	117.00	54.00	12.88	3.37	31.11
	13	117.00	55.67	12.80	3.23	25.29
No. of pods/plant	1	118.00	66.00	12.57	3.37	28.22
	2	118.00	58.33	12.95	3.87	26.53
	3	117.33	61.00	12.67	3.50	28.70
	4	122.00	58.00	12.61	3.30	30.38
	5	117.67	72.00	12.90	3.10	35.47
	6	119.00	55.00	12.49	3.57	33.21
	7	119.33	63.00	12.53	3.40	30.52
	8	116.33	64.00	13.20	3.57	32.15
	9	121.00	64.00	12.95	3.53	24.32
	10	117.67	62.00	13.20	3.43	33.34
	11	121.00	56.00	12.89	3.67	34.60
	12	121.00	58.00	12.67	3.10	33.21
	13	121.00	72.00	12.95	3.37	30.38
100-seed weight (g)	1	119.33	64.00	12.85	3.30	28.21
	2	118.67	62.00	12.71	3.70	34.34
	3	117.67	54.00	12.89	3.10	25.41
	4	119.00	44.00	12.94	3.30	24.34
	5	119.33	53.00	12.92	3.53	28.27
	6	117.67	49.00	13.01	3.43	26.20
	7	119.33	53.00	13.03	3.30	27.41
	8	118.67	60.00	12.92	3.77	30.29
	9	118.67	52.00	12.89	3.60	28.51
	10	119.33	50.00	12.94	3.70	28.32
	11	118.67	46.00	12.89	3.30	26.48
	12	118.67	44.00	12.89	3.53	26.20
	13	118.67	53.00	12.89	3.30	24.34
Forrest		131.00	67.30	11.40	2.10	21.80
H_2L_{20}		120.00	65.20	12.10	1.50	21.10
G 111		120.00	66.30	12.60	2.50	23.30
Over mean		118.56	60.41	12.71	3.30	27.85
L.S.D 5%		2.33	6.81	0.51	0.40	4.30
L.S.D 1%		3.09	9.04	0.67	0.53	5.71

However, none of the selection lines gave significantly earlier differences than the grand mean. This result is logically expected whereas the selection for earliness does not do.

For number of pods/plant, nine and two, lines were significantly higher than the population mean when selected plants with high seed yield/plant and number of pods/plant, respectively. However, six lines were significantly higher than the best parent when selected plants with high seed yield/plant. This result is logically expected. The best lines were number 7, 6, 9 and 8 when selected plants with high yield/plant.

For seed index, nine, six, nine and thirteen lines were significantly heavier than the best parent for selection high seed yield/plant, number of seeds/pod, number of pods/plant and seed index, respectively. None of the lines in the F_5 surpassed population mean.

For number of seeds/pod, the lines number 7, 2 and 8 when selected plants with high number of seeds/pod, pods/plant and seed index respectively, exhibited significant higher seeds than the grand mean. While, all lines surpassed significantly higher than the best parent for this trait.

Regarding seed yield/plant the range of selected lines ranged from 23.49 to 28.58g; 25.29 to 31.11; 24.32 to 35.47 and 24.34 to 34.34 when selection plants with high seed yield/plant, number of seeds/pod, number of pods/plant and heavier seed, respectively. Also, four, seven, eleven and six lines surpassed significantly higher seed yield/plant than the best parent, respectively, in the same order. Also, six lines surpassed significantly higher seed yield/plant with high number of pods/plant.

In addition, the best three lines were number 5, 11, 6 and 12 when selecting plants with high number of pods/plant.

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

The comparison of selection criteria revealed the efficiency of selecting for number of pods/plant followed by number of seeds/pod and then 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 number of pods/plant number of seeds/pod and heavier seed index). It also appeared that indirect selection for yield via number of pods/plant, seeds/pod and seed index was more efficient than direct effects of selection for yield.

Similar observations have been reported by other workers in faba bean **Bisen *et al.* (1985)** reported that indirect selection for seed weight was the best method for improving seed yield in chickpea and **Khorgada *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. These results are in harmony with **El-Hosary** ***et al.*** **(1997), Yucel (2004), Dev Vart** ***et al.*** **(2005), Sultana** ***et al.*** **(2005), Malik** ***et al.*** **(2006) and Yadav (2007).**

4.2. Second cross (L-86k-73 x H_2L_{20}):

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 13).

Mean performance of F_3 families as well as two parents' line L-86k-73 and H_2L_{20} for the five traits under study are presented in Table (14).

For maturity date, none of the selected families of F_3 showed earlier than the early patent (L-86k-73). While, all the selected F_3 families significantly surpassed the better parent for number of pods/plant except the families' number.1, 2, 11, 22, 24 and 27. The highest number of pods/plant was recorded by family number 4 and 13. The families' number 3, 4, 5, 17, 26 and 28 exhibited significantly higher number of seeds /pod than the better parent. The family number 4 gave the highest number of seed/pod followed by number 5 and 26.

Regarding 100-seed weight, the families' number 12, 7 and 30 surpassed significantly the heavier parent. With respect to seed yield/plant all F_3 families' except families' number. 1, 2, 9, 11, 24 and 27 surpassed significantly higher than the best parent (H_2L_{20}). These results indicated the importance of selection in these material for these traits.

Table (13): Mean squares of the F_3 families for the five traits in the second cross (L-86K-73 x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	1.54	118.71**	0.39	0.14**	120.99**
F_3 families	36	28.80**	5728.15**	7.69**	1.75**	1695.66**
Error	72	4.29	7.32	1.18	0.01	7.13

***, ** Significant and highly significant at 0.05 and 0.01 respectively.**

Table (14): Mean performance of the selected F_3 families in the second cross (L-86K-73 x H_2L_{20}), their parents varieties, heritability, genetic coefficient of variation and genetic advance.

F_3 families	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
1	112.67	52.00	14.49	1.53	13.72
2	117.67	63.67	7.74	3.10	25.16
3	117.33	87.00	12.49	3.70	41.60
4	114.00	193.00	13.31	4.60	122.55
5	114.67	93.00	11.92	4.10	43.53
6	112.33	192.00	13.12	1.70	44.54
7	111.67	131.67	16.36	2.07	43.42
8	117.33	146.00	14.51	2.10	44.37
9	118.00	89.00	14.07	1.60	23.85
10	112.00	158.67	11.73	2.70	54.85
11	115.67	36.67	11.97	3.10	15.36
12	118.00	176.33	16.67	2.40	74.65
13	112.33	193.00	13.77	3.08	85.74
14	117.67	171.00	14.28	2.67	65.67
15	112.00	104.00	14.11	3.10	44.16
16	112.67	131.33	12.96	2.57	41.39
17	117.33	157.33	15.07	4.07	97.78
18	118.00	166.33	13.60	2.80	62.53
19	113.67	94.33	13.61	2.50	35.08
20	113.00	116.33	14.45	2.67	44.03
21	118.00	81.00	15.03	2.70	33.98
22	117.33	52.33	14.05	2.43	33.99
23	113.00	117.33	15.77	1.73	34.99
24	118.00	64.00	13.20	2.40	23.39
25	113.67	132.00	12.50	2.43	40.54
26	114.33	134.67	12.97	4.10	69.88
27	117.00	62.67	12.64	3.07	23.74
28	110.67	141.67	14.71	3.80	83.31
29	117.67	99.00	15.12	2.50	33.35
30	112.33	152.67	16.11	2.63	64.97
31	116.67	125.00	12.49	3.10	46.10
32	113.67	106.33	14.70	2.70	45.01
33	110.67	143.67	12.75	3.10	60.57
34	115.67	120.33	13.99	2.70	44.57
35	117.33	112.00	13.06	2.50	42.69
L-86K-73	105.00	50.00	13.60	3.20	20.52
H_2L_{20}	120.00	70.00	12.41	2.10	22.94
Over mean	114.86	116.68	13.66	2.80	47.15
L.S.D $_{5\%}$	3.38	4.42	1.77	0.14	4.36
L.S.D $_{1\%}$	4.50	5.88	2.36	0.19	5.80
h^2	65.57	99.62	64.79	98.74	98.75
Δg	4.77	89.78	2.44	1.56	48.57
$\Delta g\%$	4.15	76.95	17.89	55.76	103.01
G.C.V.	7.11	1634.27	15.89	20.75	1193.77

The genetic components of variation (Table 14) showed the high estimate of ΔG and ΔG% values and G.C.V. for number of pods/plant, number of seeds/pod and seed yield/plant. However, moderate values were detected for maturity date and 100-seed weight. The high heritability values in broad sense were detected for five traits under study.

The same trend was previously reported by **Khorgada (1995); Bangar *et al.* (2003) and Shobha-Immadi *et al.* (2004)** for seed yield per plant, number of pods. (phenotypic coefficient of variation (PCV), genetic coefficient of variation (GCV), heritability and genetic advance).

4.2.2. F_4 generation:

The mean squares due to F_4 selected families were found to be significant for all studied traits except 100-seed weight (Table 15), indicating that the forty five F_4.selected families behaved some what differently from each to other. For maturity date, the range of selected families ranged from 112.33 to 118.0 with an average of 112.56 days. (Table 16).

As for number of pods/plant, the range of the selected families varied from number 39 (57.00) to number 12 (88.67) pods/plant. The selected families' number 1, 2, 4, 5, 6, 8, 9, 11, 12, 15, 18, 19, 23, 25, and 30 had significant superiority than the best parent. The family 12 followed by number 5 gave the highest number of pods/plant. However, the family number 39 gave the lowest one. (Table 16).

Table (15): Mean squares of the F_4 families for the five studied traits in the second cross (L-86K-73 x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed Weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	126.33**	121.33**	0.33	0.17*	23.84**
Lines (L)	46	24.59**	169.95**	0.26	44.68**	25.05**
Error	92	3.38	11.33	0.18	0.05	3.09

*, ** **Significant and highly significant at 0.05 and 0.01 respectively.**

Table (16): Mean performance of the selected F_4 families in the second cross, their parents varieties, heritability, genetic coefficient of variation and genetic advance.

F_4 families	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
1	112.33	76.00	12.66	2.60	26.31
2	113.33	84.00	13.10	3.03	31.85
3	117.33	74.00	12.97	3.10	28.63
4	113.67	78.00	12.82	3.00	31.22
5	112.33	87.00	12.76	2.80	33.17
6	117.33	76.00	13.42	2.90	27.61
7	113.00	74.00	12.66	3.50	33.88
8	112.33	79.00	12.61	3.40	36.23
9	112.33	76.00	12.98	3.10	33.12
10	117.33	70.00	12.79	3.00	31.46
11	112.33	80.67	12.78	2.93	32.33
12	117.00	88.67	13.14	2.70	31.80
13	112.33	73.67	12.40	3.50	30.14
14	117.33	64.67	12.95	3.07	27.24
15	116.33	81.67	13.01	3.10	30.54
16	112.33	64.00	12.53	3.10	27.25
17	117.00	71.33	13.08	3.13	32.44
18	112.33	78.00	12.81	3.20	28.25
19	117.33	79.00	13.22	2.80	26.24
20	117.00	72.00	12.71	3.00	32.44
21	112.33	64.00	13.07	3.20	27.30
22	113.00	70.00	12.37	3.20	28.27
23	112.33	81.33	12.66	2.80	31.72
24	117.33	71.33	12.76	2.87	29.41
25	117.00	78.67	13.16	3.20	28.73
26	112.00	64.00	13.00	3.40	29.42
27	118.00	69.00	13.08	3.10	32.39
28	117.33	73.00	12.32	3.20	29.57
29	112.33	71.33	13.08	3.50	31.20
30	112.33	76.00	13.25	3.10	32.27
31	113.00	73.33	12.73	3.40	31.91
32	117.33	64.00	12.73	3.10	29.56
33	117.00	65.67	13.10	3.30	32.59
34	113.00	66.00	12.50	3.10	26.56
35	112.33	69.00	12.92	3.50	29.32
36	117.33	64.00	13.05	3.40	30.34
37	117.67	68.67	13.01	3.10	28.43
38	117.33	69.33	12.91	3.20	30.34
39	117.00	57.00	13.22	3.10	30.33
40	112.33	66.00	12.48	3.10	29.31
41	117.33	74.00	12.97	3.10	30.21
42	117.67	64.00	12.95	3.10	27.23
43	117.33	71.00	13.08	3.30	30.00
44	113.00	65.00	12.45	3.40	26.21
45	117.33	73.00	13.26	3.30	29.42
L-86K-73	105.00	49.00	11.90	3.20	20.00
H_2L_{20}	120.00	69.00	12.90	2.20	22.50
Over mean	112.56	71.79	12.86	3.12	29.72
L.S.D $_{5\%}$	2.97	5.44	NS	0.36	2.84
L.S.D $_{1\%}$	3.93	7.19	NS	0.47	3.75
h^2	67.68	82.35	---	99.67	70.34
Δg	4.51	13.59	---	7.93	4.68
$\Delta g\%$	3.92	18.93	---	203.47	15.73
G.C.V.	6.16	73.64	---	381.61	24.64

Regarding number of seeds/pod, none of the selected families surpassed significantly the best parent. The mean values of selected families ranged from 2.7 to 3.5.

With regard to seed yield/plant, all selected families surpassed significantly than the better parent. The range of selected families varied from 36.23 (family no. 8) to 26.21 (family no. 44).

The percentage of superior selected families having higher seed yield/plant than the better parent and population mean were 100% and 51.1%, respectively (Table 16).

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 % and heritability in broad sense are presented in Table (16).

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 (16). High heritability values were detected for maturity date, number of seeds/pod, number of pods/plant and seed yield/plant, indicating the effectiveness of selection in these materials for these traits.

4.2.3. F_5 generation:

4.2.3.1. Comparison between breeding methods:

Mean squares due to breeding methods were significant for maturity date, yield and its components (Tables 17). This result indicated the differences between breeding methods.

The pedigree method expressed significant desirable values for maturity date, 100-seed weight, number of seeds/pod and seed yield/plant (Tables 18). While the SPD method exhibited significantly earlier of maturity date and high number of pods/plant. It could be concluded that pedigree method considered the best breeding method for early maturity, high seed yield/plant, number of seeds/pod and 100-seed weight, than those bulk and SPD method in this cross.

Working on self pollination 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), Schutz *et al.* (1968), Allard and Adams (1969), Omar (1989), Shalaby *et al.* (2001) and El-Hosary and El-Badawy (2003)** 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 from the F_3 and F_4 rather than the individual F_2 or F_3 derived lines, can be assessed by the yields obtained in the following generations.

The improvement obtained in the F_5 by selecting F_2 derived lines was much greater in the second cross. When selection is carried out in an early generation *e.g.* among F_2

Table (17): Mean squares of the breeding methods for the five studies traits in the second cross (L-86K-73 x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	6.31	93.65**	0.0008	0.064	0.157
Lines (L)	32	25.43**	114.12**	0.460**	0.207**	7.847
Methods(M)	2	23.10**	603.28**	3.473**	1.699**	27.534**
L/M	30	25.59**	81.51**	0.259**	0.108**	6.534
Error	64	5.04	9.04	0.0300	0.027	5.951

*, ** Significant and highly significant at 0.05 and 0.01 respectively.

Table (18): Mean performances of the breeding methods for the five studied traits in the second cross (L-86K-73 x H_2L_{20}).

Breeding methodology	Maturity date (days)	No. of pods/plant	100-seed Weight (g)	No. of seeds/pod	Seed yield/plant (g)
Pedigree	112.06	63.48	13.27	3.47	31.84
Bulk	113.70	62.42	12.63	3.12	30.24
Single pod	112.56	70.30	12.85	3.04	30.27
L.S.D $_{5\%}$	0.611	1.096	0.0036	0.0033	0.721
L.S.D $_{1\%}$	0.813	1.458	0.0048	0.0044	0.959

derived lines, the important consideration is the response to this selection in a late generation *e.g.* the F_5 when lines are

approaching homozygosis. 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.

Mean squares due to lines of breeding methods as well as two parents were significant for the five traits under study (Tables 19).

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 (20) show that the pedigree method produced consistently more superior lines compared to the best parent or the average population with eleven and one; eleven and zero; ten and zero for pedigree, bulk and SPD, respectively. The best lines were number 10 (34.09g), no. 4 (33.34g), no. 3 (33.29g), no. 1 (33.27g), and no. 11 (32.19g) in pedigree method no. 4 (32.22g) and no. 5 (32.36g) in bulk method and number 1 (32.90g) in SPD method.

For maturity date, two line no. 6 (107.67 days) and no. 8 (109.33 days) in pedigree method, two line no. 10 (107.33 days) and no. 9 (109.33 days) in bulk method and two line no. 6 (107.67 days) and no. 7 (109.00 days) in single pod method showed significant earlier than average over lines (grand mean).

For number of pods/plant the results indicated the SPD method produced more superior lines followed by pedigree and

Table (19): Mean squares of the breeding methods and their parents (F_5-lines) for the five studied traits in the second cross (L-86K-73 x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	6.90	76.62**	0.04	0.092	0.301
Lines (L)	34	38.33**	504.62**	0.534**	0.545**	50.61**
Error	68	4.56	8.77	0.046	0.047	5.482

*, ** Significant and highly significant at 0.05 and 0.01 respectively.

Table (20): Mean performances of the selected lines of breeding methods and their parents and check variety in the second cross (L-86K-73 x H_2L_{20}).

Breeding methods	No. of line	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
pedigree	1	112.33	53.33	13.51	3.80	33.27
	2	112.67	63.67	13.62	3.13	30.23
	3	114.00	64.33	13.22	3.70	33.29
	4	112.33	67.33	12.82	3.70	33.34
	5	112.67	58.67	13.29	3.63	30.41
	6	107.67	72.67	13.36	3.13	30.38
	7	112.33	56.67	13.32	3.77	31.06
	8	109.33	69.67	13.68	3.20	32.47
	9	112.67	73.00	13.03	3.40	29.49
	10	112.33	59.67	13.40	3.40	34.09
	11	114.33	59.33	12.69	3.27	32.19
bulk	1	112.33	57.00	12.55	3.10	30.29
	2	117.67	66.00	12.39	2.97	29.72
	3	114.33	56.67	12.66	3.13	29.19
	4	117.33	69.67	12.43	3.10	32.22
	5	110.67	69.00	12.50	3.30	32.36
	6	115.67	58.67	12.91	2.93	29.22
	7	114.33	64.00	13.10	3.20	30.17
	8	117.67	62.00	12.73	3.00	30.69
	9	109.33	57.00	12.55	3.23	28.20
	10	107.33	68.00	12.45	3.13	29.66
	11	114.00	58.67	12.65	3.17	30.96
Single pod	1	112.33	76.00	12.86	2.80	32.90
	2	110.00	73.00	13.03	3.13	31.25
	3	112.33	74.00	13.18	3.10	31.18
	4	117.67	67.67	12.42	3.00	30.39
	5	112.67	71.67	12.31	3.20	28.58
	6	107.67	64.00	13.16	2.90	31.75
	7	109.00	72.00	12.41	2.73	28.50
	8	112.33	67.33	12.69	3.13	27.68
	9	114.33	69.67	13.12	3.13	30.96
	10	112.33	68.00	13.23	3.10	29.76
	11	117.67	70.00	12.93	3.23	30.00
L-86K-73		105.00	50.00	12.16	3.20	22.17
H_2L_{20}		120.00	65.00	12.13	1.50	22.99
G 111		120.00	63.00	12.52	1.60	24.06
Over mean		112.96	64.90	12.86	3.12	30.14
$L.S.D_{5\%}$		3.47	4.81	0.35	0.35	3.80
$L.S.D_{1\%}$		4.67	6.48	0.47	0.47	5.12

then by bulk compared to the best parent or average over lines with six, one and zero lines, respectively.

Regarding to 100-seed weight, nine and eight, five and one and zero and zero lines showed, significant higher than the best parent and average over lines for pedigree, SPD and bulk methods, respectively. The heavier line was number 8 (13.68) followed by line number 2 (13.62) and then by line number 1 (13.51) in pedigree method (Table 20).

For number of seeds/pod, eight lines showed significant higher seed number than the average of all lines or best parent for pedigree breeding method.

The line number 1 and 7 in pedigree breeding method gave the highest number of seeds/pod.

The hybridization programs in soybean have been followed mainly by mass or single plant selection or bulk population procedures.

No attempts have been made so for to compare efficiency of different procedures of selection in segregating populations. This could be due to the fact that the development of improved varieties of soybean by cross-breeding is still in its early phases in many countries. Results of the present study indicate that visual selection for yield by pedigree method or early generation testing in soybean can lead to lines with increased yield.

The pedigree method seemed to be an effective than two other methods. Based on the combining ability studies, successfully applied early generation selection procedure for yield improvement in soybean. Accordingly, **Casali and Tigchelaar (1975)** compared PS, SSD and bulk breeding methods in self-pollinated populations by computer simulation. They concluded that for highly heritable characters, the pedigree method was more effective than the others, but for characters with low heritability, bulk and SSD resulted better than pedigree selection. However, **Jinks and Pooni (1980)** argued that the hierarchical structure of pedigree inbred families allows a more sophisticated genetically analysis than the simple structure of the SSD families.

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 of the four selection criteria *i.e.* number of pods/plant, number of seeds/pod, 100-seed weight (indirect selection), and high seed yield/plant (direct selection) were significant (Table 21). Significant differences between the four characters in number of pods/plant, number of seeds/pod, 100-seed weight and seed yield/plant were recorded.

Generally, the selection of high number of pods/plant, gave the highest seed yield/plant and the second for number of seeds/ pod and third for seed index (Table 22).

As early as 1964, **Grafius** suggested that improvement of complex characters like yield may be accomplished through

Table (21): Mean squares of lines, four selection criteria and lines/selection criteria in the second cross (L-86K-73 x H_2L_{20}).

Source of variation	Degrees of freedom	Maturity date (days)	No. of pods/plant	100-seed Weight (g)	No. of seeds/pod	Seed yield/plant (g)
Replications	2	13.64	36.64	0.01	0.27**	111.43**
Lines (L)	51	28.29**	77.37**	0.45**	0.09**	14.21**
Methods(M)	3	10.38	349.46**	1.07**	0.581**	106.98**
L/M	48	29.40**	60.37**	0.41**	0.06*	8.41
Error	102	5.16	11.92	0.03	0.03	6.64

***, ** Significant and highly significant at 0.05 and 0.01 respectively.**

Table (22): Mean values of the four selection criteria for all the studied traits in the second cross (L-86K-73 x H_2L_{20}).

Selection criteria	Maturity date (days)	No. of pods/plant	100-seed Weight (g)	No. of seeds/pod	Seed yield/plant (g)
Seed yield/plant (g)	112.28	64.03	13.20	3.45	31.99
No. of seeds/pod	112.15	65.05	12.897	3.19	31.54
No. of pods/plant	112.26	68.33	13.01	3.23	35.22
100-seed weight (g)	111.21	61.08	13.25	3.22	32.44
L.S.D $_{5\%}$	0.53	1.22	0.003	0.003	0.678
L.S.D $_{1\%}$	0.698	1.61	0.004	0.004	0.899

component breeding subsequently, many workers (**Takeda and Frey, 1976; Johanson *et al.*, 1983; Bahi and Vinod, 1991; Kumar and Bahi, 1992 and Dixit *et al.*, 2002)** 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 efficient as indirect selection for yield.

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 seed yield/plant. Also, it gave the second for seed yield and number of seeds/pod.

Concerning seed yield/plant, the selection method of high number of pods/plant exhibited significantly higher value of this trait followed by selection heavier seed index and then by selection plants of high seed yield/plant revealing that the selection criteria differed among them.

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.

Also, the selection for heavier 100- seed 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 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 of (high seed yield/plant) are presented in Table (23).

For maturity date, ten and two; twelve and three; twelve and two and twelve and one lines in the F_5 generation had significantly the earliest than the best parent and over all mean, respectively, when selected plants with high number of pods/plant, heavier seed index, high number of seeds and high seed yield/plant, respectively.

For number of pods/plant, five lines were significantly higher than population mean and the best parent when selected plants with high number of pods/plant only. This result is logically expected. The best lines were number 10 when selected plants with high number of pods/plant followed by number 2 and 1 when selected plants with high number of pods/plant.

For seed index, nine and five; twelve and five; ten and one, and twelve and six lines were surpassed significantly heavier than the best parent and population means over all lines for selection high number of pods/plant, seed index, number of seeds/pod, and high seeds yield/plant, respectively.

Table (23): Mean performance of the F_5 selected lines from direct and indirect selection criteria, parents and check variety in the second cross.

Selection criteria	No. of line	Maturity date (days)	No. of pods/plant	100-seed weight (g)	No. of seeds/pod	Seed yield/plant (g)
Seed yield/ plant (g)	1	112.33	53.33	13.51	3.80	32.72
	2	112.67	63.67	13.62	3.13	29.05
	3	114.00	64.33	13.22	3.70	34.11
	4	112.33	67.33	12.82	3.70	34.15
	5	112.67	58.67	13.29	3.63	31.66
	6	107.67	72.67	13.36	3.13	31.67
	7	112.33	56.67	13.32	3.77	31.26
	8	109.33	69.67	13.68	3.20	33.13
	9	112.67	73.00	13.03	3.40	30.36
	10	112.33	59.67	13.40	3.40	34.51
	11	114.33	59.33	12.69	3.27	31.63
	12	117.67	69.00	12.43	3.33	29.25
	13	109.33	65.00	13.26	3.43	32.40
No. of seeds/pod	1	112.33	63.00	12.91	3.10	33.86
	2	114.33	65.67	12.41	3.23	33.03
	3	117.67	66.00	12.76	3.17	31.09
	4	112.67	63.00	12.88	3.37	33.57
	5	107.67	66.00	12.84	3.10	29.28
	6	112.33	65.00	13.30	3.37	32.49
	7	106.00	65.00	13.00	3.13	30.28
	8	112.33	59.00	13.28	3.20	28.00
	9	114.33	64.00	12.46	3.00	31.38
	10	112.33	68.33	12.14	3.10	31.63
	11	109.33	65.67	13.31	3.20	33.71
	12	112.33	67.00	13.40	3.33	32.58
	13	114.33	68.00	12.97	3.13	29.18
No. of pods/plant	1	112.67	71.67	13.53	3.27	36.34
	2	114.00	72.00	13.53	3.37	37.12
	3	107.67	71.00	12.59	3.33	34.84
	4	117.33	64.33	12.51	3.23	36.28
	5	110.67	70.00	12.64	3.27	34.48
	6	114.00	76.00	13.14	3.30	36.09
	7	107.67	68.00	13.58	3.10	34.12
	8	109.33	63.00	13.36	3.20	33.39
	9	112.33	63.67	12.40	3.27	35.42
	10	109.33	75.00	12.42	3.30	33.27
	11	117.67	62.33	13.06	3.13	35.45
	12	117.33	68.00	13.41	3.10	35.81
	13	109.33	63.33	12.92	3.13	35.29
100-seed weight (g)	1	112.33	65.00	13.20	3.33	34.89
	2	117.67	63.00	13.26	3.20	30.23
	3	112.67	54.00	13.24	3.13	35.17
	4	108.33	58.33	13.44	3.30	32.27
	5	112.33	64.00	13.16	3.27	30.70
	6	108.67	55.33	13.38	3.10	29.46
	7	112.67	61.67	13.21	3.20	32.79
	8	109.38	65.00	13.37	3.20	32.22
	9	106.67	63.67	13.41	3.30	31.49
	10	115.67	57.67	13.31	3.17	32.36
	11	112.67	60.00	13.27	3.27	33.36
	12	109.00	61.67	13.50	3.30	32.06
	13	107.67	64.67	12.49	3.13	34.72
L-86K-73		105.20	48.80	11.80	3.20	22.18
H_2L_{20}		122.30	64.20	12.20	1.80	23.10
G 111		121.30	63.40	12.40	1.90	24.40
Over mean		112.44	64.30	13.04	3.22	32.28
L.S.D $_{5\%}$		3.69	5.61	0.28	0.27	4.19
L.S.D $_{1\%}$		4.90	7.44	0.37	0.36	5.56

For number of seeds/pod five and two lines exhibited significant higher seeds than the best parent and over all grand mean when selected plants with high seed yield/plant only.

None of the lines surpassed the grand mean or the best parent when selected plants with heavier seed index, number of seeds/pod and high number of pods/plant.

Regarding seed yield/plant the range of selected lines ranged from 33.27 to 37.12 g; 29.46 to 35.29 g; 28.00 to 33.86 g and 29.05 to 34.51 g when selecting plants with number of pods/plant, heavier seed index, number of seeds/pod and high seed yield/plant, respectively. Also, twelve and one; twelve and zero; twelve and zero; and twelve and zero lines surpassed significantly higher seed yield/plant than the best parent and grand mean in the same order.

In addition, the best lines were number 2, 6, 4, 9, 11 and 1 when selecting plants with high number of pods/plant, and number 3 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 effectiveness of selecting for number of pods/plant in improving mean yield of F_5 lines in this cross and also extracting a higher number of high yielding lines (selection for high number of pods/plant and heavier seed index). It also appeared that indirect selection for yield via number of pods/plant was more efficient than direct effects of selection for yield. Similar observations have been reported by other workers in faba bean **Bisen *et al.* (1985)** reported that indirect selection for seed size was the best method for improving seed yield in chickpea and **Khorgada *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. **(Arunachalam *et al.*, 2002; Destro *et al.*, 2003; Shobha-Immadi *et al.*, 2004 and Shobha-Immadi *et al.*, 2006).**

4.3. Oil and protein percentage:

The differences among genotypes were significant for oil and protein continents in both crosses (Table 24).

The first cross:

For oil percentage, the line number 5 in pedigree method gave significant the highest value relative to other genotypes. However, lines number 6 and 11 in pedigree method, number 1 in bulk method and number 8 in single pod descent ranked the second highest oil percentage but without superiority than the best parent. Also, the line number 8 in single pod descent gave the highest value of protein percentage but without superiority than the best parent (H_2L_{20}).

The second cross:

The all selected promising lines except number 4 and 11 in bulk method and number 10 in pedigree method gave significant higher oil percentage compared with the best parent. However, the lines number 4 and 11 in bulk method gave insignificant differences with the best parent. While, the parent H_2L_{20} had the highest protein percentage and significantly differed when compared with other genotypes, followed by lines number 4 and 2 in bulk and single pod, respectively.

From the previous our results it could be concluded that the some new lines were considered the best genotypes for high yield and seed quality and must be evaluated under different location, years and other cultural treatments for high yield and seed quality. (**Li XinHai *et al.* 1999 and Cober and Voldeng 2000**).

Table (24): Oil and protein percentage of the selected lines of breeding methods and two parents in the first cross (forrest x H_2L_{20}) and the second cross (L-86K-73 x H_2L_{20}).

Breeding methods	No. of line	Oil %	Protein %
The first cross (forrest x H_2L_{20})			
Pedigree	5	19.29	35.73
	6	18.26	33.97
	11	16.97	34.43
Bulk	1	16.87	34.48
	3	17.61	33.83
	8	15.07	37.75
Single pod	8	16.89	39.60
	9	16.65	35.73
	11	15.14	37.47
parent	Forrest	17.80	38.60
	H_2L_{20}	16.97	39.53
L.S.D $_{5\%}$		0.827	1.263
The second cross (L-86K-73 x H_2L_{20})			
Pedigree	10	17.88	32.77
	3	18.03	34.53
	4	18.18	37.77
Bulk	4	17.24	38.17
	5	18.09	33.40
	11	17.31	35.90
Single pod	1	20.94	37.77
	2	19.87	38.17
	6	18.56	37.83
parent	L-86K-73	16.73	37.17
	H_2L_{20}	16.97	39.47
L.S.D $_{5\%}$		0.971	1.125