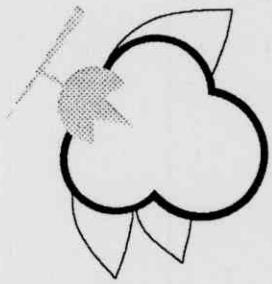
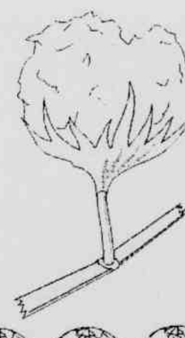


RESULTS AND DISCUSSION



4. RESULTS AND DISCUSSION

It is axiomatic that the genetic variability present in the germplasm be utilised either for direct selection or hybridization for further augmentation of variability through recombination. For quantitative characters, selection can be effective only when the segregating generations of a cross posses potential genetic variability which is further utilized to develop appropriate superior genotypes.

Previous work on cotton refers to that additive, dominance and epistatic gene effects are the major components of genetic variance. Therefore, a sound program for improving cotton depends on the relative importance of these components. Generally, maximum progress in improving a trait would be attained with pedigree selection when the additive gene action is the main component, and the presence of high non-additive gene action would suggest hybrid breeding program. Results will be presented and discussed in two major parts as follows:

4.1. Type of Gene Action

4.1.1. Generation means

The mean performance of the six populations P_1, P_2, F_1, BC_1, BC_2, F_2 of the two crosses (G. 45 x G. 75) and (G. 88 x G. 89) showed existence of substantial variability in the material for the improvement of most characters dealt with in this study (Table 9). Parents showed wide divergence for lint yield/plant, bolls/plant and micronaire reading in both crosses. Also, parents showed wide

Table 9. Generation means, standard errors for lint yield and lint components, seed characters and fiber quality in the two studied crosses.

Character	Cross	P_1	P_2	F_1	BC_1	BC_2	F_2
Lint yield/ plant (g)	I	9.59±0.261	16.15±0.310	11.55±0.336	9.68±0.292	8.84±0.302	9.57±0.251
	II	8.73±0.343	12.81±0.385	13.01±0.346	10.75±0.319	10.82±0.325	9.68±0.267
Bolls/plant	I	13.87±0.374	15.43±0.280	13.55±0.373	12.68±0.342	10.25±0.315	11.64±0.274
	II	12.16±0.451	16.05±0.484	16.20±0.419	14.11±0.349	14.06±0.400	12.25±0.296
Seeds/boll	I	16.99±0.157	18.20±0.171	17.14±0.190	17.29±0.135	16.71±0.149	16.89±0.112
	II	16.41±0.149	17.53±0.151	16.44±0.143	17.69±0.144	16.04±0.142	15.60±0.107
Lint/seed (g)	I	0.040±0.0006	0.059±0.0007	0.048±0.0006	0.045±0.0005	0.050±0.0006	0.048±0.0004
	II	0.044±0.0007	0.046±0.0006	0.049±0.0005	0.042±0.0007	0.049±0.0007	0.050±0.0005
Lint percentage	I	32.49±0.219	38.21±0.217	32.90±0.220	32.45±0.195	34.23±0.193	33.83±0.158
	II	33.53±0.268	35.42±0.205	33.18±0.209	31.68±0.235	33.82±0.200	34.71±0.183
Seed index (g)	I	8.32±0.084	9.39±0.085	9.79±0.097	9.27±0.079	9.56±0.074	9.42±0.061
	II	8.86±0.095	8.31±0.095	9.90±0.088	9.11±0.081	9.67±0.083	9.34±0.066
100-seed volume (cm^3)	I	9.44±0.070	10.15±0.104	10.29±0.090	10.07±0.076	9.97±0.077	9.81±0.055
	II	9.51±0.082	7.93±0.080	8.82±0.078	9.25±0.061	8.15±0.059	9.24±0.054
Seed density (g/cm^3)	I	0.88±0.008	0.93±0.008	0.95±0.008	0.92±0.006	0.96±0.006	0.96±0.004
	II	0.93±0.010	1.05±0.009	1.13±0.010	0.99±0.007	1.19±0.007	1.01±0.005
Heavy seed (%)	I	41.48±1.668	67.28±1.213	59.99±1.714	52.01±1.279	55.50±1.266	50.09±0.938
	II	54.55±1.793	56.52±1.701	53.60±1.786	54.84±1.355	51.45±1.332	54.64±1.036
Micronaire reading	I	2.88±0.028	4.20±0.046	3.41±0.050	3.17±0.031	3.79±0.037	3.47±0.032
	II	3.13±0.047	3.93±0.055	3.43±0.049	3.36±0.039	3.63±0.041	3.55±0.034
Pressley index	I	10.85±0.068	10.65±0.072	10.79±0.067	10.99±0.056	10.39±0.057	10.44±0.042
	II	11.03±0.075	10.19±0.046	10.74±0.073	10.72±0.044	10.43±0.055	10.53±0.041

I = G. 45 x G. 75
II = G. 88 x G. 89

variations for lint/seed, lint percentage and heavy seed percentage in cross I (G. 45 x G. 75). On the other hand, seeds/ boll, seed index, seed density and Pressley index in the two crosses did not exhibit wide variations between parents.

Table 9 shows in general that F_1 mean performance was better than either parents for seed index and seed density in the two crosses, 100-seed volume in cross I, lint yield/plant, bolls/plant and lint/seed in cross II, indicating overdominance.

With regard to both BC_1 and BC_2 mean performance results show that they are relatively associated with both P_1 and P_2 means, respectively for most characters investigated in the two crosses.

Concerning F_2 mean performance, it was lower than its F_1 mean for lint yield/plant, bolls/plant, seeds/boll, seed index and Pressley index in the two crosses, 100-seed volume and heavy seed percentage in cross I and seed density in cross II, suggesting the presence of dominance and epistatic interaction (Table 10). On the other hand, F_2 means were higher than F_1 mean for lint/seed, lint percentage and micronaire reading in both crosses, seed density in cross I, 100-seed volume and heavy seed percentage in cross II. This indicates no distinct depression occurring from F_1 to F_2.

4.1.2. Scaling test, F_2-deviation and BC-deviation

Results of the scaling tests (A, B and C) are shown in (Table 10). These tests demonstrated the presence of non-allelic gene interactions for all studied characters except micronaire reading in the two crosses. These results indicated the inadequacy of the additive-dominance model.

Table 10. Scaling test values (A, B and C) and epistatic deviations (E_1 and E_2) for the eleven cotton characters in the two studied crosses.

Character	Cross	Scaling test			Epistasis	
		A	B	C	E_1	E_2
Lint yield/ plant (g)	I	-1.78*±0.723	-10.02**±0.758	-10.56**±1.273	-2.64**±0.318	-5.90**±0.575
	II	-0.24±0.803	-4.18**±0.832	-8.84**±1.374	-2.21**±0.344	-2.21**±0.628
Bolls/plant	I	-2.06*±0.864	-8.48**±0.784	-9.84**±1.405	-2.46**±0.351	-5.27**±0.640
	II	-0.14±0.931	-4.13**±1.025	-11.61**±1.593	-2.90**±0.398	-2.14**±0.753
Seeds/boll	I	0.45±0.366	-1.92**±0.393	-1.91**±0.632	-0.48**±0.158	-0.74*±0.300
	II	2.53**±0.354	-1.89**±0.351	-4.42**±0.557	-1.11**±0.139	0.32±0.269
Lint/seed (g)	I	0.002±0.0013	-0.007**±0.0014	-0.003±0.0023	-0.001±0.0006	-0.003**±0.0011
	II	-0.009**±0.0016	0.003±0.0016	0.012**±0.0026	0.003**±0.0007	-0.003*±0.0012
Lint percentage	I	-0.49±0.498	-2.65**±0.495	-1.18±0.829	-0.30±0.207	-1.57**±0.384
	II	-3.35**±0.580	-0.96*±0.488	3.53**±0.908	0.88**±0.227	-2.16**±0.407
Seed index (g)	I	0.43*±0.204	-0.06±0.197	0.39±0.335	0.10±0.084	0.19±0.158
	II	-0.54**±0.208	1.13**±0.211	0.39±0.344	0.10±0.086	0.30±0.161
100-seed volume (cm^3)	I	0.41*±0.190	-0.50*±0.207	-0.93**±0.311	-0.23**±0.078	-0.05±0.154
	II	0.17±0.167	-0.45**±0.163	1.88**±0.289	0.47**±0.072	-0.14±0.129
Seed density (g/cm^3)	I	0.01±0.016	0.04*±0.016	0.13**±0.025	0.03**±0.006	0.03**±0.013
	II	-0.08**±0.020	0.20**±0.020	-0.20**±0.032	-0.05**±0.008	0.06**±0.016
Heavy seed (%)	I	2.55±3.502	-16.27**±3.289	-28.38**±5.484	-7.09**±1.371	-6.86*±2.691
	II	1.53±3.708	-7.22*±3.630	0.29±6.004	0.07±1.501	-2.85±2.886
Micronaire reading	I	0.05±0.085	-0.03±0.101	-0.02±0.170	-0.01±0.043	0.01±0.075
	II	0.16±0.104	-0.10±0.111	0.28±0.181	0.07±0.045	0.03±0.083
Pressley index	I	0.34*±0.148	-0.66**±0.151	-1.32**±0.235	-0.33**±0.059	-0.16±0.116
	II	-0.33*±0.137	-0.07±0.140	-0.58*±0.236	-0.15*±0.059	-0.20±0.111

I = G. 45 x G. 75
II = G. 88 x G. 89

E_1 refer to F_2-deviation
E_2 refer to BC-deviation

* Significant at 5% probability level
** Significant at 1% probability level

F_2-deviation (E_1) and BC-deviation (E_2) Table 10 showed significant values for all studied characters in the two crosses except seed index and micronaire reading in the two crosses and heavy seed percentage in cross II. Also, epistatic deviations E_1 and E_2 for the studied characters were in the same direction with the outcome of A, B and C scaling tests (Table 10) indicating that there were non-allelic gene interactions. Similar results were obtained by **El-Okkia** ***et al.*** **(1989), El-Okkia** ***et al.*** **(1990), El-Lawendey (1999) and Awad (2001)**.

4.1.3. Gene action effects

Genetic analysis of generation means to give estimates of additive (a), dominance (d) and the three epistatic effects; additive x additive (aa), additive x dominance (ad) and dominance x dominance (dd) were calculated according to the relationships illustrated by **Gamble (1962)**.

Types of gene effects using generation means are shown in (Table 11). Estimated mean effects parameters (m), which reflects the contribution due to the overall mean plus the locus effects and interaction of the fixed loci were found to be highly significant for all characters in both crosses. Initially, it is clear that all the studied characters were quantitatively inherited. The additive gene effects were significant and positive or negative for all studied characters except lint yield/plant and bolls/plant (cross II), 100-seed volume (cross I) and heavy seed percentage (both crosses), suggesting the potentiality for attaining further improvements of most studied characters. **El-Adl and Miller (1971)**, found that the additive genetic effects appeared to be predominant for lint yield, bolls/plant

Table 11. Types of gene effects using generation means of the eleven cotton characters in the two studied crosses.

Character	Cross	F$_2$ means m	Types of gene effects				
			a	d	aa	ad	dd
Lint yield/ plant (g)	I	9.57**	0.84*±0.420	-2.56±1.366	-1.24±1.308	4.12**±0.467	13.04**±2.109
	II	9.68**	-0.07±0.456	6.66**±1.470	4.42**±1.405	1.97**±0.524	0.00±2.283
Bolls/plant	I	11.64**	2.43**±0.465	-1.80±1.503	-0.70±1.437	3.21**±0.520	11.24**±2.331
	II	12.25**	0.05±0.531	9.44**±1.677	7.34**±1.589	2.00**±0.626	-3.07±2.656
Seeds/boll	I	16.89**	0.58**±0.201	-0.02±0.642	0.44±0.602	1.19**±0.232	1.03±1.023
	II	15.60**	1.65**±0.202	4.53**±0.615	5.06**±0.589	2.21**±0.228	-5.70**±0.981
Lint/seed (g)	I	0.048**	-0.005**±0.0007	-0.004±0.0023	-0.002±0.0022	0.005**±0.0009	0.007±0.0037
	II	0.050**	-0.007**±0.0010	-0.014**±0.0030	-0.018**±0.0029	-0.006**±0.0011	0.024**±0.0046
Lint percentage	I	33.83**	-1.78**±0.274	-4.41**±0.878	-1.96*±0.837	1.08**±0.315	5.10**±1.375
	II	34.71**	-2.14**±0.306	-9.14**±0.991	-7.84**±0.954	-1.20**±0.349	12.15**±1.522
Seed index (g)	I	9.42**	-0.29**±0.109	0.92**±0.348	-0.02±0.328	0.25*±0.124	-0.35±0.549
	II	9.34**	-0.56**±0.116	1.52**±0.368	0.20±0350	-0.84**±0.134	-0.79±0.578
100-seed volume (cm^3)	I	9.81**	0.10±0.108	1.34**±0.327	0.84**±0.308	0.46**±0.125	-0.75±0.533
	II	9.24**	1.10**±0.085	-2.06**±0.291	-2.16**±0.275	0.31**±0.103	2.44**±0.448
Seed density (g/cm^3)	I	0.96**	-0.04**±0.008	-0.035±0.025	-0.08**±0.023	-0.015±0.010	0.03±0.042
	II	1.01**	-0.20**±0.010	0.46**±0.032	0.32**±0.030	-0.14**±0.015	-0.44**±0.052
Heavy seed (%)	I	50.09**	-3.49±1.799	20.27**±5.570	14.66**±5.198	9.41**±2.074	-0.94±9.049
	II	54.64**	3.39±1.900	-7.92±6.028	-5.98±5.623	3.39*±1.720	11.67±9.685
Micronaire reading	I	3.47**	-0.62**±0.049	-0.09±0.169	0.04±0.159	0.04±0.055	-0.06±0.258
	II	3.55**	-0.27**±0.057	-0.32±0.187	-0.22±0.176	0.13±0.068	0.16±0.292
Pressley index	I	10.44**	0.60**±0.080	1.04**±0.245	1.00**±0.231	0.50**±0.094	-0.68±0.398
	II	10.53**	0.29**±0.071	0.31±0.232	0.18±0.216	-0.13*±0.060	0.22±0.368

I = G. 45 x G. 75
II = G. 88 x G. 89

* Significant at 5% probability level
** Significant at 1% probability level

and seed index. On the other hand, both types of genetic variance were involved for lint yield (**Meredith and Bridge, 1972**).

Dominance gene effects were found to be significant for lint yield/plant, bolls/plant, seeds/boll, lint/seed and seed density (cross II), lint percentage, seed index and 100-seed volume (both crosses), heavy seed percentage and Pressley index (cross I).

Significant additive x additive epistatic type was detected for lint percentage, 100-seed volume and seed density (the two crosses), heavy seed percentage and Pressley index (cross I), lint yield/plant, bolls/plant, seeds/boll and lint/seed (cross II). Additive x dominance type of digenic epistasis was significant for all characters under investigation except seed density (cross I) and micronaire reading (both crosses). Dominance x dominance type of gene action was significant for lint percentage (the two crosses), both lint yield and bolls/plant (cross I), seeds/boll, lint/seed, 100-seed volume and seed density (cross II).

Generally, it may be concluded from the results of the present studies that all types of gene effects were significant and govern the inheritance of most studied characters with some exceptions indicating that selection index and phenotypic trait selection based on the accumulation of additive effects were successful in improving most of the characters under investigation. However to maximize selection advance, procedures known to be effective in shifting gene frequency-viz., recurrent selection when both additive and non additive genetic variations are involved would be preferred. These findings were in conformity with those obtained by **Bedair *et al.* (1973), El-Fawal *et al.* (1974), Khan *et al.* (1980), Khattab *et al.* (1984), El-Kilany and El-Okkia (1986), Hassoub (1986), El-Okkia *et al.* (1989), El-Okkia *et al.* (1990), Jagtap (1993), Esmail (1996), Gomaa (1997), Khalil and Khattab (1997), El-Lawendey (1999), Gomaa *et al.* (1999), Ahmmed and Mehra (2000), Abdel-Gelil (2001), Nassar (2002) and Abd El-Bary (2003)**.

4.1.4. Potence ratio and heritability estimates

Potence ratio values in (Table 12) indicated existence of overdominance for bolls/plant, seed index and seed density (both crosses), 100-seed volume (cross I), lint yield/plant, lint/seed, lint percentage and heavy seed percentage (cross II), however, other characters under investigation expressed partial dominance. The existence of overdominance in lint yield/plant was previously reported (**Abdel-Gelil, 2001; Awad, 2001**) in bolls/plant and seed index by **Khalil and Khattab (1997), El-Lawendey (1999) and Awad (2001)** in lint percentage **El-Agamy (1971) and El-Lawendey (1999)**. On the other hand, **El-Okkia *et al.* (1989)** found overdominance for seeds/boll and Pressley index, but lint yield/plant, lint/seed, lint percentage and seed index expressed partial dominance.

Phenotypic and genotypic coefficients of variation, broad and narrow sense heritabilities and expected genetic advance (Δg%) are presented in Table 12. The estimates of phenotypic and genotypic coefficients of variation (PCV % and GCV%) were higher for lint yield/plant, bolls/plant and heavy seed percentage (both crosses) than all other characters. Generally, there were relatively distinct

Table 12. Phenotypic (PCV) and genotypic (GCV) coefficients of variation in F_2 generations, potence ratio (P), heritability in broad (h^2_b) and narrow (h^2_n) sense, and expected genetic advance (Δg%) of the eleven cotton characters in the two studied crosses.

Character	Cross	PCV %	GCV %	(P)	h^2_b	h^2_n	Δg %
Lint yield/ plant (g)	I	45.4	36.1	0.40	63.3	59.5	55.6
	II	47.8	35.5	-1.10	55.0	54.7	53.9
Bolls/plant	I	40.7	31.6	1.41	60.3	55.8	46.8
	II	41.8	26.9	-1.08	41.4	38.4	33.0
Seeds/boll	I	11.5	7.3	0.75	40.1	38.3	9.1
	II	11.9	8.6	0.95	52.7	22.8	5.6
Lint/seed (g)	I	14.8	9.4	0.16	40.7	38.0	11.6
	II	18.6	14.9	-4.00	64.1	43.0	16.4
Lint percentage	I	8.1	5.8	0.86	52.1	48.8	8.1
	II	9.1	7.1	1.37	60.9	60.6	11.4
Seed index (g)	I	11.3	7.8	-1.75	47.8	43.7	10.2
	II	12.2	8.6	-4.78	50.2	43.1	10.8
100-seed volume (cm^3)	I	9.7	5.7	-1.39	34.0	6.3	1.3
	II	10.2	6.9	-0.13	45.6	76.1	15.9
Seed density (g/cm^3)	I	7.5	2.4	-1.80	10.4	2.8	0.4
	II	9.0	3.9	-2.33	18.6	5.8	1.1
Heavy seed (%)	I	32.4	18.3	-0.43	31.9	15.9	10.7
	II	32.8	17.3	1.96	27.8	31.9	21.6
Micronaire reading	I	15.8	11.6	0.20	54.7	81.7	26.5
	II	16.4	10.9	0.25	44.0	56.0	18.9
Pressley index	I	6.9	3.8	-0.40	30.7	13.1	1.9
	II	6.7	4.0	-0.31	34.7	50.0	6.9

differences between phenotypic and genotypic coefficients of variation for most characters in the two crosses indicating that environmental effects had their important on these characters under the circumstance of this study. These results were in agreement with those reported by **Younis (1986), El-Okkia *et al.* (1989) and Gooda (2001)**.

High heritability values in broad sense (> 50%) were observed for lint yield/plant and lint percentage (the two crosses), bolls/plant and micronaire reading (cross I), seeds/boll, lint/seed and seed index (cross II). Similar results were obtained by **Younis (1980)**. Moderate heritability values in broad sense (from 30 to 50%), were obtained for the remaining characters in both crosses except seed density and heavy seed percentage in cross II. High to moderate narrow sense heritability estimates were found for all characters except seed density in the two crosses, 100-seed volume, heavy seed percentage and Pressley index (cross I) and seeds/boll (cross II) where low narrow sense heritability values (< 30%) were observed for these characters. The difference between broad and narrow sense heritabilities may be due to the presence of non-additive gene action in the inheritance of most characters. These results were in coincidence with those reported by **Yousef (1979), Atta *et al.* (1982), Jagtap and Kolhe (1986), El-Okkia *et al.* (1989), El-Helw (1990), Esmail (1996), Abo-Arab *et al.* (1997), Khalil and Khattab (1997), El-Lawendey (1999), Gomaa *et al.* (1999), Awad (2001), El-Disouqi and Ziena (2001) and Nassar (2002)**.

Regarding heritability estimates in narrow sense of some studied characters in both crosses (Table 12), it is noticeable that these estimates were higher than their corresponding broad sense heritability estimates. This may be attributed to using samples of different sizes. It is worth mentioning that samples of 75 plants for each P_1, P_2 and F_1, 150 plants for each BC_1 and BC_2 and 300 plants for F_2. These results were in agreement with those obtained by **Gomaa and Shaheen (1995 a, b), El-Lawendey (1999) and Awad (2001)**.

4.1.5. Predicted genetic advance

The highest predicted genetic advances as percentage of F_2 mean ($\Delta g\%$) (Table 12) were achieved for lint yield/plant and bolls/plant in the two crosses, lint/seed, 100-seed volume and heavy seed percentage in the cross II. On the other hand, low predicted genetic advances were detected for seed density in the two crosses, 100-seed volume and Pressley index in the cross I. **Awaad (1989)** found that high expected genetic advance were observed for seed index. While, low genetic gains were calculated for yield characters, lint percentage and most fiber properties.

High to moderate values of heritability estimates in narrow sense were found to be associated with high and moderate genetic advance in most characters investigated, so selection for these characters may be highly effective. Similar conclusions were found by **Hendawy *et al.* (1989) and Hendawy (1994)**.

4.2. Selection Procedures

Different selection methods-phenotypic individual character selection, selection index and recurrent selection-were used to improve lint yield in three populations of Egyptian cottons (*G. barbadense*). Information on type of gene action, phenotypic and genotypic variances, phenotypic and genotypic correlation coefficients and phenotypic weights are important to examine the effectiveness of selection procedures.

4.2.1. Selection index and phenotypic trait selection

4.2.1.1. Variance components

Estimates of variance components for lint yield and its components in each of the three populations are presented in Tables 13, 14 and 15. Both phenotypic and genotypic variances were larger in F_2 of populations I and II than population III for lint yield/plant, bolls/plant and lint percentage. In F_3 and S_1 generations, significant phenotypic variances were observed for all studied characters except seeds/boll in populations II and III, lint/seed and lint percentage in population III. The phenotypic variances in F_4 and S_2 generations were higher than F_3 and S_1 for all studied characters with the exception of lint percentage in populations I and II. The increase in phenotypic and most genotypic variances in F_4 and S_2 generations is due to the efficiency of selection procedures in creating substantial genetic variation. This finding is in agreement with those obtained by **El-Okkia (1979) and Gooda (2001)**. As to environmental variances, it is clear that all values with the exception of these pertaining to lint yield and bolls/plant were small in magnitude, would be minor to effect genetic parameters.

Table 13. Estimates of phenotypic, genotypic and environmental variances for lint yield and its components in F_2, F_3 and F_4 generations of population I (G. 45 x G. 75).

Characters	Generations	$\hat{\sigma}^2_p$	$\hat{\sigma}^2_g$	$\hat{\sigma}^2_e$
Lint yield/ plant (g) (X_w)	F_2	184.4941+	122.6641	61.8300
	F_3	3.6217**	2.2413	1.3804
	F_4	7.7098*	5.4495	2.2603
Bolls/plant (X_1)	F_2	202.3592+	125.4782	76.8810
	F_3	3.5376**	1.9603	1.5773
	F_4	7.5165*	4.5034	3.0131
Seeds/boll (X_2)	F_2	2.3770+	0.9786	1.3984
	F_3	0.5982**	0.3200	0.2782
	F_4	1.3178*	0.8600	0.4578
Lint/seed (g) (X_3)	F_2	0.000038+	0.000023	0.000015
	F_3	0.000007**	0.000004	0.000003
	F_4	0.000015*	0.000010	0.000005
Lint percentage	F_2	4.5966+	2.5532	2.0434
	F_3	2.0813**	1.4081	0.6732
	F_4	1.6041*	1.1552	0.4489
Seed index (g)	F_2	0.8668+	0.4658	0.4010
	F_3	0.2063**	0.1445	0.0618
	F_4	0.2988	0.1234	0.1754

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

+ Estimates of phenotypic variance for 300 F_2 plants in population I.

Table 14. Estimates of phenotypic, genotypic and environmental variances for lint yield and its components in F_2, F_3 and F_4 generations of population II (G. 87 x G. 89).

Characters	Generations	$\hat{\sigma}^2_p$	$\hat{\sigma}^2_g$	$\hat{\sigma}^2_e$
Lint yield/ plant (g) (X_w)	F_2	184.1051+	104.5882	79.5169
	F_3	5.3651**	3.4099	1.9552
	F_4	13.7356	7.2286	6.5070
Bolls/plant (X_1)	F_2	203.6194+	92.9098	110.7096
	F_3	6.3466**	4.0014	2.3452
	F_4	26.4393*	15.9157	10.5236
Seeds/boll (X_2)	F_2	2.9449+	1.1281	1.8168
	F_3	0.2925	0.0495	0.2430
	F_4	0.5350	0.2174	0.3176
Lint/seed (g) (X_3)	F_2	0.000035+	0.000020	0.000015
	F_3	0.000009**	0.000006	0.000003
	F_4	0.000011	0.000005	0.000006
Lint percentage	F_2	4.1027+	1.6761	2.4266
	F_3	2.0763**	1.1693	0.9070
	F_4	1.7457	0.7236	1.0221
Seed index (g)	F_2	0.6629+	0.3223	0.3406
	F_3	0.1509**	0.0876	0.0633
	F_4	0.2298	0.0263	0.2035

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

\+ Estimates of phenotypic variance for 300 F_2 plants in population II.

Table 15. Estimates of phenotypic, genotypic and environmental variances for lint yield and its components in S_0, S_1 and S_2 generations of population III (G. 86 open-pollinated).

Characters	Generations	$\hat{\sigma}^2_p$	$\hat{\sigma}^2_g$	$\hat{\sigma}^2_e$
Lint yield/ plant (g) (X_w)	S_0	95.7682+	67.2987	28.4695
	S_1	6.4089**	4.1599	2.2490
	S_2	10.2974*	6.8461	3.4513
Bolls/plant (X_1)	S_0	86.8629+	54.7160	32.1469
	S_1	5.7634**	3.9515	1.8119
	S_2	5.8974	2.4743	3.4231
Seeds/boll (X_2)	S_0	2.4430+	0.9973	1.4457
	S_1	0.5373	0.1677	0.3696
	S_2	0.7386	0.3487	0.3899
Lint/seed (g) (X_3)	S_0	0.000039+	0.000014	0.000025
	S_1	0.0000064	0.0000016	0.0000048
	S_2	0.000040	0.000017	0.000023
Lint percentage	S_0	2.7255+	0.9510	1.7745
	S_1	0.7175	0.1082	0.6093
	S_2	1.3939	0.5940	0.7999
Seed index (g)	S_0	0.7057+	0.4472	0.2585
	S_1	0.4621**	0.2137	0.2484
	S_2	0.5155	0.1592	0.3563

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

+ Estimates of phenotypic variance for 300 S_0 plants in population III.

4.2.1.2. Means, ranges, phenotypic and genotypic coefficients of variation and heritability estimates

Results of the base generations of the three studied populations, are shown graphically in Figures 4, 5, 6 and 7 for lint yield/plant, bolls/plant, seeds/boll and lint/seed, respectively. Means, ranges, phenotypic and genotypic coefficients of variation and heritability are presented in Tables 16, 17 and 18.

Both F_2 and S_0 means for lint yield/plant, bolls/plant and seeds/boll were higher than those of the succeeding generations although intensive selection was practiced. Similarly, wide ranges in lint yield, bolls/plant and seeds/boll in F_2 and S_0 generations were noticed compared with those of the other segregating generations. The difference between generation means was due to skipping of one row between each two planted rows in both F_2 and S_0 generations. However, this method was not applied in succeeding generations. Furthermore, one plant was left per hill that was spaced 50 cm apart, but this was not the case in the other succeeding generations.

The observed phenotypic and genotypic coefficients of variability were larger in F_2 and S_0 than those of the succeeding generations for all the studied characters of populations I, II and III. This indicates that, the magnitude of the genetic variability persisted in these material was sufficient for providing rather substantial amounts of improvement through the selection of superior progenies. Similar results were obtained by **El-Okkia (1979), Mahdy *et al.* (1987a), Meena *et al.* (1991), Younis (2000) and Meena *et al.* (2001)**.

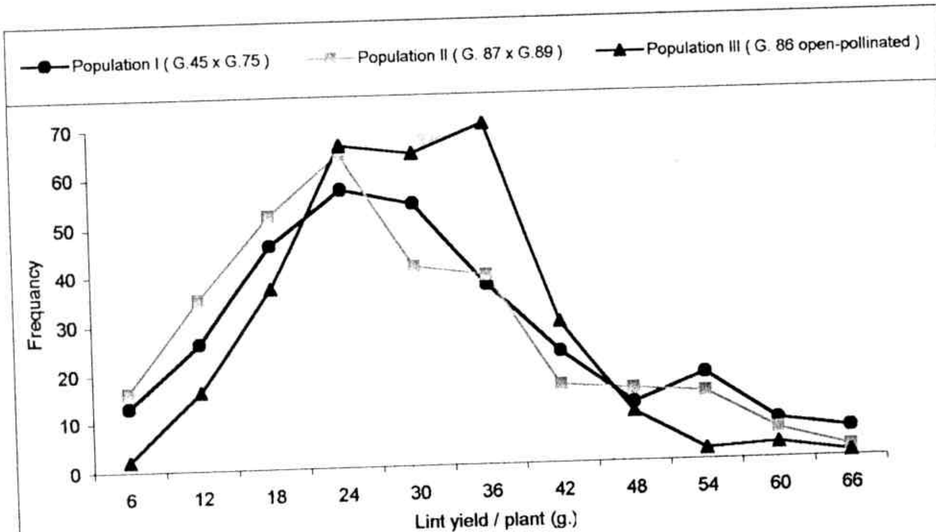


Fig. 4. Frequency distrbution curves of lint yield / plant in the three basic populations.

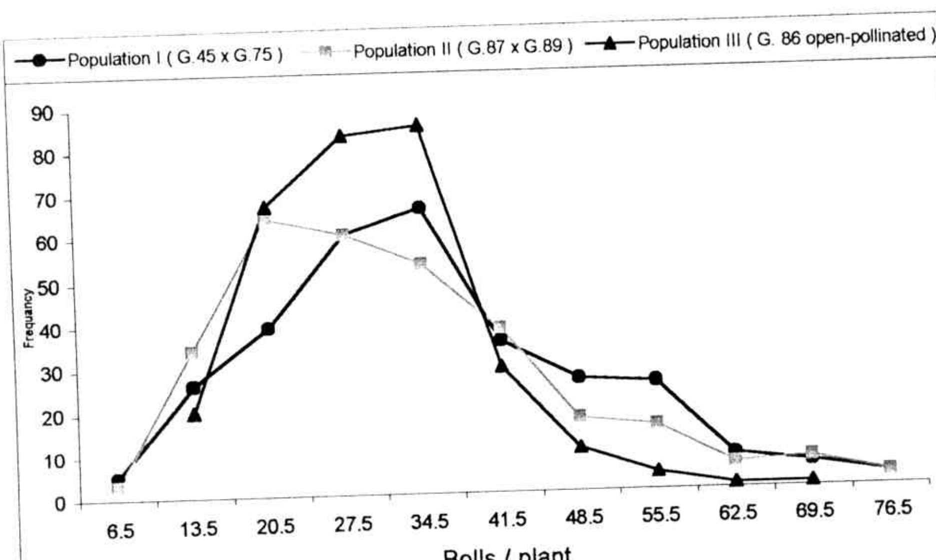


Fig. 5. Frequency distrbution curves of bolls / plant in the three basic populations.

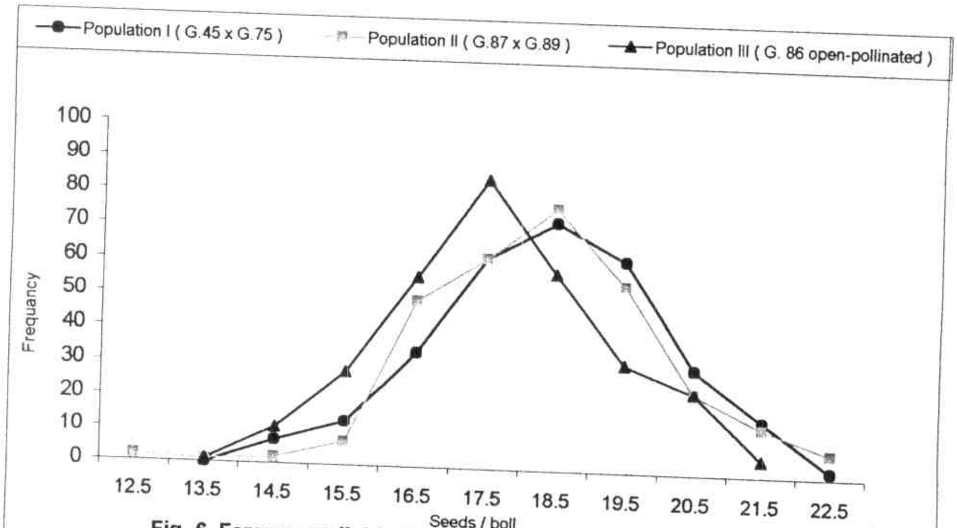


Fig. 6. Ferquency distrbution curves of seeds / boll in the three basic populations.

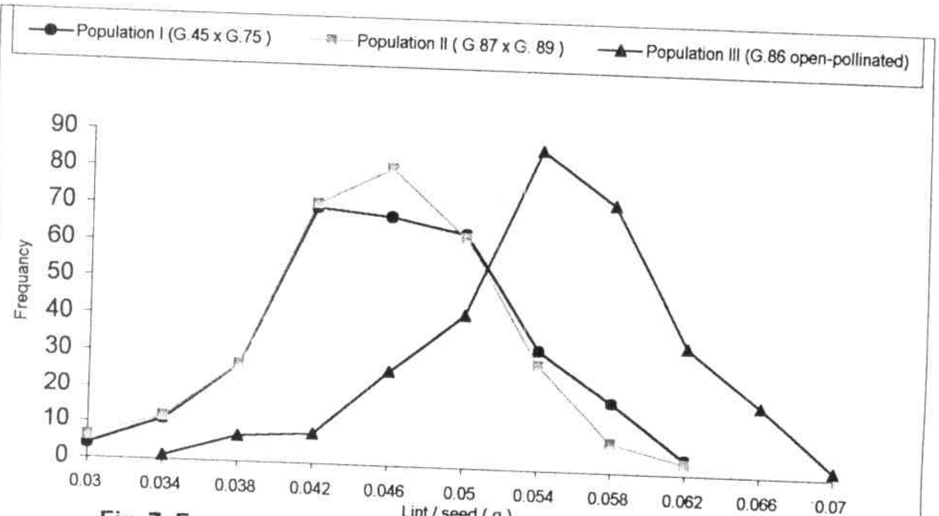


Fig. 7. Frequancy distrbution cuves of lint / seed in the three basic populations.

Table 16. Means, standard errors, ranges, phenotypic (PCV) and genotypic (GCV) coefficients of variation and broad sense heritability (h^2_b) for six characters in F_2, F_3 and F_4 generations of population I (G. 45 x G. 75).

Characters	Generations	Mean $\pm$ S$\bar{x}$	Range	PCV%	GCV%	h^2_b
Lint yield/ plant (g) (X_w)	F_2	29.37±0.784	3.4–68.7	46.2	37.7	66.5
	F_3	12.22±1.175	8.7–16.4	15.6	12.3	61.9
	F_4	15.40±1.503	11.2–19.1	18.0	15.2	70.7
Bolls/plant (X_1)	F_2	33.63±0.821	5.0–79.0	42.3	33.3	62.0
	F_3	15.31±1.256	11.5–19.5	12.3	9.1	55.4
	F_4	16.63±1.736	12.9–21.5	16.5	12.8	59.9
Seeds/boll (X_2)	F_2	18.34±0.089	14.6–22.0	8.4	5.4	41.2
	F_3	17.25±0.527	15.0–19.1	4.5	3.3	53.5
	F_4	15.71±0.677	14.4–17.9	7.3	5.9	65.3
Lint/seed (g) (X_3)	F_2	0.046±0.0004	0.030–0.062	13.4	10.4	60.5
	F_3	0.046±0.002	0.041–0.053	5.8	4.3	57.1
	F_4	0.059±0.002	0.052–0.064	6.6	5.4	66.7
Lint percentage	F_2	33.58±0.124	26.4–39.7	6.4	4.8	55.5
	F_3	33.94±0.820	30.6–37.3	4.3	3.5	67.7
	F_4	34.60±0.670	31.5–36.4	3.7	3.1	72.0
Seed index (g)	F_2	9.05±0.054	6.1–11.4	10.3	7.5	53.7
	F_3	8.99±0.249	8.0–10.3	5.1	4.2	70.0
	F_4	11.22±0.419	10.0–12.0	4.9	3.1	41.3

Table 17. Means, standard errors, ranges, phenotypic (PCV) and genotypic (GCV) coefficients of variation and broad sense heritability (h^2_b) for six characters in F_2, F_3 and F_4 generations of population II (G. 87 x G. 89).

Characters	Generations	Mean ± $S\bar{x}$	Range	PCV%	GCV%	h^2_b
Lint yield/ plant (g) (X_w)	F_2	27.47±0.783	3.9–67.6	49.4	37.2	56.8
	F_3	15.6±1.398	9.3–19.6	14.8	11.8	63.6
	F_4	17.36±2.551	11.9–24.9	21.3	15.5	52.6
Bolls/plant (X_1)	F_2	31.40±0.824	6.0–74.0	45.4	30.7	45.6
	F_3	19.37±1.531	13.7–23.9	13.0	10.3	63.0
	F_4	20.53±3.244	14.3–33.6	25.0	19.4	60.2
Seeds/boll (X_2)	F_2	18.32±0.099	12.0–23.0	9.4	5.8	38.3
	F_3	17.44±0.493	16.3–18.7	3.1	1.3	16.9
	F_4	16.36±0.564	14.9–17.7	4.5	2.9	40.6
Lint/seed (g) (X_3)	F_2	0.045±0.0003	0.029–0.063	13.1	9.9	57.1
	F_3	0.046±0.002	0.038–0.053	6.5	5.3	66.7
	F_4	0.053±0.002	0.046–0.057	6.3	4.2	45.5
Lint percentage	F_2	34.36±0.117	27.7–40.5	5.9	3.8	40.9
	F_3	34.33±0.952	30.4–37.1	4.2	3.1	56.3
	F_4	34.42±1.011	32.1–36.6	3.8	2.5	41.5
Seed index (g)	F_2	8.55±0.047	5.4–10.6	9.5	6.6	48.6
	F_3	8.78±0.252	8.0–9.4	4.4	3.4	58.1
	F_4	9.99±0.451	9.0–10.6	4.8	1.6	11.4

Table 18. Means, standard errors, ranges, phenotypic (PCV) and genotypic (GCV) coefficients of variation and broad sense heritability (h^2_b) for six characters in S_0, S_1 and S_2 generations of population III (G. 86 open-pollinated).

Characters	Generations	Mean $\pm S\bar{x}$	Range	PCV%	GCV%	h^2_b
Lint yield/ plant (g) (X_w)	S_0	29.70±0.565	6.0–63.1	32.9	27.6	70.3
	S_1	16.85±1.500	11.9–24.5	15.0	12.1	64.9
	S_2	22.82±1.858	17.9–27.4	14.1	11.5	66.5
Bolls/plant (X_1)	S_0	29.20±0.538	10.0–69.0	31.9	25.3	63.0
	S_1	16.40±1.346	11.1–21.8	14.6	12.1	68.6
	S_2	20.95±1.850	15.7–24.7	11.6	7.5	42.0
Seeds/boll (X_2)	S_0	17.60±0.090	13.2–21.4	8.9	5.7	40.8
	S_1	17.31±0.608	15.3–18.8	4.2	2.4	31.2
	S_2	16.08±0.624	14.8–17.5	5.3	3.7	47.2
Lint/seed (g) (X_3)	S_0	0.054±0.0004	0.032–0.071	11.6	6.9	35.9
	S_1	0.060±0.002	0.054–0.065	4.2	2.1	25.0
	S_2	0.069±0.005	0.060–0.076	9.2	6.0	42.5
Lint percentage	S_0	37.86±0.095	30.0–41.7	4.4	2.6	34.9
	S_1	38.40±0.781	36.0–40.6	2.2	0.9	15.1
	S_2	38.46±0.894	36.1–40.0	3.1	2.0	42.6
Seed index (g)	S_0	8.89±0.049	5.3–10.6	9.4	7.5	63.4
	S_1	9.45±0.498	8.9–10.2	7.2	4.9	46.2
	S_2	10.96±0.597	9.9–12.2	6.6	3.6	30.9

Comparing means of F_3 and S_1 generations with those of F_4 and S_2, it is apparent that the means of F_4 and S_2 were higher than those of F_3 and S_1 for all studied characters except seeds/boll in the three populations. Also, comparing the lowest and highest values of F_3 and S_1 with those of F_4 and S_2 (Tables 16, 17 and 18), it is clear that the lowest and the highest for F_4 and S_2 surpassed those for F_3 and S_1 for all studied characters except seeds/boll and lint percentage in the three populations. This may be attributed to the efficiency of selection procedures application in this study.

Concerning both phenotypic and genotypic coefficients of variation in F_3 generations, these were lower than F_4 for lint yield/plant, bolls/plant, seeds/boll and lint/seed in populations I and II, with the exception of lint/seed in population II. On the other hand, phenotypic and genotypic coefficients of variation in S_1 generation were larger than S_2 for lint yield/plant, bolls/plant and seed index in population III. Both lint yield and bolls/plant exhibited the highest estimated of phenotypic and genotypic coefficients of variation in the three populations, however, seeds/boll, lint/seed, lint percentage and seed index showed moderate to low variability.

Regarding heritability values in broad sense, high estimates (>50%) were observed for lint yield and bolls/plant in the three populations, yet for remaining characters, estimates fluctuated widely over the successive generations of selection probably due to varied environmental factors. Similar conclusions were found by **Lasheen and Abo-Sen (1998)**. However, higher estimates were noticed from F_3 to F_4 and from S_1 to S_2 generations for most characters in populations I and III. On the other hand, a decrease from F_3 to F_4 generations is shown for most characters in population II.

Burton (1952), Shaheen *et al.* (2000) and Meena *et al.* (2001) suggested that the genetic coefficient of variation with heritability would give the best indication of the amount of genetic variance to be expected from selection.

Mean lint yield/plant for the best 5% selection intensity scored for each selection index in F_2 and F_3 for populations I and II, and for S_0 and S_1 generations for population III are shown in Table 19. In the three populations, mean estimates of lint yield/plant for the three different phenotypic trait selection; Ixw, Ix_1 and Ix_3 were consistently higher than their generation means. While, phenotypic selection for seeds/boll (Ix_2) exhibited lower mean of lint yield/plant than its F_2 and S_0 generation mean in the three populations.

Mean lint yield/plant for the eight different selection indices and the four phenotypic trait selection were higher than their F_3 and S_1 generation means in the three populations, except phenotypic selection for lint/seed (Ix_3) in population III. However, means were extensively variable among indices with obvious higher means for all indices including lint yield/plant.

Means, phenotypic and genotypic variances and phenotypic and genotypic coefficients of variation for lint yield and its components for the eight different selection indices and the four phenotypic trait selection, parental inbred lines, and random sample of the generation under study for population I, II and III are presented in Tables 20, 21 and 22.

Table 19. Means of lint yield (g)/plant for the best 5% selection intensity scored by each selection index and phenotypic traits selection in F_2 and F_3 for populations I and II, and S_0, S_1 generations for population III.

Indices	Population I (G. 45 x G. 75)		Population II (G. 87 x G. 89)		Population III (G. 86 open-pollinated)	
	$\overline{F}_2$ selected plants	$\overline{F}_3$ selected families	$\overline{F}_2$ selected plants	$\overline{F}_3$ selected families	$\overline{S}_o$ selected plants	$\overline{S}_1$ selected families
I_{w123}		15.99		19.10		22.41
I_{123}		16.03		18.79		22.08
I_{w1}		15.99		19.10		22.41
I_{w2}		15.99		19.10		22.41
I_{w3}		16.03		19.01		22.41
I_{12}		16.03		18.38		22.41
I_{13}		15.30		18.79		22.08
I_{23}		15.12		17.31		20.35
Ix_w	60.87	16.03	57.74	19.10	49.65	22.41
Ix_1	59.31	15.01	55.69	18.38	49.09	22.08
Ix_2	28.43	13.45	24.40	15.95	28.41	19.22
Ix_3	33.07	14.13	32.77	17.31	32.55	16.44
Generation mean	29.37	12.22	27.47	15.60	29.70	16.85

Table 20. Means, standard errors, phenotypic ($\sigma^2 p$) and genotypic ($\sigma^2 g$) variances and phenotypic (PCV) and genotypic (GCV) coefficients of variation for lint yield and its components in the twelve different selection procedures as evaluated from F_3 selected families and their F_4 progenies for population I (G. 45 x G. 75).

Indices	Characters	Mean ± S $\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_{w123}	Lint yield/plant (g)	15.21+2.09	10.889	6.510	21.7	16.8
	Bolls/plant	14.87+2.00	4.381	0.397	14.1	4.2
	Seeds/boll	16.63+0.52	1.921*	1.649	8.3	7.7
	Lint/seed (g)	0.061+0.0004	0.0000034*	0.0000032	3.0	2.9
	Lint percentage	35.01+0.32	0.268	0.167	1.5	1.2
	Seed index (g)	11.34+0.17	0.308*	0.278	4.9	4.6
I_{123}	Lint yield/plant (g)	14.11+2.03	2.016	0.000+	10.1	-
	Bolls/plant	14.76+2.38	3.685	0.000+	13.0	-
	Seeds/boll	16.09+0.47	0.796	0.572	5.5	4.7
	Lint/seed (g)	0.060+0.0017	0.0000014	0.0000+	2.0	-
	Lint percentage	34.81+0.46	0.735	0.525	2.5	2.1
	Seed index (g)	11.24+0.42	0.152	0.000+	3.5	-
I_{w1}	Lint yield/plant (g)	15.21+2.09	10.889	6.510	21.7	16.8
	Bolls/plant	14.87+2.00	4.381	0.397	14.1	4.2
	Seeds/boll	16.63+0.52	1.921*	1.649	8.3	7.7
	Lint/seed (g)	0.061+0.0004	0.0000034*	0.0000032	3.0	2.9
	Lint percentage	35.01+0.32	0.268	0.167	1.5	1.2
	Seed index (g)	11.34+0.17	0.308*	0.278	4.9	4.6
I_{w2}	Lint yield/plant (g)	15.21+2.09	10.889	6.510	21.7	16.8
	Bolls/plant	14.87+2.00	4.381	0.397	14.1	4.2
	Seeds/boll	16.63+0.52	1.921*	1.649	8.3	7.7
	Lint/seed (g)	0.061+0.0004	0.0000034*	0.0000032	3.0	2.9
	Lint percentage	35.01+0.32	0.268	0.167	1.5	1.2
	Seed index (g)	11.34+0.17	0.308*	0.278	4.9	4.6
I_{w3}	Lint yield/plant (g)	14.11+2.03	2.016	0.000+	10.1	-
	Bolls/plant	14.76+2.38	3.685	0.000+	13.0	-
	Seeds/boll	16.09+0.47	0.796	0.572	5.5	4.7
	Lint/seed (g)	0.060+0.0017	0.0000014	0.00000+	2.0	-
	Lint percentage	34.81+0.46	0.735	0.525	2.5	2.1
	Seed index (g)	11.24+0.42	0.152	0.000+	3.5	-

+ Negative value for genotypic variance component.
* and ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 20. Continued.

Indices	Characters	Mean $\pm$ S $\bar{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_{12}	Lint yield/plant (g)	14.11±2.03	2.016	0.000+	10.1	-
	Bolls/plant	14.76±2.38	3.685	0.00+	13.0	-
	Seeds/boll	16.09±0.47	0.796	0.572	5.5	4.7
	Lint/seed (g)	0.060±0.0017	0.0000014	0.00000+	2.0	-
	Lint percentage	34.81±0.46	0.735	0.525	2.5	2.1
	Seed index (g)	11.24±0.42	0.152	0.000+	3.5	-
I_{13}	Lint yield/plant (g)	14.36±1.97	1.714	0.000+	9.1	-
	Bolls/plant	15.21±1.79	4.006	0.807	13.2	5.9
	Seeds/boll	15.62±0.89	1.565	0.770	8.0	5.6
	Lint/seed (g)	0.061±0.0033	0.0000023	0.00000+	2.5	-
	Lint percentage	34.88±0.65	0.067	0.000+	0.7	-
	Seed index (g)	11.36±0.38	0.178	0.030	3.7	1.5
I_{23}	Lint yield/plant (g)	14.59±1.22	0.905	0.000+	6.5	-
	Bolls/plant	15.79±0.96	1.002	0.073	6.3	1.7
	Seeds/boll	15.03±1.04	0.348	0.000+	3.9	-
	Lint/seed (g)	0.061±0.0033	0.0000003	0.0000+	0.9	-
	Lint percentage	34.97±0.72	0.168	0.000+	1.2	-
	Seed index (g)	11.44±0.28	0.080	0.003	2.5	0.5
Ix_w	Lint yield/plant (g)	14.11±2.03	2.016	0.000+	10.1	-
	Bolls/plant	14.76±2.38	3.685	0.000+	13.0	-
	Seeds/boll	16.09±0.47	0.796	0.572	5.5	4.7
	Lint/seed (g)	0.060±0.0017	0.0000014	0.00000+	2.0	-
	Lint percentage	34.81±0.46	0.735	0.525	2.5	2.1
	Seed index (g)	11.24±0.42	0152	0.000+	3.5	-
Ix_1	Lint yield/plant (g)	14.02±1.60	2.158	0.000+	10.5	-
	Bolls/plant	15.60±2.20	5.514	0.692	15.1	5.3
	Seeds/boll	15.84±0.29	1.676**	1.592	8.2	8.0
	Lint/seed (g)	0.058±0.0015	0.0000084	0.0000062	5.0	4.3
	Lint percentage	34.69±0.59	0.552	0.207	2.1	1.3
	Seed index (g)	10.87±0.35	0.668	0.546	7.5	6.8

+ Negative value for genotypic variance component.

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

Table 20. Continued.

Indices	Characters	Mean $\pm$ S $\bar{x}$	σ^2_p	σ^2_g	PCV %	GCV %
Ix2	Lint yield/plant (g)	14.56$\pm$0.80	14.780**	14.135	26.4	25.8
	Bolls/plant	16.43$\pm$0.85	19.514**	18.800	26.9	26.4
	Seeds/boll	15.63$\pm$0.51	0.610	0.347	5.0	3.8
	Lint/seed (g)	0.057$\pm$0.0016	0.0000238*	0.0000213	8.6	8.1
	Lint percentage	33.90$\pm$0.82	4.323	3.657	6.1	5.6
	Seed index (g)	11.10$\pm$0.56	0.031	0.000+	1.6	-
Ix3	Lint yield/plant (g)	16.41$\pm$0.97	5.825	4.875	14.7	13.5
	Bolls/plant	17.70$\pm$0.83	5.333*	4.639	13.0	12.2
	Seeds/boll	14.92$\pm$1.09	0.352	0.000+	4.0	-
	Lint/seed (g)	0.062$\pm$0.0031	0.0000018	0.00000+	2.2	-
	Lint percentage	35.28$\pm$0.71	0.894	0.390	2.7	1.8
	Seed index (g)	11.43$\pm$0.45	0.090	0.000+	2.6	-
P1 G. 45	Lint yield/plant (g)	9.88$\pm$0.91	0.218	0.000+	4.7	-
	Bolls/plant	13.36$\pm$0.28	0.123	0.045	2.6	1.6
	Seeds/boll	16.67$\pm$0.48	1.914*	1.680	8.3	7.8
	Lint/seed (g)	0.045$\pm$0.0026	0.0000267	0.0000199	11.5	9.9
	Lint percentage	32.11$\pm$0.62	0.005	0.000+	0.2	-
	Seed index (g)	9.54$\pm$0.36	1.068*	0.935	10.8	10.1
P2 G. 75	Lint yield/plant (g)	13.97$\pm$0.38	0.563	0.422	5.4	4.7
	Bolls/plant	13.69$\pm$0.35	2.103*	1.977	10.6	10.3
	Seeds/boll	16.43$\pm$0.18	0.588**	0.557	4.7	4.5
	Lint/seed (g)	0.062$\pm$0.0003	0.0000468**	0.0000467	11.0	11.0
	Lint percentage	37.32$\pm$0.25	0.780*	0.717	2.4	2.3
	Seed index (g)	10.41$\pm$0.14	0.588**	0.568	7.4	7.2
Random sample	Lint yield/plant (g)	15.24$\pm$1.33	3.362	1.598	12.0	8.3
	Bolls/plant	18.11$\pm$1.92	3.868	0.176	10.9	2.3
	Seeds/boll	16.41$\pm$0.91	2.250	1.418	9.1	7.3
	Lint/seed (g)	0.053$\pm$0.0026	0.0000380	0.0000313	11.6	10.6
	Lint percentage	34.89$\pm$0.86	0.123	0.000+	1.0	-
	Seed index (g)	9.94$\pm$0.83	1.362	0.666	11.7	8.2

+ Negative value for genotypic variance component.

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

Table 21. Means, standard errors, phenotypic (σ^2_p) and genotypic (σ^2_g) variances and phenotypic (PCV) and genotypic (GCV) coefficients of variation for lint yield and its components in the twelve different selection procedures as evaluated from F_3 selected families and their F_4 progenies for population II (G. 87 x G. 89).

Indices	Characters	Mean ± S $\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
Iw_{123}	Lint yield/plant (g)	16.16±3.03	3.207	0.000+	11.1	-
	Bolls/plant	18.83±3.17	10.290	0.212	17.0	2.4
	Seeds/boll	16.40±0.66	0.164	0.000+	2.5	-
	Lint/seed (g)	0.052±0.0030	0.0000030	0.00000+	3.3	-
	Lint percentage	33.90±0.60	3.445*	3.079	5.5	5.2
	Seed index (g)	10.22±0.51	0.394	0.132	6.1	3.6
I_{123}	Lint yield/plant (g)	18.58±1.28	30.880**	29.249	29.9	29.1
	Bolls/plant	23.79±2.93	79.922*	71.340	37.6	35.5
	Seeds/boll	16.02±0.42	0.979	0.804	6.2	5.6
	Lint/seed (g)	0.051±0.0018	0.0000180	0.0000147	8.3	7.5
	Lint percentage	33.99±1.37	0.294	0.000+	1.6	-
	Seed index (g)	9.84±0.44	0.700	0.507	8.5	7.2
Iw_1	Lint yield/plant (g)	16.16±3.03	3.207	0.000+	11.1	-
	Bolls/plant	18.83±3.17	10.290	0.212	17.0	2.4
	Seeds/boll	16.40±0.66	0.164	0.000+	2.5	-
	Lint/seed (g)	0.052±0.0030	0.0000030	0.000+	3.3	-
	Lint percentage	33.90±0.60	3.445*	3.079	5.5	5.2
	Seed index (g)	10.22±0.51	0.394	0.132	6.1	3.6
Iw_2	Lint yield/plant (g)	16.16±3.03	3.207	0.000+	11.1	-
	Bolls/plant	18.83±3.17	10.290	0.212	17.0	2.4
	Seeds/boll	16.40±0.66	0.164	0.000+	2.5	-
	Lint/seed (g)	0.052±0.0030	0.0000030	0.000+	3.3	-
	Lint percentage	33.90±0.60	3.445*	3.079	5.5	5.2
	Seed index (g)	10.22±0.51	0.394	0.132	6.1	3.6
Iw_3	Lint yield/plant (g)	15.60±1.80	1.003	0.000+	6.4	-
	Bolls/plant	18.64±2.60	8.414	1.632	15.6	6.9
	Seeds/boll	15.98±0.47	0.953	0.728	6.1	5.3
	Lint/seed (g)	0.053±0.0030	0.0000001	0.000+	0.6	-
	Lint percentage	34.69±1.02	1.367	0.335	3.4	1.7
	Seed index (g)	10.02±0.44	0.327	0.133	5.7	3.6

+ Negative value for genotypic variance component.
* and ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 21. Continued.

Indices	Characters	Mean ± S $\bar{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_{12}	Lint yield/plant (g)	17.24±1.67	9.397	6.622	17.8	14.9
	Bolls/plant	19.59±1.93	15.083	11.355	19.8	17.2
	Seeds/boll	16.48±0.90	0.727	0.000+	5.2	-
	Lint/seed (g)	0.054±0.0023	0.0000055	0.0000001	4.3	0.6
	Lint percentage	34.08±0.76	0.446	0.000+	2.0	-
	Seed index (g)	10.43±0.33	0.085	0.000+	2.8	-
I_{13}	Lint yield/plant (g)	18.58±1.28	30.880**	29.249	29.9	29.1
	Bolls/plant	23.79±2.93	79.922*	71.340	37.6	35.5
	Seeds/boll	16.02±0.42	0.979	0.804	6.2	5.6
	Lint/seed (g)	0.051±0.0018	0.0000180	0.0000147	8.3	7.5
	Lint percentage	33.99±1.37	0.294	0.000+	1.6	-
	Seed index (g)	9.84±0.44	0.700	0.507	8.5	7.2
I_{23}	Lint yield/plant (g)	17.26±1.64	27.527*	24.837	30.4	28.9
	Bolls/plant	19.13±3.05	33.818	24.507	30.4	25.9
	Seeds/boll	16.89±0.13	0.553**	0.537	4.4	4.3
	Lint/seed (g)	0.054±0.0034	0.0000036	0.000+	3.5	-
	Lint percentage	35.60±0.91	0.751	0.000+	2.4	-
	Seed index (g)	9.78±0.78	0.049	0.000+	2.3	-
Ixw	Lint yield/plant (g)	16.16±3.03	3.207	0.000+	11.1	-
	Bolls/plant	18.83±3.17	10.290	0.212	17.0	2.4
	Seeds/boll	16.40±0.66	0.164	0.000+	2.5	-
	Lint/seed (g)	0.052±0.0030	0.0000030	0.000+	3.3	-
	Lint percentage	33.90±0.60	3.445*	3.079	5.5	5.2
	Seed index (g)	10.22±0.51	0.394	0.132	6.1	3.6
Ix_1	Lint yield/plant (g)	17.24±1.67	9.397	6.622	17.8	14.9
	Bolls/plant	19.59±1.93	15.083	11.355	19.8	17.2
	Seeds/boll	16.48±0.90	0.727	0.000+	5.2	-
	Lint/seed (g)	0.054±0.0023	0.0000055	0.0000001	4.3	0.6
	Lint percentage	34.08±0.76	0.446	0.000+	2.0	-
	Seed index (g)	10.43±0.33	0.085	0.000+	2.8	-

+ Negative value for genotypic variance component.

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

Table 21. Continued.

Indices	Characters	Mean $\pm$ S $\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
Ix2	Lint yield/plant (g)	15.64±2.20	10.922	6.065	21.1	15.7
	Bolls/plant	18.32±2.72	7.929	0.526	15.4	4.0
	Seeds/boll	16.36±0.68	0.429	0.000+	4.0	-
	Lint/seed (g)	0.052±0.0013	0.0000274*	0.0000256	10.1	9.7
	Lint percentage	33.97±0.71	3.010	2.502	5.1	4.7
	Seed index (g)	10.12±0.18	0.064	0.032	2.5	1.8
Ix3	Lint yield/plant (g)	17.87±1.05	39.301**	38.194	35.1	34.6
	Bolls/plant	21.79±1.71	106.492**	103.553	47.4	46.7
	Seeds/boll	16.40±0.14	0.031	0.011	1.1	0.6
	Lint/seed (g)	0.052±0.0024	0.0000283	0.0000224	10.2	9.1
	Lint percentage	35.18±1.41	1.962	0.000+	4.0	-
	Seed index (g)	9.56±0.72	0.294	0.000+	5.7	-
P1 G. 87	Lint yield/plant (g)	13.78±0.34	2.668**	2.550	11.9	11.6
	Bolls/plant	19.07±0.43	2.055*	1.873	7.5	7.2
	Seeds/boll	16.02±0.84	0.267	0.000+	3.2	-
	Lint/seed (g)	0.045±0.0035	0.0000267	0.0000147	11.5	8.5
	Lint percentage	32.58±0.57	0.872	0.551	2.9	2.3
	Seed index (g)	9.21±0.46	0.445	0.231	7.2	5.2
P2 G. 89	Lint yield/plant (g)	17.04±0.46	0.018	0.000+	0.8	-
	Bolls/plant	19.74±0.99	0.010	0.000+	0.5	-
	Seeds/boll	16.62±0.64	1.034	0.623	6.1	4.7
	Lint/seed (g)	0.052±0.0021	0.0.000203	0.0000160	8.7	7.7
	Lint percentage	36.18±0.24	0.055	0.000+	0.6	-
	Seed index (g)	9.19±0.08	0.063*	0.057	2.7	2.6
Random sample	Lint yield/plant (g)	15.62±1.58	1.323	0.000+	7.4	-
	Bolls/plant	20.09±2.10	0.080	0.000+	1.4	-
	Seeds/boll	16.69±0.25	1.103**	1.042	6.3	6.1
	Lint/seed (g)	0.047±0.0016	0.0000514**	0.0000488	15.3	14.9
	Lint percentage	33.06±0.50	1.247	0.995	3.4	3.0
	Seed index (g)	9.41±0.23	1.000**	0.949	10.6	10.4

+ Negative value for genotypic variance component.

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

Table 22. Means, standard errors, phenotypic (σ^2_p) and genotypic (σ^2_g) variances and phenotypic (PCV) and genotypic (GCV) coefficients of variation for lint yield and its components in the twelve different selection procedures as evaluated from S_1 selected families and their S_2 progenies for population III (G. 86 open-pollinated).

Indices	Characters	Mean ± $S\bar{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_{w123}	Lint yield/plant (g)	23.42+2.28	5.578	0.387	10.1	2.7
	Bolls/plant	20.74+1.39	5.903	3.967	11.7	9.6
	Seeds/boll	16.69+0.56	0.500	0.188	4.2	2.6
	Lint/seed (g)	0.069+0.0051	0.0000339	0.0000082	8.4	4.2
	Lint percentage	38.54+0.54	1.294	0.999	3.0	2.6
	Seed index (g)	10.92+0.66	0.553	0.122	6.8	3.2
I_{123}	Lint yield/plant (g)	22.30+1.40	16.501*	14.537	18.2	17.1
	Bolls/plant	21.40+2.77	3.040	0.000+	8.1	-
	Seeds/boll	16.23+0.50	1.791*	1.542	8.2	7.7
	Lint/seed (g)	0.066+0.0068	0.0000500	0.0000038	10.7	3.0
	Lint percentage	37.32+0.83	1.416	0.730	3.2	2.3
	Seed index (g)	10.93+0.82	0.543	0.000+	6.7	-
I_{w1}	Lint yield/plant (g)	23.42+2.28	5.578	0.387	10.1	2.7
	Bolls/plant	20.74+1.39	5.903	3.967	11.7	9.6
	Seeds/boll	16.69+0.56	0.500	0.188	4.2	2.6
	Lint/seed (g)	0.069+0.0051	0.0000339	0.0000082	8.4	4.2
	Lint percentage	38.54+0.54	1.294	0.999	3.0	2.6
	Seed index (g)	10.92+0.66	0.553	0.122	6.8	3.2
I_{w2}	Lint yield/plant (g)	23.42+2.28	5.578	0.387	10.1	2.7
	Bolls/plant	20.74+1.39	5.903	3.967	11.7	9.6
	Seeds/boll	16.69+0.56	0.500	0.188	4.2	2.6
	Lint/seed (g)	0.069+0.0051	0.0000339	0.0000082	8.4	4.2
	Lint percentage	38.54+0.54	1.294	0.999	3.0	2.6
	Seed index (g)	10.92+0.66	0.553	0.122	6.8	3.2
I_{w3}	Lint yield/plant (g)	23.42+2.28	5.578	0.387	10.1	2.7
	Bolls/plant	20.74+1.39	5.903	3.967	11.7	9.6
	Seeds/boll	16.69+0.56	0.500	0.188	4.2	2.6
	Lint/seed (g)	0.069+0.0051	0.0000339	0.0000082	8.4	4.2
	Lint percentage	38.54+0.54	1.294	0.999	3.0	2.6
	Seed index (g)	10.92+0.66	0.553	0.122	6.8	3.2

+ Negative value for genotypic variance component.
* and ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 22. Continued.

Indices	Characters	Mean $\pm$ S $\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_{12}	Lint yield/plant (g)	23.42±2.28	5.578	0.387	10.1	2.7
	Bolls/plant	20.74±1.39	5.903	3.967	11.7	9.6
	Seeds/boll	16.69±0.56	0.500	0.188	4.2	2.6
	Lint/seed (g)	0.069±0.0051	0.0000339	0.0000082	8.4	4.2
	Lint percentage	38.54±0.54	1.294	0.999	3.0	2.6
	Seed index (g)	10.92±0.66	0.553	0.122	6.8	3.2
I_{13}	Lint yield/plant (g)	22.30±1.40	16.501*	14.537	18.2	17.1
	Bolls/plant	21.40±2.77	3.040	0.000+	8.1	-
	Seeds/boll	16.23±0.50	1.791*	1.542	8.2	7.7
	Lint/seed (g)	0.066±0.0068	0.0000500	0.0000038	10.7	3.0
	Lint percentage	37.32±0.83	1.416	0.730	3.2	2.3
	Seed index (g)	10.93±0.82	0.543	0.000+	6.7	-
I_{23}	Lint yield/plant (g)	24.07±2.06	2.721	0.000+	6.9	-
	Bolls/plant	21.06±1.81	1.583	0.000+	6.0	-
	Seeds/boll	16.82±0.88	1.247	0.477	6.6	4.1
	Lint/seed (g)	0.069±0.0031	0.0000469	0.0000374	9.9	8.9
	Lint percentage	38.60±0.66	0.323	0.000+	1.5	-
	Seed index (g)	10.98±0.36	0.889	0.758	8.6	7.9
Ixw	Lint yield/plant (g)	23.42±2.28	5.578	0.387	10.1	2.7
	Bolls/plant	20.74±1.39	5.903	3.967	11.7	9.6
	Seeds/boll	16.69±0.56	0.500	0.188	4.2	2.6
	Lint/seed (g)	0.069±0.0051	0.0000339	0.0000082	8.4	4.2
	Lint percentage	38.54±0.54	1.294	0.999	3.0	2.6
	Seed index (g)	10.92±0.66	0.553	0.122	6.8	3.2
Ix_1	Lint yield/plant (g)	22.30±1.40	16.501*	14.537	18.2	17.1
	Bolls/plant	21.40±2.77	3.040	0.000+	8.1	-
	Seeds/boll	16.23±0.50	1.791*	1.542	8.2	7.7
	Lint/seed (g)	0.066±0.0068	0.000050	0.0000038	10.7	3.0
	Lint percentage	37.32±0.83	1.416	0.730	3.2	2.3
	Seed index (g)	10.93±0.82	0.543	0.000+	6.7	-

+ Negative value for genotypic variance component.

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

Table 22. Continued.

Indices	Characters	Mean ± S $\bar{X}$	σ^2_p	σ^2_g	PCV %	GCV %
Ix_2	Lint yield/plant (g)	25.47±1.43	5.101	3.062	8.9	6.9
	Bolls/plant	21.78±1.28	6.277	4.634	11.5	9.9
	Seeds/boll	16.11±0.59	1.460	1.117	7.5	6.6
	Lint/seed (g)	0.073±0.0020	0.0000005	0.000+	1.0	-
	Lint percentage	39.23±0.67	0.640	0.192	2.0	1.1
	Seed index (g)	11.29±0.22	0.205	0.156	4.0	3.5
Ix_3	Lint yield/plant (g)	23.14±1.98	17.760	13.837	18.2	16.1
	Bolls/plant	19.24±1.37	10.090	8.211	16.5	14.9
	Seeds/boll	16.21±0.62	0.016	0.000+	0.8	-
	Lint/seed (g)	0.075±0.0037	0.0000041	0.000+	2.7	-
	Lint percentage	38.91±0.97	0.194	0.000+	1.1	-
	Seed index (g)	11.69±0.52	0.185	0.000+	3.7	-
P_1 G. 86 pure	Lint yield/plant (g)	20.51±0.63	0.490	0.089	3.4	1.5
	Bolls/plant	20.99±0.68	6.003*	5.547	11.7	11.2
	Seeds/boll	16.37±0.97	0.081	0.000+	1.7	-
	Lint/seed (g)	0.060±0.0009	0.0000028	0.0000020	2.8	2.4
	Lint percentage	38.42±0.75	0.514	0.000+	1.9	-
	Seed index (g)	9.69±0.18	0.303*	0.272	5.7	5.4
P_2 G. 86 open-pollinated	Lint yield/plant (g)	24.49±1.37	6.003	4.117	10.0	8.3
	Bolls/plant	21.08±0.91	3.122	2.286	8.4	7.2
	Seeds/boll	16.70±0.27	0.008	0.000+	0.5	-
	Lint/seed (g)	0.069±0.0014	0.0000007	0.000+	1.2	-
	Lint percentage	38.81±0.51	0.090	0.000+	0.8	-
	Seed index (g)	10.92±0.13	0.0003	0.000+	0.2	-
Random sample	Lint yield/plant (g)	16.38±0.59	2.890*	2.539	10.4	9.7
	Bolls/plant	16.06±0.32	1.323*	1.222	7.2	6.9
	Seeds/boll	15.81±0.33	0.090	0.000+	1.9	-
	Lint/seed (g)	0.062±0.0022	0.0000321	0.0000274	9.1	8.4
	Lint percentage	38.16±0.35	0.123	0.00002	0.9	0.01
	Seed index (g)	10.08±0.23	1.210**	1.158	10.9	10.7

+ Negative value for genotypic variance component.

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

As shown in Table 20 application selection indices I_{w123}, I_{w1} and I_{w2} resulted in the same selected families also, application of the indices I_{123}, I_{w3}, I_{12} and Ixw involved the same selected families. Mean lint yield/plant, bolls/plant and seed index increased over the better parent in the twelve selection procedures. The phenotypic selection (Ix_3) had high influence on both lint yield and bolls/plant. Similar results were obtained by **El-Okkia (1979) and Gooda (2001)**. The twelve selection procedures were highest in means of lint/seed and seed index than those in random sample.

With regard to σ^2_p, σ^2_g, PCV and GCV, the results showed that sufficient genetic variability persisted for lint yield/plant (index Ix_2), bolls/plant (indices Ix_2 and Ix_3), seeds/boll (indices I_{w123}, I_{w1}, I_{w2} and Ix_1), lint/seed (indices I_{w123}, I_{w1}, I_{w2} and Ix_2) and seed index (indices I_{w123}, I_{w1} and I_{w2}).

Concerning genetic variability between selected families, the twelve selection procedures were not sufficient to improve lint percentage.

The data indicated slight discrepancy between PCV and GCV for seeds/boll and lint/seed. This was reflected in high heritability estimates for the two traits in the three generations (Table 16). Similar results were obtained by **Younis (1993)**.

Results in Table 21 indicate that the selected families using the indices I_{w123}, I_{w1}, I_{w2} and Ixw were the same families for each index also, the selected families by the indices I_{123} and I_{13} included the same families for each index.

Means of the selected families for lint yield, bolls/plant and seed index exceeded those of the better parent and random sample of indices I_{123}, I_{13} and Ix_3. Means of the lint/seed exceeded the better parent and random sample for indices I_{w3}, I_{12}, I_{23} and Ix_1. Means of seeds/boll were higher than the better parent and random sample in index I_{23} only. While the means of seed index surpassed their respective better parent and random sample for the twelve different selection procedures. The selection index involving lint/seed was effective for improving lint yield. The same results were recorded by **El-Okkia (1979), Younis (1986) and Gooda (2001)**.

Estimated σ^2_p, σ^2_g, PCV and GCV for both lint yield and bolls/plant were sufficient and the highest in indices I_{123}, I_{12}, I_{13}, I_{23} Ix_1, Ix_2 and Ix_3, indicating that further improvements could be attained through more cycles of selection. Similar results were detected by **Singh *et al.* (1985), El-Kilany (1986) and Younis (1993)**.

With respect to σ^2_p, σ^2_g, PCV and GCV, the results indicated that genetic variation persisted for both lint/seed and seed index in indices I_{123}, I_{13} and Ix_2. Sufficient genetic variability was observed for lint percentage in indices I_{w123}, I_{w1}, I_{w2} and Ixw, while it was also observed for seeds/boll in index I_{23} only.

Table 22 indicates that the selected families by each of the indices I_{w123}, I_{w1}, I_{w2}, I_{w3}, I_{12} and Ixw involved the same families also, the indices I_{123}, I_{13} and Ix_1 resulted in the same families.

Means of most selection indices showed values over the parent Giza 86 pure line and random sample for lint yield, lint/seed, lint percentage and seed index. Means bolls/plant exceeded Giza 86 pure line and random sample for selection indices I_{123}, I_{13}, I_{23}, Ix_1 and Ix_2, while the means of seeds/ boll surpassed Giza 86 pure line and random sample in indices I_{w123}, I_{w1}, I_{w2}, I_{w3}, I_{12}, I_{23} and I_{xw}.

The magnitude of the genetic variability for both lint yield/plant and seeds/boll which persisted in selection indices I_{123}, I_{13} and Ix_1 was large enough to lead to further appreciable improvement in S_2. These results are in agreement with **Mahdy *et al.* (1987a) and Gooda (2001)**.

Some characters exhibited negative value for genotypic variance in various indices due to the large magnitude of the experimental error, which masked the genetic variations and led to inaccurate estimates of genetic parameters.

4.2.13 Phenotypic and genotypic correlation

Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters in F_2, F_3 and F_4 for populations I and II, and S_0, S_1 and S_2 generations for population III are presented in Tables 23, 24 and 25.

The phenotypic and genotypic correlations between lint yield/plant and bolls/plant in the three populations were positive and highly significant in the three generations except S_2 generation indicating that bolls/plant was the most effective yield-contributing variable. Similar results were reported by **Walker (1960), Singh *et al.* (1985), Hassaballa *et al.* (1987), El-Okkia *et al.* (1989), Younis**

Table 23. Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters in F_2, F_3 and F_4 generations for population I (G. 45 x G. 75).

Relationships	F_2		F_3		F_4	
	r_p	r_g	r_p	r_g	r_p	r_g
1. **Lint yield (g)/plant** and **bolls/plant**	0.957**	0.957**	0.917**	0.935**	0.843**	0.845**
2. **Lint yield (g)/plant** and **seeds/boll**	-0.025	-0.029	0.237	0.300*	0.046	0.104
3. **Lint yield (g)/plant** and **lint (g)/seed**	0.096	0.096	0.499**	0.522**	0.641**	0.789**
4. **Lint yield (g)/plant** and **lint percentage**	0.245**	0.244**	0.440**	0.535**	0.476	0.549
5. **Lint yield (g)/plant** and **seed index (g)**	0.167**	0.170**	-0.045	-0.180	0.330	0.567
6. **Bolls/plant** and **seeds/boll**	-0.113*	-0.116*	0.043	0.150	-0.393	-0.340
7. **Bolls/plant** and **lint (g)/seed**	0.043	0.043	0.295*	0.364**	0.312	0.476
8. **Bolls/plant** and **lint percentage**	0.138*	0.137*	0.350*	0.487**	0.448	0.581
9. **Bolls/plant** and **seed index (g)**	0.048	0.052	-0.138	-0.277	-0.080	-0.010
10. **Seeds/boll** and **lint (g)/seed**	-0.066	-0.068	-0.322*	-0.385**	0.009	0.064
11. **Seeds/boll** and **lint percentage**	-0.219**	-0.229**	-0.183	-0.145	-0.431	-0.588
12. **Seeds/boll** and **seed index (g)**	-0.073	-0.076	-0.151	-0.245	0.520	1.018**
13. **Lint (g)/seed** and **lint percentage**	0.194**	0.192**	0.633**	0.666**	0.684**	0.836**
14. **Lint (g)/seed** and **seed index (g)**	0.301**	0.301**	0.293*	0.247	0.552	0.454
15. **Lint percentage** and **seed index (g)**	-0.121*	-0.119*	-0.513**	-0.582**	-0.226	-0.117

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

Table 24. Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters in F_2, F_3 and F_4 generations for population II (G. 87 x G. 89).

Relationships	F_2		F_3		F_4	
	r_p	r_g	r_p	r_g	r_p	r_g
1. **Lint yield (g)/plant** and **bolls/plant**	0.950**	0.951**	0.896**	0.905**	0.950**	0.977**
2. **Lint yield (g)/plant** and **seeds/boll**	0.099	0.099	0.122	0.148	0.032	0.468
3. **Lint yield (g)/plant** and **lint (g)/seed**	0.304**	0308**	0.464**	0.552**	-0.192	-0.823**
4. **Lint yield (g)/plant** and **lint percentage**	0.311**	0.329**	0.566**	0.757**	0.037	-0.310
5. **Lint yield (g)/plant** and **seed index (g)**	0.124*	0.118*	-0.091	-0.242	-0.299	-1.266**
6. **Bolls/plant** and **seeds/boll**	0.007	0.006	-0.001	-0.045	-0.111	0.250
7. **Bolls/plant** and **lint (g)/seed**	0.135*	0.138*	0.101	0.184	-0.389	-0.926**
8. **Bolls/plant** and **lint percentage**	0.176**	0.196**	0.350*	0.570**	-0.111	-0.468
9. **Bolls/plant** and **seed index (g)**	0.022	0.011	-0.280	-0.416**	-0.401	-1.252**
10. **Seeds/boll** and **lint (g)/seed**	-0.181**	-0.181**	-0.402**	0.034	-0.307	-0.298
11. **Seeds/boll** and **lint percentage**	-0.025	-0.033	-0.224	-0.198	-0.186	-0.007
12. **Seeds/boll** and **seed index (g)**	-0.217**	-0.219**	0.022	0.446**	-0.138	-0.474
13. **Lint (g)/seed** and **lint percentage**	0.693**	0.702**	0.702**	0.670**	0.710**	0.967**
14. **Lint (g)/seed** and **seed index (g)**	0.989**	1.000**	0.378**	0.274	0.502	0.443
15. **Lint percentage** and **seed index (g)**	0.014	0.027	-0.352*	-0.607**	-0.248	0.169

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

Table 25. Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters in S_0, S_1 and S_2 generations for population III (G. 86 open-pollinated).

Relationships	S_0		S_1		S_2	
	r_p	r_g	r_p	r_g	r_p	r_g
1. **Lint yield (g)/plant** and **bolls/plant**	0.920**	0.920**	0.906**	0.912**	0.542	0.437
2. **Lint yield (g)/plant** and **seeds/boll**	0.023	0.022	0.054	-0.057	0.346	0.467
3. **Lint yield (g)/plant** and **lint (g)/seed**	0.279**	0.278**	0.349*	0.280	0.568	1.141**
4. **Lint yield (g)/plant** and **lint percentage**	0.202**	0.201**	0.161	-0.038	0.516	0.989**
5. **Lint yield (g)/plant** and **seed index (g)**	0.203**	0.206**	0.138	0.113	0.441	1.090**
6. **Bolls/plant** and **seeds/boll**	-0.075	-0.077	-0.265	-0.334*	-0.154	-0.423
7. **Bolls/plant** and **lint (g)/seed**	0.086	0.083	0.090	0.069	-0.313	0.106
8. **Bolls/plant** and **lint percentage**	0.063	0.061	-0.078	-0.478**	-0.155	0.223
9. **Bolls/plant** and **seed index (g)**	0.068	0.072	0.117	0.220	-0.334	0.049
10. **Seeds/boll** and **lint (g)/seed**	0.167**	0.173**	-0.055	0.005	0.194	0.713*
11. **Seeds/boll** and **lint percentage**	-0.050	-0.057	0.119	1.069**	0.210	0.843**
12. **Seeds/boll** and **seed index (g)**	-0.160**	-0.172**	-0.131	-0.499**	0.145	0.451
13. **Lint (g)/seed** and **lint percentage**	0.570**	0.573**	0.747**	0.961**	0.752**	0.816**
14. **Lint (g)/seed** and **seed index (g)**	0.808**	0.818**	0.240	-0.046	0.889**	0.946**
15. **Lint percentage** and **seed index (g)**	-0.029	-0.028	-0.062	-0.118	0.358	0.563

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

(1993), Gomaa *et al.* (1999), Younis (2000), Younis *et al.* (2000) and Abo-Sen (2001).

Insignificant correlations between lint yield/plant and seeds/boll were shown in almost all generations for populations I, II and III indicating weak relationship between the two traits. **El-Okkia (1979) and Hassaballa *et al.* (1987)** also reported similar findings.

The phenotypic and genotypic correlations of lint yield with lint/seed increased from F_2 to F_4 and from S_0 to S_2 generations for the three populations except population II which showed increase from F_2 to F_3 only. The change in correlation coefficient form low to high was also observed by **El-Okkia (1979), Younis (1993) and Gooda (2001)**.

Concerning both phenotypic and genotypic correlation coefficients between lint yield and lint percentage, they were positively high and increased from F_2 to F_4 and **from** S_0 to S_2 generations in most studied generations. Similar results were reported by **Younis (2000), Younis *et al.* (2000) and Gooda (2001)**.

Lint yield/plant showed significant positive relationship with seed index in F_2 and S_0 generations of the three populations. This relationship increased from S_0 to S_2 in population III, while decreased from F_2 to F_4 in population II. Regarding pseudo-genotypic correlation coefficients (-1.266 and 1.090) these were due to lower values of genotypic variances (σ^2_g of seed index) than genotypic covariances in both population II and III. These results coincided with those reported by **El-Kilany (1976) and Singh *et al.* (1985)**.

Bolls/plant showed low negative or positive association with seeds/boll and seed index in most generations of the three studied populations. **EL-Kilany (1976)** also found that genetic associations between bolls/plant and seeds/boll were negative and minor to the extent that would make them mutually incompatible in a selection program.

The phenotypic and genotypic correlations between bolls/plant and each of lint/seed and lint percentage were positive and either moderate or low in magnitude in most studied generations. The result obtained here was similar to those obtained by **El-Kilany (1976), Singh *et al.* (1985) and El-Harony (1999a)**.

Generally, seeds/boll exhibited negative associations with each of lint/seed, lint percentage and seed index in F_2, F_3, S_0 and S_1 generations of the three populations. On the other hand, this relationship changed in relation to F_4 generation for population I, due to seed index showing large increase from F_3 to F_4, while seeds/boll exhibited slight decrease from F_3 to F_4 (Table 16). **Kittock and Pinkas (1975), Okasha (1998) and Gooda (2001)** found that the phenotypic and genotypic correlations between seeds/boll and each of lint/seed, lint percentage and seed index were negative and low in magnitude.

In the three studied populations, the phenotypic and genotypic correlations between lint/seed and each of lint percentage and seed index were positive and highly significant for most studied generations. Similar results were reported by **El-Kilany (1970), Singh *et al.* (1985), Okasha (1998), Gooda (2001) and Abdel-Zaher and Nagib (2002)**.

Lint percentage was negatively significant or insignificant associated with seed index in most generations for the three populations. **Singh *et al.* (1985) and El-Harony (1999a)** also reported similar findings.

4.2.1.4. The phenotypic weights (b's)

Phenotypic weights for various indices used in the selection of the three populations are presented in Tables 26, 27 and 28. Phenotypic weights for lint yield (b_w) were positive for the four selection indices involving lint yield character in F_3, F_4 and S_1, S_2 generations in the three populations. The phenotypic weights for bolls/plant (b_1) were consistently positive in all indices of the three populations except selection indices involving lint yield (I_{w123} and I_{w1}) in both populations I and III. The weights of seeds/boll (b_2) and lint/seed (b_3) varied in both magnitude and sign over different indices, however, the magnitudes of the phenotypic weights in general were increased during selection since the weights of the four characters were higher in F_4 and S_2 compared with F_3 and S_1 generations with some exceptions.

The complete model was used for comparison. Deletion of lint yield (X_w) resulted in major adjustments of phenotypic weights of other yield components to compensate for the loss of this variable. While the deletions of bolls/plant (X_1) and/or seeds/boll (X_2) and/or lint/seed (X_3) had little effects on the magnitude of weights of lint yield. This was related to the extremely small magnitudes of phenotypic weights for these characters in the complete model. These results were in agreement with those

Table 26. Phenotypic weights (b's) for various selection indices constructed in F_3 and F_4 generations of population I (G. 45 x G. 75).

Indices	Lint yield (g)/ plant (Xw) bw		Bolls/plant (X_1) b_1		Seeds/boll (X_2) b_2		Lint (g)/seed (X_3) b_3	
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
I_{w123}	9.6518	13.8326	-1.6274	-2.6582	-0.0039	-0.0174	-0.3754	1.8170
I_{123}	-	-	0.4610	0.5929	0.4934	0.7567	180.4918	250.5009
I_{w1}	9.1813	13.1196	-1.2950	-2.0672	-	-	-	-
I_{w2}	7.5089	10.8845	-	-	1.2034	2.0655	-	-
I_{w3}	7.5218	9.5073	-	-	-	-	244.5754	1800.0780
I_{12}	-	-	0.4583	0.5869	0.4909	0.7214	-	-
I_{13}	-	-	0.4450	0.5566	-	-	182.3809	248.0290
I_{23}	-	-	-	-	0.3422	0.6718	143.9622	183.8151

Table 27. Phenotypic weights (b's) for various selection indices constructed in F_3 and F_4 generations of population II (G. 87 x G. 89).

Indices	Lint yield (g)/plant (Xw) bw		Bolls/plant (X_1) b_1		Seeds/boll (X_2) b_2		Lint (g)/seed (X_3) b_3	
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
I_{w123}	10.2681	0.9047	0.2680	6.8542	-0.2139	0.5919	23.7797	-122.8476
I_{123}	-	-	0.5182	0.4093	0.4363	1.0616	251.0487	-188.9598
I_{w1}	9.6935	0.4826	0.7014	7.2465	-	-	-	-
I_{w2}	9.9397	9.2968	-	-	-1.8254	18.4325	-	-
I_{w3}	9.5232	8.2742	-	-	-	-	822.9589	-5651.1604
I_{12}	-	-	0.5031	0.5668	0.0975	1.6360	-	-
I_{13}	-	-	0.5237	0.3545	-	-	228.1840	-263.8460
I_{23}	-	-	-	-	0.4478	0.4502	218.0112	139.1706

Table 28. Phenotypic weights (b's) for various selection indices constructed in S_1 and S_2 generations of population III (G. 86 open-pollinated).

Indices	Lint yield (g)/plant (Xw) bw		Bolls/plant (X_1) b_1		Seeds/boll (X_2) b_2		Lint (g)/seed (X_3) b_3	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
I_{w123}	9.4953	18.5837	2.4557	-5.8336	0.0444	-0.5200	2.5123	8.6830
I_{123}	-	-	0.6980	0.6847	0.3990	0.7722	45.2623	286.8746
I_{w1}	9.2022	17.7703	2.7700	-5.1727	-	-	-	-
I_{w2}	11.0309	15.2080	-	-	-3.2428	3.7448	-	-
I_{w3}	11.7678	11.3631	-	-	-	-	-2143.3223	4023.2102
I_{12}	-	-	0.6926	0.3834	0.3844	0.2593	-	-
I_{13}	-	-	0.7125	0.7068	-	-	37.3251	247.4956
I_{23}	-	-	-	-	0.3208	1.2285	75.5116	172.4466

obtained by **Walker (1960), El-Kilany (1976), El-Okkia (1979), Younis (1986) and Gooda (2001)**.

4.2.1.5. Predicted and realized genetic advances of lint yield

Table 29 shows predicted and realized genetic advances of lint yield (g)/plant and percent advances estimated from F_3 and F_4 means for different selection procedures in population I (G. 45 x G. 75). The results indicated that the highest predicted genetic advance of F_3 generation for lint yield occurred when selecting for lint/seed with bolls/plant (I_{23}). On the other hand, the lowest predicted genetic advances for lint yield were when selecting for seeds/boll (Ix_2) or lint/seed alone (Ix_3). **El-Okkia (1979)** showed that the selection for yield and the other two yield components (seeds/boll and lint/seed) resulted in reduction of predicted advance.

The highest predicted genetic advance of F_4 generation for lint yield was when selecting for lint yield alone (I_{xw}). The lowest predicted genetic advances for lint yield occurred with the indices I_{w1} and I_{w123}.

The results indicated that overall estimates of predicted genetic advances either as lint (g)/plant or as percentage of generation mean were obviously higher in the F_3 than those of the F_4 generations.

The highest realized genetic advance for lint yield occurred when selecting for lint/seed only (Ix_3). Estimates of phenotypic and genotypic correlation coefficients between lint yield/plant and lint/seed indicated that lint/seed was the most effective yield contributing character and was positively associated with lint yield. On the other hand, the index Ix_1 exhibited lowest realized gain in lint yield/plant but, it was a desirable and a useful value.

Table 29. Predicted and realized genetic advances of lint yield (g)/plant and advances % as estimated from F_3 and F_4 means for different selection procedures in population I (G. 45 x G. 75).

Indices	Genetic advances lint (g)/plant			Advances from generation mean %		
	Realized F_3/F_4	Predicted F_3/F_4	Predicted F_4	Realized % F_3/F_4	Predicted % F_3/F_4	Predicted % F_4
I_{w123}	2.99	2.11	0.12	22.43	17.27	0.78
I_{123}	1.89	3.00	1.21	14.18	24.55	7.86
I_{w1}	2.99	2.17	0.12	22.43	17.76	0.78
I_{w2}	2.99	2.80	0.16	22.43	22.91	1.04
I_{w3}	1.89	3.00	1.10	14.18	24.55	7.14
I_{12}	1.89	2.74	1.08	14.18	22.42	7.01
I_{13}	2.14	2.45	0.90	16.05	20.05	5.84
I_{23}	2.37	4.90	0.94	17.78	40.10	6.10
Ix_w	1.89	2.43	4.04	14.18	19.89	26.23
Ix_1	1.80	2.15	3.14	13.50	17.59	20.39
Ix_2	2.34	0.68	0.40	17.55	5.56	2.60
Ix_3	4.19	1.24	3.09	31.43	10.15	20.06

$\overline{F_3} = 12.22$

$\overline{F_4} = 15.40$

Check mean = 13.33

Predicted and realized genetic advances of lint yield (g)/plant and percentage advance estimated from F_3 and F_4 means for different selection procedures in population II (G. 87 x G. 89) are presented in Table 30. In F_3 generation, the selection index involving seeds/boll and lint/seed (I_{23}) was the most effective in improving lint yield/plant. Direct phenotypic individual character selection for seeds/boll (Ix_2) proved in efficient in improving lint yield in comparison with other selection procedures.

Concerning F_4 generation, the highest predicted genetic advances of lint yield were obtained for both phenotypic individual selection bolls/plant (Ix_1) and lint yield (Ix_3). Direct phenotypic individual trait selection for lint/seed (Ix_3) provided a poor estimate for lint yield improvement due to negative genetic correlation between lint yield and lint/seed in F_4 generation (Table 24).

The indices I_{123} and I_{13} were superior to all selection procedures in amount of realized advance. Therefore, selection based on bolls/plant, seeds/boll and lint/seed is recommended in lint yield improvement for population II (G. 87 x G. 89). On the other hand, the lowest realized genetic advance for lint yield occurred when selecting for lint yield with lint/seed (I_{w3}) due to negative genetic correlation of lint yield with lint/seed in F_4 generation (Table 24).

Predicted and realized genetic advances of lint yield (g)/plant and percent advances estimated from S_1 and S_2 means for different selection procedures in population III (G. 86 open-pollinated) are presented in Table 31. The indices I_{12}, I_{w3}, I_{w2} and I_{123} gave high values of predicted genetic advance in S_1 generation. This may be interpreted on the basis of the kind of association between lint yield/plant and each

Table 30. Predicted and realized genetic advances of lint yield (g)/plant and advances % as estimated from F_3 and F_4 means for different selection procedures in population II (G. 87 x G. 89).

Indices	Genetic advances lint (g)/plant			Advances from generation mean %		
	Realized F_3/F_4	Predicted F_3/F_4	Predicted F_4	Realized % F_3/F_4	Predicted % F_3/F_4	Predicted % F_4
I_{w123}	0.56	1.97	0.57	3.86	12.63	3.28
I_{123}	2.98	2.56	0.84	20.57	16.41	4.84
I_{w1}	0.56	1.98	0.58	3.86	12.69	3.34
I_{w2}	0.56	2.77	0.90	3.86	17.76	5.18
I_{w3}	0.00	2.71	1.45	0.00	17.37	8.35
I_{12}	1.64	2.01	0.08	11.32	12.88	0.46
I_{13}	2.98	2.53	0.81	20.57	16.22	4.67
I_{23}	1.66	5.10	-0.17	11.46	32.69	-0.98
Ix_w	0.56	3.03	4.02	3.86	19.42	23.16
Ix_1	1.64	2.73	4.20	11.32	17.50	24.19
Ix_2	0.04	0.23	1.65	0.28	1.47	9.50
Ix_3	2.27	1.61	-2.92	15.67	10.32	-16.82

$\overline{F}_3 = 15.60$

$\overline{F}_4 = 17.36$

Check mean = 14.49

Table 31. Predicted and realized genetic advances of lint yield (g)/plant and advances % as estimated from S_1 and S_2 means for different selection procedures in population III (G. 86 open-pollinated).

Indices	Genetic advances lint (g)/plant			Advances from generation mean %		
	Realized S_1/S_2	Predicted S_1/S_2	Predicted S_2	Realized % S_1/S_2	Predicted % S_1/S_2	Predicted % S_2
I_{w123}	6.57	3.28	0.43	39.77	19.47	1.88
I_{123}	5.45	4.35	0.68	32.99	25.82	2.98
I_{w1}	6.57	3.26	0.44	39.77	19.35	1.93
I_{w2}	6.57	4.52	0.47	39.77	26.82	2.06
I_{w3}	6.57	4.56	0.53	39.77	27.06	2.32
I_{12}	6.57	4.61	0.37	39.77	27.36	1.62
I_{13}	5.45	4.20	0.63	32.99	24.93	2.76
I_{23}	7.22	1.67	2.07	43.70	9.91	9.07
Ix_w	6.57	3.38	4.39	39.77	20.06	19.24
Ix_1	5.45	3.17	1.53	32.99	18.81	6.70
Ix_2	8.62	-0.13	1.73	52.18	-0.77	7.58
Ix_3	6.29	0.58	4.02	38.08	3.44	17.62

$\overline{S_1} = 16.85$

$\overline{S_2} = 22.82$

Check mean = 16.52

of bolls/plant, seeds/boll and lint/seed (Table 25). The indices Ix_2 and Ix_3 gave low values of predicted genetic advance in S_1 generation that could be due to the rather negative and/or low genetic correlation of lint yield with seeds/boll and lint/seed (Table 25).

The highest predicted genetic advances of lint yield were achieved by the indices Ixw and Ix_3. On the other hand, the indices I_{w123} and I_{12} gave lowest values of predicted genetic advances in S_2 generation. These results are in good agreement with those obtained by **El-Okkia (1979), Al-Rawi and Ahmed (1984), El-Kilany (1986), Mahdy *et al.* (1987a), Younis (1999) and Gooda (2001)**.

In general, the results indicated that overall estimates of predicted genetic advances were higher in F_3 and S_1 than those of the F_4 and S_2 generations. This is not in parallel with the magnitudes of phenotypic and genotypic variances in these generations.

All selection procedures indices in population III gave high values of realized genetic advances. This may be due to the unexpected favourable environmental conditions prevailing in 2002 season which resulted in high actual yield for this material.

Deviations of the realized advance from the predicted for lint yield/plant using different selection procedures in the three populations are presented in Table 32. These deviations were positive and high for all indices in population III. Selection indices I_{w123}, I_{w1}, I_{w2}, Ix_2 and Ix_3 in population I result in the realized advance that is higher than the predicted. While the indices I_{123}, I_{13} and Ix_3 gave high value of realized advances in population II. There was very close agreement between predicted and realized advance of lint yield in population I with using

Table 32. Deviations of realized advance from predicted advance for lint yield/plant using different selection procedures in the three populations.

Indices	Population I (G. 45 x G. 75) F_3/F_4	Population II (G. 87 x G. 89) F_3/F_4	Population III (G. 86 open-pollinated) S_1/S_2
I_{w123}	+0.88♦	-1.41	+3.29
I_{123}	-1.11	+0.42	+1.10
I_{w1}	+0.82	-1.42	+3.31
I_{w2}	+0.19	-2.21	+2.05
I_{w3}	-1.11	-2.71	+2.01
I_{12}	-0.85	-0.37	+1.96
I_{13}	-0.31	+0.45	+1.25
I_{23}	-2.53	-3.44	+5.55
Ix_w	-0.54	-2.47	+3.19
Ix_1	-0.35	-1.09	+2.28
Ix_2	+1.66	-0.19	+8.75
Ix_3	+2.95	+0.66	+5.71

♦ The deviations of realized advance from predicted advance are given as lint gram per plant.

the indices I_{w2}, I_{13}, Ix_w and Ix_1. While those of using the indices I_{123}, I_{12}, I_{13}, Ix_2 and Ix_3 in population II were in very close agreement for lint yield. The close agreement between predicted and realized responses to selection indices may be due to the non additive effects (dominance, epistasis and interactions) which were relatively of minor importance and the additive genetic effects would appear to be predominant. On the other hand, there was disagreement between predicted and realized advance in lint yield when using the various models of selection indices for population III. Such large discrepancies between predicted and realized gains did not raise doubt as to the validity of the general theory of selection index.

4.2.1.6. Correlated response to selection for lint yield and unselected traits

Predicted and realized responses to selection obtained from using twelve different selection procedures for lint percentage and seed index in the three populations are given in Tables 33, 34 and 35.

As shown in Table 33, the indices I_{23}, Ix_3, Ixw and I_{13} gave high values of predicted advances for lint percentage in F_3 generation, while the indices Ix_3, I_{23} and I_{13} exhibited positive values of predicted advance for seed index. The highest predicted advances for both lint percentage and seed index in F_4 generation were obtained by using Ix_3 and Ix_2, respectively. There was close agreement between the predicted and realized responses for lint percentage obtained from most selection procedures. On the other hand, there was disagreement between predicted and realized responses for seed index obtained from all indices. The large discrepancies between predicted and realized gains were expected

Table 33. Predicted and realized responses to selection using twelve different selection procedures as estimated from F_3 and F_4 means for lint percentage and seed index in population I (G. 45 x G. 75).

Indices	Lint percentage						Seed index (g)					
	Realized F_3/F_4	Predicted F_3/F_4	Predicted F_4	Realized % F_3/F_4	Predicted % F_3/F_4	Predicted % F_4	Realized F_3/F_4	Predicted F_3/F_4	Predicted F_4	Realized % F_3/F_4	Predicted % F_3/F_4	Predicted % F_4
I_{w123}	1.07	0.49	0.13	3.10	1.44	0.38	2.35	-0.039	0.024	26.80	-0.43	0.21
I_{123}	0.87	0.34	0.10	2.52	1.00	0.29	2.25	-0.028	0.006	25.66	-0.31	0.05
I_{w1}	1.07	0.50	0.13	3.10	1.47	0.38	2.35	-0.041	0.024	26.80	-0.46	0.21
I_{w2}	1.07	0.64	0.16	3.10	1.89	0.46	2.35	-0.057	0.031	26.80	-0.63	0.28
I_{w3}	0.87	0.33	0.10	2.52	0.97	0.29	2.25	-0.027	0.005	25.66	-0.30	0.04
I_{12}	0.87	0.26	0.06	2.52	0.77	0.17	2.25	-0.037	0.005	25.66	-0.41	0.04
I_{13}	0.94	1.01	0.15	2.72	2.98	0.43	2.37	0.012	0.021	27.02	0.13	0.19
I_{23}	1.03	2.01	0.14	2.98	5.92	0.40	2.45	0.073	0.130	27.94	0.81	1.16
Ixw	0.87	1.03	1.02	2.52	3.03	2.95	2.25	-0.111	0.345	25.66	-1.23	3.07
Ix_1	0.75	0.89	1.00	2.17	2.62	2.89	1.88	-0.161	-0.006	21.44	-1.79	-0.05
Ix_2	-0.04	-0.26	-1.05	-0.12	-0.77	-3.03	2.11	-0.140	0.595	24.06	-1.56	5.30
Ix_3	1.34	1.25	1.51	3.88	3.68	4.36	2.44	0.149	0.265	27.82	1.66	2.36

Generation means of lint percentage $F_3 = 33.94$, $F_4 = 34.60$ — Generation means of seed index $F_3 = 8.99$, $F_4 = 11.22$

Check mean of lint percentage $= 34.55$ — Check mean of seed index $= 8.77$

Table 34. Predicted and realized responses to selection using twelve different selection procedures as estimated from F_3 and F_4 means for lint percentage and seed index in population II (G. 87 x G. 89).

Indices	Lint percentage						Seed index (g)					
	Realized F_3/F_4	Predicted F_3/F_4	Predicted F_4	Realized % F_3/F_4	Predicted % F_3/F_4	Predicted % F_4	Realized F_3/F_4	Predicted F_3/F_4	Predicted F_4	Realized % F_3/F_4	Predicted % F_3/F_4	Predicted % F_4
I_{w123}	-0.43	0.28	-0.09	-1.35	0.82	-0.26	1.44	-0.012	-0.031	17.12	-0.14	-0.31
I_{123}	-0.34	1.07	-0.12	-1.06	3.12	-0.35	1.06	-0.034	-0.027	12.60	-0.39	-0.27
I_{w1}	-0.43	0.28	-0.10	-1.35	0.82	-0.29	1.44	-0.013	-0.031	17.12	-0.15	-0.31
I_{w2}	-0.43	0.39	-0.11	-1.35	1.14	-0.32	1.44	-0.017	-0.047	17.12	-0.19	-0.47
I_{w3}	0.36	0.94	-0.10	1.13	2.74	-0.29	1.24	-0.053	-0.006	14.74	-0.60	-0.06
I_{12}	-0.25	0.36	-0.08	-0.78	1.05	-0.23	1.65	-0.110	-0.082	19.62	-1.25	-0.82
I_{13}	-0.34	1.07	-0.13	-1.06	3.12	-0.38	1.06	-0.039	-0.026	12.60	-0.44	-0.26
I_{23}	1.27	4.72	1.59	3.98	13.75	4.62	1.00	0.277	0.039	11.89	3.15	0.39
Ixw	-0.43	1.34	-0.39	-1.35	3.90	-1.13	1.44	-0.117	-0.307	17.12	-1.33	-3.07
Ix_1	-0.25	1.01	-0.63	-0.78	2.94	-1.83	1.65	-0.201	-0.325	19.62	-2.29	-3.25
Ix_2	-0.36	-0.18	-0.01	-1.13	-0.52	-0.03	1.34	0.112	-0.101	15.93	1.28	-1.01
Ix_3	0.85	1.14	1.11	2.66	3.32	3.22	0.78	0.128	0.092	9.27	1.46	0.92

Generation means of lint percentage $F_3 = 34.33$
$F_4 = 34.42$
Check mean of lint percentage $= 31.93$

Generation means of seed index $F_3 = 8.78$
$F_4 = 9.99$
Check mean of seed index $= 8.41$

Table 35. Predicted and realized responses to selection using twelve different selection procedures as estimated from S_1 and S_2 means for lint percentage and seed index in population III (G. 86 open-pollinated).

Indices	Lint percentage						Seed index (g)					
	Realized S_1/S_2	Predicted S_1/S_2	Predicted S_2	Realized % S_1/S_2	Predicted % S_1/S_2	Predicted % S_2	Realized S_1/S_2	Predicted S_1/S_2	Predicted S_2	Realized % S_1/S_2	Predicted % S_1/S_2	Predicted % S_2
I_{w123}	0.14	-0.002	0.03	0.36	-0.01	0.08	1.47	0.000	0.012	16.44	0.00	0.11
I_{123}	-1.08	-0.055	0.72	-2.81	-0.14	1.87	1.48	0.012	0.013	16.55	0.13	0.12
I_{w1}	0.14	-0.002	0.03	0.36	-0.01	0.08	1.47	0.000	0.012	16.44	0.00	0.11
I_{w2}	0.14	-0.002	0.03	0.36	-0.01	0.08	1.47	0.000	0.013	16.44	0.00	0.12
I_{w3}	0.14	-0.003	0.04	0.36	-0.01	0.10	1.47	0.000	0.014	16.44	0.00	0.13
I_{12}	0.14	-0.004	0.02	0.36	-0.01	0.05	1.47	0.000	0.005	16.44	0.00	0.05
I_{13}	-1.08	-0.063	0.60	-2.81	-0.16	1.56	1.48	0.013	0.011	16.55	0.14	0.10
I_{23}	0.20	0.327	0.13	0.52	0.85	0.34	1.53	0.021	0.012	17.11	0.22	0.11
Ixw	0.14	-0.020	1.28	0.36	-0.05	3.33	1.47	0.087	0.731	16.44	0.92	6.67
Ix_1	-1.08	-0.270	0.23	-2.81	-0.70	0.60	1.48	0.173	0.026	16.55	1.83	0.24
Ix_2	0.83	0.400	0.92	2.16	1.04	2.39	1.84	-0.265	0.255	20.58	-2.80	2.33
Ix_3	0.51	0.330	0.85	1.32	0.86	2.21	2.24	-0.022	0.523	25.06	-0.23	4.77

Generation means of lint percentage $S_1 = 38.40$, $S_2 = 38.46$
Check mean of lint percentage $= 38.50$

Generation means of seed index $S_1 = 9.45$, $S_2 = 10.96$
Check mean of seed index $= 8.94$

because genotypic variances and covariances used to calculate predicted gains were likely biased by certain genotypic x environment interaction. Similar results were obtained by **Culp and Harrell (1975), Singh *et al.* (1986), Mahdy *et al.* (1987a), Younis (1993) and Gooda (2001)**.

As shown in Table 34, the index involving bolls/plant and lint/seed (I_{23}) showed the highest predicted and realized responses for lint percentage. Most selection procedures gave high values of predicted advance for lint percentage. However, with all selection procedures except index I_{23}, predicted responses were in agreement with the realized ones for lint percentage in population II.

Also, in population II, the predicted advance of seed index was negative for most indices in both generations. In general, the realized responses for seed index were greater than the predicted with all indices.

As shown in Table 35, the results indicated close agreement between the predicted and the realized responses in S_1 of population III for lint percentage of majority selection indices. The predicted responses of lint percentage in most different selection procedures were higher in S_2 than S_1 generation.

The direct selection for bolls/plant exhibited the highest expected gain of 1.83% in seed index relative to S_1 mean. Concerning S_2 generation, direct selection for lint yield/plant exhibited the highest expected gain of 6.67% in seed index. The realized responses for seed index were greater than the predicted with all indices.

4.2.2. Recurrent selection

4.2.2.1. Mean performance and mean square estimates

All possible mating among four selections of the highest lint percentage and four selections of the highest seed index were made of each population to produce desirable recombinations. Mean performance of the eight selected plants used in recurrent selection for lint yield and its components in the three populations are presented in Table 36. In population I, selection for lint percentage gave high means for both lint percentage and lint/seed, but the mean of selected parents for seed index was high for lint yield/plant, bolls/plant, seeds/boll and seed index. Concerning population II, selection for lint percentage gave high means for lint yield/plant, bolls/plant, lint/seed and lint percentage, the mean of selected parents for seed index was high for seeds/boll and seed index. In population III, selection for lint percentage gave high means for lint yield/plant, bolls/plant and lint percentage, the mean of selected parents for seed index was high for seeds/boll, lint/seed and seed index.

Table 37 shows mean square estimates for lint yield and its components of recurrent selection in the three populations. Mean squares of genotypes were highly significant for lint yield and its components at the three populations except seeds/boll in population III. Original parents mean squares were significant for lint percentage in both population I and II, and lint/seed in population I. Mean squares of selected parents were highly significant for lint yield and its components in populations I and II, while these mean squares were highly significant for lint percentage and seed index in population III. Random

Table 36. Mean performance of the eight selected plants used in recurrent selection for the studied characters of populations I, II and III.

Populations	Parents	No.	Lint yield/ plant (g)	Bolls/plant	Seeds/boll	Lint/seed (g)	Lint percentage	Seed index (g)
Population I (G. 45 x G. 75)	Selected for lint percentage	1	32.6	35	18.6	0.050	38.0	8.2
		2	22.1	21	17.8	0.059	39.7	8.9
		3	38.4	39	18.6	0.053	38.1	8.6
		4	13.9	15	16.8	0.055	38.6	8.8
	Mean		26.8	28	18.0	0.054	38.6	8.6
	Selected for seed index	1	33.8	31	18.8	0.058	34.7	10.9
		2	25.7	30	18.2	0.047	30.3	10.9
		3	23.2	18	20.8	0.062	35.2	11.4
		4	46.4	58	18.2	0.044	33.9	10.9
	Mean		32.3	34	19.0	0.053	33.5	11.0
Population II (G. 87 x G. 89)	Selected for lint percentage	1	46.6	44	19.6	0.054	38.4	8.6
		2	20.9	20	18.0	0.058	40.5	8.5
		3	23.9	21	19.6	0.058	38.5	9.3
		4	43.5	39	18.6	0.060	40.1	8.9
	Mean		33.7	31	19.0	0.058	39.4	8.8
	Selected for seed index	1	37.9	37	21.8	0.047	31.7	10.1
		2	19.0	23	19.2	0.043	30.1	10.1
		3	30.1	26	18.4	0.063	37.1	10.6
		4	24.3	28	17.0	0.051	33.3	10.2
	Mean		27.8	29	19.1	0.051	33.1	10.3
Population III (G. 86 open-pollinated)	Selected for lint percentage	1	26.4	29	14.0	0.065	41.3	9.2
		2	25.6	23	17.4	0.064	41.2	9.2
		3	38.9	33	17.6	0.067	41.3	9.5
		4	30.6	30	18.2	0.056	41.7	7.8
	Mean		30.4	29	16.8	0.063	41.4	8.9
	Selected for seed index	1	18.2	18	15.8	0.064	37.7	10.6
		2	17.9	14	18.8	0.068	39.3	10.5
		3	35.8	30	17.8	0.067	38.8	10.5
		4	22.0	18	17.2	0.071	40.1	10.6
	Mean		23.5	20	17.4	0.068	39.0	10.6

Table 37. Mean square estimates for the studied characters of recurrent selection in the three populations.

Populations	S.O.V.	d.F	Lint yield/plant (g)	Bolls/plant	Seeds/boll	Lint/seed (g)	Lint percentage	Seed index (g)
Population I (G. 45 x G. 75)	Replications	2	6.408	54.610	4.325	0.00001	0.316	0.158
	Genotypes	(39)	37.460**	144.222**	4.588**	0.00015**	15.629**	3.279**
	Original parents	1	54.602	3.082	0.240	0.00052**	54.602**	0.540
	Selected parents	7	64.627**	152.410**	8.188**	0.00007*	11.640**	3.726**
	Random samples	1	0.135	22.427	2.282	0.00003	1.500	0.007
	Hybrids	27	31.243*	153.318**	3.992**	0.00014**	16.716**	3.070**
	Hybrid Vs. original parent	1	92.449*	312.107**	5.041	0.00042**	13.620**	3.878*
	Hybrid Vs. selected parent Hybrid	1	16.427	1.886	1.761	0.00020*	0.097	7.714**
	Vs. random sample	1	1.380	78.700	4.524	0.00060**	6.894	6.761**
	Error	78	15.859	42.837	1.928	0.00003	1.930	0.965
Population II (G. 87 x G. 89)	Replications	2	9.944	12.104	1.810	0.00001	0.421	0.048
	Genotypes	(39)	70.9923**	194.038**	3.378**	0.00013**	9.847**	3.066**
	Original parents	1	0.082	12.327	0.015	0.00007	8.882*	0.082
	Selected parents	7	100.412**	269.317**	4.832**	0.00022**	16.192**	3.984**
	Random samples	1	0.882	0.482	0.082	0.000002	5.607	0.540
	Hybrids	27	73.910**	204.845**	3318**	0.00012**	9.133**	3.170**
	Hybrid Vs. original parent	1	10.902	49.207	1.844	0.00005	1.170	0.622
	Hybrid Vs. selected parent Hybrid	1	45.296	2.156	5.622*	000018**	4.159	3.710**
	Vs. random sample	1	13.085	87.269	0.783	0.00009*	4.276	1.134
	Error	78	32.677	67.328	1.370	0.00002	1.979	0.425
Population III (G. 86 open-pollinated)	Replications	2	49.017	55.715	1.001	0.00005	1.226	0.383
	Genotypes	(39)	74.506**	67.985**	2.215	0.00009**	2.802**	2.507**
	Original parents	1	9.627	61.440	0.002	0.00007	0.882	1.127
	Selected parents	7	25.690	28.930	2.687	0.00004	4.536**	1.652**
	Random samples	1	51.627	13.202	1.815	0.00001	2.535	0.082
	Hybrids	27	80.200**	71.262**	2.411	0.00011**	2.693*	3.087**
	Hybrid Vs. original parent	1	17.620	20.983	0.138	0.000002	0.912	0.075
	Hybrid Vs. selected parent Hybrid	1	480.208**	420.006**	0.427	0.0000004	0.465	0.167
	Vs. random sample	1	1.440	9.189	0.086	0.00004	0.008	1.393
	Error	78	24.645	26.264	1.524	0.000023	1.473	0.558

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

samples mean squares were not significant for all studied characters at the three populations.

Hybrid mean squares were highly significant for lint yield and its components in the three populations except seeds/boll in population III. Mean squares of hybrid vs original parent as an indication to average heterosis overall hybrids were significant for lint yield/plant, bolls/plant, lint/seed, lint percentage and seed index in population I only. Mean squares of hybrid vs selected parent were significant for lint/seed and seed index in population I, seeds/boll, lint/seed and seed index in population II, lint yield/plant and bolls/plant in population III. Hybrid vs random sample mean squares were significant for lint/seed in populations I and II, and seed index in population I only. These results may be due that some hybrids were superior and others were inferior compared to original parents, selected parental lines and random samples.

4.2.2.2. Genetic variability and predicted genetic advance

Estimates of variance components, phenotypic and genotypic coefficients of variation and predicted genetic advances for lint yield and its components of recurrent selection according to hybrids data in the three populations are presented in Table 38. Both phenotypic and genotypic variances were significant and large in magnitude for all studied characters in the three populations except seeds/boll in population III. The increase in phenotypic and genotypic variances in the three populations is due to new recombinations which create substantial genetic variation. These results are in same line with that obtained by **Manning (1963), Mahdy (1983), Younis (1986) and Ahmmed and Mehra (2000)**.

Table 38. Estimates of phenotypic (σ^2_p) and genotypic (σ^2_g) variances, phenotypic (PCV) and genotypic (GCV) coefficients of variation and predicted genetic advance for studied characters of recurrent selection according to hybrids data in the three populations.

Populations	Characters	σ^2_p	σ^2_g	PCV %	GCV %	Predicted (unit)	Predicted (%)
Population I (G. 45 x G. 75)	1. Lint yield/plant (g)	10.414*	4.939	18.54	12.76	3.15	18.09
	2. Bolls/plant	51.106**	35.628	32.67	27.28	10.27	46.94
	3. Seeds/boll	1.331*	0.595	7.03	4.70	1.06	6.46
	4. Lint/seed (g)	0.000045**	0.000037	13.15	11.93	0.01	19.61
	5. Lint percentage	5.572**	4.946	7.02	6.61	4.32	12.85
	6. Seed index (g)	1.023**	0.808	10.08	8.96	1.65	16.45
Population II (G. 87 x G. 89)	1. Lint yield/plant (g)	24.637*	11.723	26.57	18.33	4.87	26.07
	2. Bolls/plant	68.282**	40.327	34.39	26.43	10.05	41.82
	3. Seeds/boll	1.106**	0.656	6.52	5.02	1.28	7.94
	4. Lint/seed (g)	0.000041**	0.000036	12.81	12.00	0.01	20.00
	5. Lint percentage	3.044**	2.389	5.09	4.51	2.82	8.23
	6. Seed index (g)	1.057**	0.950	10.65	10.10	1.90	19.69
Population III (G. 86 open-pollinated)	1. Lint yield/plant (g)	26.733**	18.272	22.01	18.20	7.28	30.99
	2. Bolls/plant	23.754**	14.989	21.54	17.11	6.34	28.02
	3. Seeds/boll	0.804	0.217	5.63	2.92	0.50	3.14
	4. Lint/seed (g)	0.000037**	0.000030	9.22	8.30	0.01	15.15
	5. Lint percentage	0.898*	0.374	2.46	1.59	0.81	2.10
	6. Seed index (g)	1.029**	0.844	9.62	8.71	1.71	16.21

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

The estimates of phenotypic and genotypic coefficients of variation (PCV % and GCV%) were large in magnitude for all the studied characters in the three populations except for seeds/boll and lint percentage in population III. This indicates that the magnitude of the genetic variability which persisted in these materials was sufficient for providing rather substantial amounts of improvement through the selection of superior hybrids. Also, the data indicated slight discrepancy between PCV and GCV for seeds/boll, lint/seed, lint percentage and seed index in the three populations, as well as lint yield and bolls/plant in population III. The same results were recorded by **Al-Jibouri *et al.* (1958), Galal (1960), Seyam (1977), El-Okkia (1979), Singh *et al.* (1985), Mahdy *et al.* (1987a), Mahdy *et al.* (1987b), Meena *et al.* (1991), Younis (1993), El-Harony (1999b) and Gooda (2001)**.

Table 38 indicates that the highest predicted genetic advances were achieved for lint yield/plant, bolls/plant, lint/seed and seed index in the three populations. On the other hand, moderate to low predicted genetic advances as percentage of hybrids mean were detected for both seeds/boll and lint percentage in the three populations. High to low values of GCV were found associated with high to low genetic advances in most studied characters in the three populations.

4.2.2.3. Evaluation of recurrent selection hybrids

Table 39 shows means of original parents, selected parental lines, random samples, 28-hybrids, 6-hybrids for lint percentage, 6-hybrids for seed index and 16-hybrids between lint percentage and seed index for lint yield and its component characters in the three populations.

Table 39. Means of the studied characters of recurrent selection in the three populations.

Populations	Character / Estimate	Lint yield/ plant (g)	Bolls/plant	Seeds/boll	Lint/seed (g)	Lint percentage	Seed index (g)
Population I (G. 45 x G. 75)	P_1 (Giza 45)	10.33	13.70	15.27	0.050	32.17	10.57
	P_2 (Giza 75)	16.37	15.13	15.67	0.069	38.20	11.17
	F_4 Random samples	16.92	18.13	15.52	0.061	34.73	11.13
	8- Selected parental lines	16.48	22.20	16.11	0.048	33.70	9.39
	28-Hybrids	17.41	21.88	16.42	0.051	33.62	10.03
	6-Hybrids for lint percentage	14.71	17.81	16.64	0.050	35.01	9.36
	6-Hybrids for seed index	18.29	21.07	16.49	0.055	33.12	10.98
	16- Hybrids between lint percentage and seed index	18.10	23.72	16.30	0.050	33.30	9.93
Population II (G. 87 x G. 89)	P_1 (Giza 87)	17.40	22.50	15.50	0.050	33.50	9.87
	P_2 (Giza 89)	17.17	19.63	15.60	0.057	35.93	10.10
	F_4 Random samples	17.15	20.08	15.75	0.055	35.13	10.10
	8- Selected parental lines	17.12	24.37	15.58	0.047	33.79	9.20
	28-Hybrids	18.68	24.03	16.12	0.050	34.26	9.65
	6-Hybrids for lint percentage	17.65	19.59	17.33	0.053	35.92	9.38
	6-Hybrids for seed index	18.01	24.12	15.65	0.049	32.88	9.95
	16- Hybrids between lint percentage and seed index	19.31	25.66	15.85	0.050	34.15	9.64
Population III (G. 86 open-pollinated)	P_1 (Giza 86 pure)	26.53	27.77	16.07	0.062	37.70	10.23
	P_2 (Giza 86 open-pollinated)	24.00	21.37	16.10	0.069	38.47	11.10
	S_2 Random samples	24.00	21.35	16.05	0.069	38.45	11.05
	8- Selected parental lines	18.42	17.89	15.78	0.066	38.33	10.65
	28-Hybrids	23.49	22.63	15.93	0.066	38.49	10.55
	6-Hybrids for lint percentage	23.48	23.41	16.07	0.063	38.83	9.93
	6-Hybrids for seed index	25.37	24.01	15.90	0.067	38.34	10.79
	16- Hybrids between lint percentage and seed index	22.79	21.83	15.88	0.067	38.41	10.69

In population I, the 28-hybrids resulted in higher means of lint yield/plant, bolls/plant and seeds/boll compared with the better parent. Six-hybrids for lint percentage resulted in higher means of seeds/boll and lint percentage compared with 6-hybrids for seed index and 16-hybrids between lint percentage and seed index. Six-hybrids for seed index exceeded means for lint yield/plant, lint/seed and seed index compared with 6-hybrids for lint percentage and 16-hybrids between lint percentage and seed index. Sixteen-hybrids between lint percentage and seed index resulted in higher means of bolls/plant compared with rest hybrids. These results indicated that selection for seed index in this population was more important than selection for lint percentage in improving lint yield.

In population II, mean performance of twenty eight-hybrids was higher than of better parent mean for lint yield/plant, bolls/plant and seeds/boll. Six-hybrids for lint percentage showed high means of seeds/boll, lint/seed and lint percentage, while 6-hybrids for seed index exhibited high mean of seed index only. Both lint yield and bolls/plant showed high means in 16-hybrids between lint percentage and seed index. These results indicated that selection from hybrids between lint percentage and seed index in this population was more efficient than selection from both hybrids for lint percentage and for seed index. **Meredith and Bridge (1973)** found that a modified form of recurrent selection for lint percentage, which is also highly correlated with yield, can result in yield increases.

In population III, the 28-hybrids resulted in higher means of lint/seed, lint percentage and seed index compared with Giza 86 pure line. Six-hybrids for lint percentage showed high means of seeds/boll and lint percentage, while 6-hybrids for seed index exhibited high means of lint yield/plant, bolls/plant, lint/seed and seed index. These results indicated that selection for seed index in population III was more efficient than selection for lint percentage in improving lint yield.

Generally, this could explain that the superiority of hybrids in lint yield and its components is due to the existence of average heterosis contributed by the particular set of parents used in hybrids and specific heterosis that occurs when a given parent is mated (hybrid) to other parent. Also, using recurrent selection in each population increases the frequency of favourable genes so that the populations and population crosses are improved with each selection cycle. In this phase recombination of desirable characters should be increased **(Opondo and Pathak, 1982)**.

Mean performances of lint yield and its components for recurrent selection hybrids in the three populations are presented in Tables 40, 41 and 42. The superior parental lines for lint percentage were from P_1 to P_4 and those for seed index from P_5 to P_8.

Regarding population I (Table 40), only one hybrid (P_3 x P_7) showed significant positive increase for lint yield/plant over selected parents mean and better parent mean. The hybrids P_2 x P_8, P_3 x P_7, P_4 x P_7 and P_7 x P_8 exhibited significant positive increases for bolls/plant over selected parents mean and better parent mean. The best hybrids which exhibited the high performance for both lint yield and bolls/plant were a combination among selection for lint percentage and selection for seed index, except the hybrid P_7 x P_8. Three hybrids (P_2 x P_4, P_2 x P_7 and P_4 x P_5) exhibited significant positive increases for seeds/boll over the better parent, while only two hybrids out of them showed significant positive increases for this character over selected parents mean.

Table 40. Mean performances of recurrent selection hybrids for lint yield and its components in population I (G. 45 x G. 75).

Hybrids \ Characters	Lint yield/ plant (g)	Bolls/ plant	Seeds/ boll	Lint/ seed (g)	Lint percentage	Seed index (g)
$P_1 \times P_2$	16.50	18.23	16.57	0.055	36.97*	9.27
$P_1 \times P_3$	12.50	19.73	14.70	0.045	33.33	8.97
$P_1 \times P_4$	13.03	14.50	15.33	0.058*	34.57	11.00*
$P_1 \times P_5$	18.10	25.47	15.07	0.053	34.20	10.07
$P_1 \times P_6$	15.07	15.17	17.27	0.058*	33.93	11.33*
$P_1 \times P_7$	17.13	24.63	15.63	0.047	33.60	9.40
$P_1 \times P_8$	16.70	22.83	15.17	0.050	36.13*	8.73
$P_2 \times P_3$	14.03	15.30	17.70	0.052	36.90*	8.83
$P_2 \times P_4$	16.10	18.30	18.97*+	0.047	35.43	8.57
$P_2 \times P_5$	19.47	19.73	16.33	0.061*	35.87	10.90
$P_2 \times P_6$	17.33	21.63	16.07	0.050	34.37	9.57
$P_2 \times P_7$	20.57	22.50	18.57*+	0.049	35.87	8.83
$P_2 \times P_8$	20.63	34.13*+	16.43	0.037	26.13	10.37
$P_3 \times P_4$	16.10	20.77	16.60	0.047	32.83	9.53
$P_3 \times P_5$	13.47	15.57	15.53	0.055	32.87	11.20*
$P_3 \times P_6$	13.80	16.53	16.57	0.052	31.97	10.93
$P_3 \times P_7$	25.73*+	34.20*+	16.37	0.047	33.70	9.30
$P_3 \times P_8$	16.33	19.73	16.00	0.052	34.13	10.00
$P_4 \times P_5$	20.73	21.57	18.17+	0.053	34.30	10.13
$P_4 \times P_6$	13.60	18.17	17.10	0.045	31.73	9.50
$P_4 \times P_7$	22.73	45.57*+	14.87	0.035	30.00	8.10
$P_4 \times P_8$	18.17	22.03	15.67	0.054	33.93	10.57
$P_5 \times P_6$	15.93	16.57	17.20	0.056	33.53	11.10*
$P_5 \times P_7$	15.97	15.93	16.73	0.060*	35.13	11.00*
$P_5 \times P_8$	16.47	16.30	17.60	0.057*	35.30	10.57
$P_6 \times P_7$	20.27	21.33	16.27	0.057*	33.23	11.47*
$P_6 \times P_8$	22.07	22.87	16.83	0.058*	32.70	11.87*
$P_7 \times P_8$	19.03	33.40*+	14.33	0.040	28.80	9.87
$\bar{x}$	17.41	21.88	16.42	0.051	33.62	10.03
Selected parents mean	16.48	22.20	16.11	0.048	33.70	9.39
$\bar{x}$ of better parent	16.37	15.13	15.67	0.069	38.20	11.17
L.S.D. 0.05	6.47	10.63	2.26	0.009	2.26	1.60

* Significant at 0.05 level of probability was of the difference among the hybrid mean and selected parents mean.

\+ Significant at 0.05 level of probability was of the difference among the hybrid mean and original better parent mean.

Table 41. Mean performances of recurrent selection hybrids for lint yield and its components in population II (G. 87 x G. 89).

Characters / Hybrids	Lint yield/ plant (g)	Bolls/ plant	Seeds/ boll	Lint/ seed (g)	Lint percentage	Seed index (g)
P_1 x P_2	22.63	24.27	18.57*+	0.050	33.40	10.03
P_1 x P_3	18.07	20.00	16.60	0.054*	35.80	9.73
P_1 x P_4	7.33	9.23	17.17	0.048	36.13*	8.40
P_1 x P_5	12.00	15.47	15.40	0.051	35.00	9.47
P_1 x P_6	15.67	18.47	15.73	0.055*	33.57	10.83*
P_1 x P_7	14.37	16.00	15.83	0.057*	35.60	10.27*
P_1 x P_8	23.90	31.17	17.27	0.045	35.93	8.00
P_2 x P_3	13.63	14.30	16.97	0.056*	36.20*	9.87
P_2 x P_4	14.67	14.43	17.60*+	0.057*	37.40*	9.60
P_2 x P_5	22.07	49.00*+	14.27	0.032	31.77	6.93
P_2 x P_6	23.60	28.17	16.60	0.051	33.60	10.10
P_2 x P_7	18.17	21.53	15.73	0.055*	33.23	10.93*
P_2 x P_8	21.10	28.30	16.93	0.045	34.07	8.80
P_3 x P_4	29.57*+	35.30	17.10	0.050	36.57*	8.63
P_3 x P_5	19.23	31.63	15.00	0.040	33.20	8.13
P_3 x P_6	18.10	22.27	15.37	0.055*	34.47	10.37*
P_3 x P_7	29.47*+	34.33	15.13	0.058*	36.30*	10.20
P_3 x P_8	19.40	21.93	16.03	0.055*	35.40	10.10
P_4 x P_5	18.13	28.43	14.33	0.045	32.97	9.17
P_4 x P_6	17.77	27.93	15.87	0.041	30.87	9.07
P_4 x P_7	23.47	23.40	16.50	0.061*	34.97	11.40*+
P_4 x P_8	12.60	12.57	17.57*+	0.058*	35.53	10.47*
P_5 x P_6	19.03	25.77	15.70	0.048	31.50	10.30*
P_5 x P_7	18.50	24.93	14.73	0.051	30.87	11.33*+
P_5 x P_8	12.67	16.43	16.70	0.047	33.63	9.23
P_6 x P_7	20.00	26.27	15.33	0.051	34.50	9.63
P_6 x P_8	17.87	25.60	15.23	0.046	33.03	9.30
P_7 x P_8	20.00	25.73	16.20	0.051	33.77	9.90
$\overline{X}$	18.68	24.03	16.12	0.050	34.26	9.65
Selected parents mean	17.12	24.37	15.58	0.047	33.79	9.20
$\overline{X}$ of better parent	17.40	22.50	15.60	0.057	35.93	10.10
L.S.D. 0.05	9.29	13.33	1.90	0.007	2.29	1.06

* Significant at 0.05 level of probability was of the difference among the hybrid mean and selected parents mean.

\+ Significant at 0.05 level of probability was of the difference among the hybrid mean and original better parent mean.

Table 42. Mean performances of recurrent selection hybrids for lint yield and its components in population III (G. 86 open-pollinated).

Characters / Hybrids	Lint yield/ plant (g)	Bolls/ plant	Seeds/ boll	Lint/ seed (g)	Lint percentage	Seed index (g)
P_1 x P_2	22.87	24.27	17.00	0.056	39.40	8.70
P_1 x P_3	15.23	15.70	16.47	0.059	39.60	9.00
P_1 x P_4	24.50	24.47	17.10	0.060	38.77	9.43
P_1 x P_5	23.10	32.17*	14.13	0.051	36.80	8.80
P_1 x P_6	19.07	18.40	17.50	0.060	38.73	9.47
P_1 x P_7	31.17*	26.20	16.43	0.072	38.73	11.50
P_1 x P_8	30.73*	25.80	16.10	0.074*	38.63	11.70
P_2 x P_3	25.07	24.20	15.80	0.065	38.57	10.37
P_2 x P_4	25.63	26.37*	15.13	0.065	38.47	10.37
P_2 x P_5	22.37	21.03	15.97	0.068	39.27	10.50
P_2 x P_6	9.63	9.60	16.20	0.063	37.83	10.43
P_2 x P_7	27.47*	24.23	16.50	0.068	39.00	10.63
P_2 x P_8	29.43*	27.63*	16.10	0.067	39.27	10.30
P_3 x P_4	27.60*	25.43	14.93	0.072	38.20	11.70
P_3 x P_5	23.87	22.90	15.13	0.069	39.17	10.70
P_3 x P_6	16.87	15.27	16.43	0.068	40.10	10.10
P_3 x P_7	21.67	17.97	16.47	0.073	38.57	11.53
P_3 x P_8	20.33	18.57	16.27	0.067	38.47	10.77
P_4 x P_5	24.47	21.63	15.43	0.072	38.17	11.73
P_4 x P_6	20.03	18.13	15.53	0.072	38.73	11.30
P_4 x P_7	21.87	21.50	15.23	0.069	36.57	11.93*
P_4 x P_8	22.60	28.17*	14.67	0.056	36.57	9.70
P_5 x P_6	22.23	23.97	14.27	0.066	36.73	11.33
P_5 x P_7	35.43*+	29.60*	16.77	0.071	38.73	11.27
P_5 x P_8	21.10	25.37	14.77	0.056	39.03	8.77
P_6 x P_7	21.97	19.47	16.37	0.070	37.17	11.70
P_6 x P_8	22.87	19.83	15.87	0.073	38.77	11.60
P_7 x P_8	28.63*	25.80	17.37	0.066	39.60	10.10
$\overline{X}$	23.49	22.63	15.93	0.066	38.49	10.55
Selected parents mean	18.42	17.89	15.78	0.066	38.33	10.65
$\overline{X}$ of better parent	26.53	27.77	16.10	0.069	38.47	11.10
L.S.D. 0.05	8.07	8.33	2.01	0.008	1.97	1.21

* Significant at 0.05 level of probability was of the difference among the hybrid mean and selected parents mean.

\+ Significant at 0.05 level of probability was of the difference among the hybrid mean and original better parent mean.

Regarding lint/seed, seven out of the twenty eight hybrids exhibited significant positive increases for such trait over selected parents mean only. Three hybrids (P_1 x P_2, P_1 x P_8 and P_2 x P_3) showed significant positive increases for lint percentage over the selected parents mean only. With regard to seed index, seven out of the twenty eight hybrids were surpassed the selected parents mean and manifested significant positive increases.

In population II (Table 41), only two hybrids (P_3 x P_4 and P_3 x P_7) showed significant positive increases for lint yield/plant over selected parents and better parent means. The hybrid P_2 x P_5 exhibited significant positive increase for bolls/plant over the selected parents mean and better parent. Concerning seeds/boll, the three hybrids (P_1 x P_2, P_2 x P_4 and P_4 x P_8) showed significant positive increases over the selected parents mean and the better parent. Eleven out of the twenty eight hybrid combinations were over the selected parents mean exhibited significant positive increases for lint/seed. Five hybrids (P_1 x P_4, P_2 x P_3, P_2 x P_4, P_3 x P_4 and P_3 x P_7) were over the selected parents mean and manifested significant positive increases for lint percentage. These results indicated that selection for lint percentage in this population was more efficient than selection for seed index in improving lint percentage. With regard to seed index, eight out of the twenty eight hybrid combinations exhibited significant positive increases over the selected parents mean, while only tow hybrids (P_4 x P_7 and P_5 x P_7) out of them appeared significant positive increases for this character over the better parent.

In population III (Table 42), seven out of the twenty eight hybrids showed significant positive increases for lint yield/plant relative to the selected parents mean, while only one hybrid (P_5 x P_7) out of them exhibited significant over the better parent. Regarding bolls/plant, five hybrids (P_1 x P_5, P_2 x P_4, P_2 x P_8, P_4 x P_8 and P_5 x P_7) appeared significant positive increases over the selected parents mean only. No useful increases were found to be significant over the better parent and selected parents mean for both seeds/boll and lint percentage. The best hybrids which exhibited significant positive increases for lint/seed (P_1 x P_8) and lint percentage (P_4 x P_7) were the combinations among selections of lint percentage and seed index.

Generally, an examination of the individual hybrids for the lint yield and its components revealed that certain hybrids significantly exceeded their respective selected parents and better parents. The same findings were obtained by **El-Kilany and El-Shishtawy (1986), Mahdy *et al.* (1987a) and Singh *et al.* (1989)**.

4.2.2.4. Phenotypic and genotypic correlation

Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters of recurrent selection for the three populations are presented in Table 43.

Phenotypic and genotypic correlations between lint yield/plant and bolls/plant were positive and significant, indicating that bolls/plant was more important in improving lint yield. Similar results were reported by **Walker (1960), Singh *et al.* (1985), Hassaballa *et al.* (1987), El-Okkia *et al.* (1989), Younis (1993), Gomaa *et al.* (1999), Younis (2000), Younis *et al.* (2000) and Abo-Sen (2001)**.

Both lint yield/plant with seeds/boll and seeds/boll with seed index in the three populations showed insignificant positive or

Table 43. Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters of recurrent selection according to hybrids data for the three populations.

Relationships \ Populations	Population I (G. 45 x G. 75)		Population II (G. 87 x G. 89)		Population III (G. 86 open-pollinated)	
	r_p	r_g	r_p	r_g	r_p	r_g
1. **Lint yield (g)/plant** and **bolls/plant**	0.739**	0.711**	0.785**	0.646**	0.799**	0.773**
2. **Lint yield (g)/plant** and **seeds/boll**	0.027	0.071	-0.077	-0.012	0.060	-0.039
3. **Lint yield (g)/plant** and **lint (g)/seed**	-0.236	-0.348	-0.069	-0.019	0.359	0.470*
4. **Lint yield (g)/plant** and **lint percentage**	-0.244	-0.379*	-0.038	-0.037	0.086	0.113
5. **Lint yield (g)/plant** and **seed index (g)**	-0.080	-0.069	-0.054	-0.005	0.305	0.408*
6. **Bolls/plant** and **seeds/boll**	-0.403*	-0.496**	-0.433*	-0.558**	-0.314	-0.420*
7. **Bolls/plant** and **lint (g)/seed**	-0.744**	-0.870**	-0.605**	-0.716**	-0.192	-0.165
8. **Bolls/plant and lint percentage**	-0.611**	-0.720**	-0.387*	-0.510**	-0.190	-0.196
9. **Bolls/plant** and **seed index (g)**	-0.402*	-0.442*	-0.465*	-0.538**	-0.123	-0.124
10. **Seeds/boll** and **lint (g)/seed**	0.258	0.554**	0.342	0.494**	0.147	0.196
11. **Seeds/boll** and **lint percentage**	0.365	0.598**	0.515**	0.761**	0.596**	1.318**
12. **Seeds/boll** and **seed index (g)**	0.007	0.155	0.047	0.105	-0.096	-0.162
13. **Lint (g)/seed** and **lint percentage**	0.657**	0.680**	0.582**	0.572**	0.144	0.039
14. **Lint (g)/seed** and **seed index (g)**	0.663**	0.640**	0.805**	0.838**	0.924**	0.960**
15. **Lint percentage** and **seed index (g)**	-0.114	-0.128	-0.018	0.009	-0.261	-0.250

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

negative r_p and r_g. **El-Okkia (1979)** showed a weak negative and inconsistent phenotypic and genotypic associations between lint yield and seeds/boll characters for the three studied generations. **Kittock and Pinkas (1975) and Okasha (1998)** reported that the increase in seeds/boll was concomitant with decreased mean seed weight.

Lint yield/plant with lint/seed and seed index exhibited weak negative phenotypic and genotypic associations in populations I and II, while r_g was significant and positive in population III. These results indicated that seed index was associated with lint/seed in influencing lint yield in the three populations. **El-Harony (1999a)** found that phenotypic and genotypic correlation coefficients of lint yield had high to moderate positive values with all characters except seed index. On the other hand, **Zeina (2002)** found that r_p and r_g of lint yield had high positive values with seed index. Table 39 indicates that selection for seed index in population III was more important to improve lint yield.

Bolls/plant was significant or insignificant and negatively associated with seeds/boll, lint/seed, lint percentage and seed index for the three populations. **El-Kilany (1976) and Singh *et al.* (1985)** also reported similar findings.

In populations I and II, the genotypic correlations between seeds/boll and lint/seed were positively and highly significant, but in population III it was positive and insignificant.

Generally, seeds/boll exhibited positive and significant associations with lint percentage in the three populations. The pseudo-genotypic correlation coefficient (1.318) between seeds/boll and lint percentage in population III was due to lower values of genotypic variance for seeds/boll and lint percentage than the genotypic covariances. Thus, breeding procedures (recurrent selection) have been successful in breaking negative linkage between seeds/boll and lint percentage can be adopted. Similar conclusions were found by **Smith and Coyle (1997)**. The correlations of seeds/boll with lint/seed and lint percentage in recurrent selection hybrids tended to increase compared to any other selection procedure.

Lint/seed showed positively and highly significant associations with lint percentage and seed index in the three populations. These results indicated that selection for both lint percentage and seed index was more important in improving lint/seed. Our results are similar to those obtained by **El-Kilany (1970), Singh** ***et al.*** **(1985), Okasha (1998), Gooda (2001) and Abdel-Zaher and Nagib (2002)**.

Lint percentage was insignificantly and negatively associated with seed index in the three populations except r_g in population II. **Zeina (2002)** found that lint percentage with seed index showed highly significant negative values for both phenotypic and genotypic correlation coefficients.

4.2.3. Comparative efficiency of the different selection procedures

Predicted and actual relative efficiencies for different selection procedures for improving lint yield (g)/plant as estimated from F_4 and S_2 in the three populations are shown in Table 44.

In population I, the ranks of expected relative efficiencies relative to selection for lint yield alone (Ixw) in F_3 generation were 201.65% for I_{23}, 123.46% for I_{123}, 123.46% for I_{w3}, 115.23% for I_{w2} and 112.76% for I_{12}. On the other hand, the direct phenotypic selection procedure for lint yield only (Ixw) was superior to the other selection procedures in F_4 generation. The ranks of actual relative efficiencies relative to selection for lint yield alone (Ixw) were 274.60% for recurrent selection, 221.69% for Ix_3, 158.20% for I_{w123}, 158.20% for I_{w1}, 158.20% for I_{w2}, 125.40% for I_{23}, 123.81% for Ix_2 and 113.23% for I_{13}. This indicates that the recurrent selection method was more efficient than the other selection procedures in improving lint yield due to the enhanced genetic variability provided by the recurrent selection compared to selection index. Similar results were obtained by **Ali (1977), Mahdy (1983) and Younis (1986)**.

Concerning population II, the selection index involving seeds/boll and lint/seed (I_{23}) was more efficient than the other selection procedures in F_3 generation. Both recurrent selection and index Ix_1 were more efficient than the other selection procedures in F_4 generation. The ranks of actual relative efficiencies relative to selection for lint yield alone (Ixw) were 550.00% for recurrent selection, 532.14% for I_{123}, 532.14% for I_{13}, 405.36% for Ix_3,

Table 44. Predicted and actual relative efficiencies for the different selection procedures for improving lint yield (g)/plant as estimated from F_4, and S_2 in the three populations.

Populations	Selection procedures	Actual advance F_3/F_4 (S_1/S_2)		Predicted advance F_3/F_4 (S_1/S_2)		Predicted advance F_4 (S_2)	
		i	ii %	i	ii %	i	ii %
Population I (G. 45 x G. 75)	I_{w123}	2.99	158.20	2.11	86.83	0.12	2.97
	I_{123}	1.89	100.00	3.00	123.46	1.21	29.95
	I_{w1}	2.99	158.20	2.17	89.30	0.12	2.97
	I_{w2}	2.99	158.20	2.80	115.23	0.16	3.96
	I_{w3}	1.89	100.00	3.00	123.46	1.10	27.23
	I_{12}	1.89	100.00	2.74	112.76	1.08	26.73
	I_{13}	2.14	113.23	2.45	100.82	0.90	22.28
	I_{23}	2.37	125.40	4.90	201.65	0.94	23.27
	Ix_w	1.89	100.00	2.43	100.00	4.04	100.00
	Ix_1	1.80	95.24	2.15	88.48	3.14	77.72
	Ix_2	2.34	123.81	0.68	27.98	0.40	9.90
	Ix_3	4.19	221.69	1.24	51.03	3.09	76.49
	Recurrent selection	5.19	274.60	-	-	3.15	77.97
Population II (G. 87 x G. 89)	I_{w123}	0.56	100.00	1.97	65.02	0.57	14.18
	I_{123}	2.98	532.14	2.56	84.49	0.84	20.90
	I_{w1}	0.56	100.00	1.98	65.35	0.58	14.43
	I_{w2}	0.56	100.00	2.77	91.42	0.90	22.39
	I_{w3}	0.00	0.00	2.71	89.44	1.45	36.07
	I_{12}	1.64	292.8	2.01	66.34	0.08	1.99
	I_{13}	2.98	532.14	2.53	83.50	0.81	20.15
	I_{23}	1.66	296.43	5.10	168.32	-0.17	-4.23
	Ix_w	0.56	100.00	3.03	100.00	4.02	100.00
	Ix_1	1.64	292.86	2.73	90.10	4.20	104.48
	Ix_2	0.04	7.14	0.23	7.59	1.65	41.04
	Ix_3	2.27	405.36	1.61	53.14	-2.92	-72.64
	Recurrent selection	3.08	550.00	-	-	4.87	121.14
Population III (G. 86 open-pollinated)	I_{w123}	6.57	100.00	3.28	97.04	0.43	9.79
	I_{123}	5.45	82.95	4.35	128.70	0.68	15.49
	I_{w1}	6.57	100.00	3.26	96.45	0.44	10.02
	I_{w2}	6.57	100.00	4.52	133.73	0.47	10.71
	I_{w3}	6.57	100.00	4.56	134.91	0.53	12.07
	I_{12}	6.57	100.00	4.61	136.39	0.37	8.43
	I_{13}	5.45	82.95	4.20	124.26	0.63	14.35
	I_{23}	7.22	109.89	1.67	49.41	2.07	47.15
	Ix_w	6.57	100.00	3.38	100.00	4.39	100.00
	Ix_1	5.45	82.95	3.17	93.79	1.53	34.85
	Ix_2	8.62	131.20	-0.13	-3.85	1.73	39.41
	Ix_3	6.29	95.74	0.58	17.16	4.02	91.57
	Recurrent selection	6.64	101.07	-	-	7.28	165.83

(i) Predicted and actual advances as lint (g)/plant.

(ii%) Predicted and actual advances as a percentage of the response to truncation selection to lint yield only.

296.43% for I_{23}, 292.86% for I_{12} and 292.86% for Ix_1. These results indicted that the recurrent selection, selection index involving seeds/boll and lint/seed (I_{23}) and direct phenotypic selection procedure for bolls/plant were superior to the other selection procedures in population II. **Kamalanathan (1967), El-Kilany (1976) and Gooda (2001)** reported that the selection index involving seeds/boll and lint/seed (I_{23}) ranked first so as to improving lint yield in both generations relative to the higher-yielding parent.

Regarding population III, the ranks of predicted relative efficiencies relative to selection for lint yield alone (Ixw) in S_1 generation were 136.39% for I_{12}, 134.91% for I_{w3}, 133.73% for I_{w2}, 128.70% for I_{123} and 124.26% for I_{13}. Both recurrent selection and direct phenotypic selection procedure for lint yield/plant (Ixw) were superior to the other selection procedures in S_2 generation. Phenotypic selection of seeds/boll (Ix_2), index I_{23} and recurrent selection showed the highest percent of actual advance compared with phenotypic selection for lint yield alone (Ixw). **Gooda (2001)** found that the highest predicted and actual advances for lint yield were obtained from using the indices I_{w12}, I_{w2}, Ix_3 and I_{w1} in population II (G. 45 open-pollinated).

4.2.4. Effect of phenotypic selection for seed index on seed characters

Estimates of means, phenotypic and genotypic variances, phenotypic and genotypic coefficients of variation, heritability, correlation coefficients and actual advance of seed characters in the three populations are presented in Tables 45, 46 and 47.

Table 45. Means, phenotypic (σ^2_p) and genotypic (σ^2_g) variances, phenotypic (PCV) and genotypic (GCV) coefficients of variation, heritability (h^2_b), phenotypic (r_p) correlation coefficients and actual advance as estimated from F_4 of seed characters in population I (G. 45 x G. 75).

Parameters \ Characters		Oil percentage	Seed index (g)	100-Seed volume (cm³)	Seed density (g/cm³)	Heavy seed (%)
Mean	P_1 (G. 45)	25.20	10.57	10.00	1.05	62.17
	P_2 (G. 75)	22.00	11.17	10.67	1.05	67.70
	Random sample	23.80	11.10	11.00	1.00	52.60
	Selected families	23.96±0.634	11.37±0.782	11.11±0.509	1.02±0.039	59.03±10.381
σ^2_p		1.0026	0.0178	0.2592	0.00166	32.6878
σ^2_g		0.6006	0.0000+	0.0000+	0.00016	0.0000+
PCV %		4.18	1.17	4.58	3.99	9.69
GCV %		3.23	-	-	1.24	-
h^2_b		59.90	-	-	9.64	-
rp (with oil percentage)		-	0.848	0.734	-0.709	0.325
Actual advance (unit)		1.890++	0.500+++	0.775+++	-0.030+++	-5.905+++
Actual advance (%)		7.84	4.60	7.50	-2.86	-9.09

\+ Negative value for genotypic variance component.

++ Actual advance of oil percentage estimated from $\bar{F}_3 = 22.07$

$\bar{F}_4 = 23.96$

Check mean = 24.10

+++ Actual advance of other characters estimated from mid-parent.

Table 46. Means, phenotypic (σ^2_p) and genotypic (σ^2_g) variances, phenotypic (PCV) and genotypic (GCV) coefficients of variation, heritability (h^2_b), phenotypic (r_p) correlation coefficients and actual advance as estimated from F_4 of seed characters in population II (G. 87 x G. 89).

Parameters \ Characters		Oil percentage	Seed index (g)	100-Seed volume (cm³)	Seed density (g/cm³)	Heavy seed (%)
Mean	P_1 (G. 87)	23.9	9.87	9.33	1.06	58.60
	P_2 (G. 89)	25.3	10.10	9.67	1.05	66.50
	Random sample	23.7	10.40	9.33	1.12	75.10
	Selected families	23.53±0.764	10.09±0.631	9.33±0.471	1.08±0.018	58.84±8.927
σ^2_p		4.2133*	0.5082	0.4444	0.00214	60.0159
σ^2_g		3.6300	0.1106	0.2222	0.00181	0.0000+
PCV %		8.72	7.07	7.15	4.28	13.17
GCV %		8.10	3.30	5.05	3.94	-
h^2_b		86.16	21.76	50.00	84.58	-
rp (with oil percentage)		-	0.942	0.974	-0.066	-0.138
Actual advance (unit)		0.310++	0.105+++	-0.170+++	0.025+++	-3.710+++
Actual advance (%)		1.26	1.05	-1.79	2.37	-5.93

\+ Negative value for genotypic variance component

++ Actual advance of oil percentage estimated from $\bar{F}_3 = 23.22$, $\bar{F}_4 = 23.53$, Check mean = 24.65

+++ Actual advance of other characters estimated from mid-parent.

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

Table 47. Means, phenotypic (σ^2_p) and genotypic (σ^2_g) variances, phenotypic (PCV) and genotypic (GCV) coefficients of variation, heritability (h^2_b), phenotypic (r_p) correlation coefficients and actual advance as estimated from S_2 of seed characters in population III (G. 86 open-pollinated).

Parameters \ Characters		Oil percentage	Seed index (g)	100-Seed volume (cm^3)	Seed density (g/cm^3)	Heavy seed (%)
Mean	P_1 (G. 86 pure)	18.94	10.23	10.33	1.00	62.70
	P_2 (G. 86 open-pollinated)	18.62	10.93	11.33	0.97	59.63
	Random sample	20.00	11.17	11.00	1.02	72.60
	Selected families	20.42±1.145	11.03±0.151	11.22±0.192	0.99±0.024	61.08±2.414
σ^2_p		7.8048	0.0634	0.4815*	0.00156	46.5248*
σ^2_g		6.4928	0.0406	0.4445	0.00098	40.6978
PCV %		13.68	2.28	6.18	3.99	11.17
GCV %		12.48	1.83	5.94	3.16	10.44
h^2_b		83.19	64.04	92.32	62.82	87.48
rp (with oil percentage)		-	-0.773	-0.958	0.996	0.083
Actual advance (unit)		1.78++	0.450+++	0.390+++	0.005+++	-0.085+++
Actual advance (%)		9.83	4.25	3.60	0.51	-0.14

++ Actual advance of oil percentage estimated from $\overline{S}_1 = 18.64$

$\overline{S}_2 = 20.42$

Check mean = 18.10

+++ Actual advance of other characters estimated from mid-parent.

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

4.2.4.1. Mean performance

Means of the selected families for oil percentage, seed index and 100-seed volume showed useful values over the mid-parent and random sample in population I (Table 45). Means of the selected families for seed index and seed density exhibited increases over mid-parent in population II (Table 46). Means of the selected families for oil percentage and seed index showed increases over mid-parent value and better parent value, while 100-seed volume and seed density exhibited increases over mid-parent value only in population III (Table 47). Phenotypic selection for seed index in F_2 and S_0 generations and for oil percentage in F_3 and S_1 generations afterwards was effective for improving oil percentage due to the presence of transgressive segregation for oil percentage in population III. **El-Ashry (1979) and Narayanan *et al.* (1988)** showed transgressive segregation for seed-oil content and seed-oil index.

4.2.4.2. Genetic variability for seed characters

Residual genetic variability as expressed by σ^2_g and GCV, in general indicates that large magnitude of variability still left in oil percentage and 100-seed volume in populations II and III, and heavy seed percentage in population III. This indicates that the magnitude of the genetic variability which persisted in both population II and III was sufficient for providing rather substantial amounts of improvement in oil percentage through the selection of superior progenies. Some characters exhibited negative genotypic variance component in selected families. These results may be due to the inflated experimental error, which masked the genetic variations and led to inaccurate estimates of genetic parameters and heritabilities.

4.2.4.3. Heritability estimates

High heritability values in broad sense (> 50%) were observed for oil percentage in the three populations, seed index, 100-seed volume and heavy seed percentage in population III, and seed density in populations II and III. Low heritability values in broad sense (< 30%) were found for seed density in population I and seed index in population II. On the other hand, **El-Ashry (1979)** found low heritability values in narrow sense for oil percentage.

4.2.4.4. Phenotypic correlations and actual advances

Oil percentage showed positive and high correlation with seed index and 100-seed volume in populations I and II, and with seed density in population III. On the other hand, oil percentage exhibited negative and high correlation with seed density in population I, with seed index and 100-seed volume in population III. In the three populations, the phenotypic correlations between oil percentage and heavy seed percentage were rather low either positive or negative. These results indicated that seed index and 100-seed volume were the most effective of oil percentage in populations I and II, while seed density was the most effective in population III. **Meena and Deshmukh (1990)** found that the phenotypic correlation coefficient between oil percentage and fuzzy seed index was 0.205 at the genotypic level in *G. hirsutum* and –0.259 in *G. arboreum*.

Both population I and III showed high values of actual advance for oil percentage, seed index and 100-seed volume. As shown in Table 46, the selected families exhibited low values of actual advance for all seed characters. **Pandey (1977), Singh *et al.* (1991), Dani (1999) and Shanthi *et al.* (1999)** showed that there was a significant improvement in seed-oil content and seed-oil index compared to the base populations.