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EFFICIENCY OF TWO BREEDING METHODS FOR IMPROVING SOME TRAITS IN COTTON (*Gossypium barbadense* L.)

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ABSTRACT

Although pedigree selection was and still the breeding procedure that yielded all Egyptian cotton varieties grown commercially, recurrent selection in each population increases the frequency of favorable genes. Therefore, this investigation was carried out at Sakha agricultural research farm during , 2001, 2002 and 2003 growing seasons on the three F_2 populations i.e., Giza 45 x Giza 85, Giza 88 x Menofy and Suvin x Giza 80, to estimate the effectiveness of different selection procedures, and efficiency of repeated crosses within the three populations.

The heritability in broad sense was higher in F_2 and F_4 (> 50 %) than in F_3 for lint yield , but it was high for lint percentage and halo length in the three generations of the three populations. The phenotypic selection for lint percentage (I_1) and halo length (I_3) in F_3 was generally efficient. Improvement in lint yield after phenotypic selection for it (I_2) in two populations; Giza 88 x Menofy and Suvin x Giza 80: was also more fruitful but it was less than that by selection based on lint percentage in population I. The selection criteria (I_3 and I_4) were effective for improving halo length, while selection in early generations for improving lint yield by criterion (I_2) was not effective in population I only. The selection by individual culling level (ICL) procedure (based on three traits, I_4) was more efficient for all traits than either phenotypic individual trait selection procedures . The rank correlations between F_2, F_3 and F_4 were significant and positive for lint percentage and halo length in the three populations. Therefore, the F_2 and F_3 does give some information to F_4 , while insignificant and positive correlation for lint yield provides little information about different generations . The number of superior lines obtained from recurrent selection was higher than that from pedigree selection method. Therefore, inter-mating in early generations followed by selection seems more efficient for changes in gene frequency during selection.

Keywords: *Cotton, Breeding methods, Selection procedures, Selection efficiency, Rank correlation, Recurrent selection*

INTRODUCTION

Different selection procedures i.e., direct phenotypic individual trait selection and independent culling levels selection were used by breeders as criteria for improving lint yield in cotton. Thus hybridization followed by pedigree selection was and still the breeding procedure that yielded all Egyptian cotton varieties grown commercially (Salama *et al* 1992).

Meredith and Bridge (1973) evaluated three selection criteria i.e. high yield (Y), high fiber strength (S) and sampling random (R). Differences in yield, lint percent and fiber length among the three selection types were observed and yield selections produced 5.7% more lint than the random sampling. El-Kilany *et al* (1978) studied three selection methods i.e. direct phenotypic individual trait selection, independent culling levels (ICL) and selection index. The independent culling level procedure was observed to be more efficient in selection relative to direct phenotypic selection, based on the individual traits. Scholl and Miller (1976) found that direct selection for lint yield was predicted to be as effective as it was a correlated response to selection for any of its components. Response of yield to selection for lint percentage was predicted to be as great as direct selection for yield. Predicted change in lint yield as a function of selection for 2.5% span length was negative and substantial.

Yousef and El-Agamy (1980) reported that the pedigree line method was more effective and easier for improving quantitative characters than one cycle of recurrent selection. However, more cycles are needed for improving such traits. Tyagi (1987) suggested that intermitting in early generations followed by selection of desirable segregates may be a useful method for improving yield and quality simultaneously. El-Lawendey (2003) found the superiority of some hybrids in lint yield over better parent in two populations. No increase was found to be significant over better parents for lint percentage and seed index of three populations.

The main objectives of this study were to explore the efficiency of different selection procedures, direct phenotypic individual trait selection and independent culling levels selection. The correlation coefficients between the three generations F_2, F_3 and F_4 and the efficiency of repeated crosses within the three populations.

MATERIAL AND METODS

The present study carried out at the Agricultural Research Station, Sakha ARC, during 2001, 2002 and 2003 growing seasons.

Breeding materials used in the study included three populations:

Giza 45 x Giza 85 (extra long staple cotton variety x long staple variety), Giza 88 x Menofy (extra long staple variety x extra long staple variety) and Giza 80 x Suvin (long staple variety x long staple strain).

In the first season (2001) the three F_2 populations with the original parents were grown in non replicated ridges 7.5 meters long and 60 cm wide. Each ridge contained 15 single-plants hills spaced 50 cm apart. All plants were self pollinated and plants from each population were selected in the field mainly on the basis of number of retained open bolls and productivity. Selfed as well as open pollinated bolls per plant were picked up separately and the total seed cotton yield per plant was ginned and lint yield was determined. Moreover, the characters i.e., lint yield, lint percentage and halo length were determined for F_2 plants.

The 10% superior plants for each character i.e, lint percentage (I1), lint yield (I2), halo length (I3) and 10% superior plants for the three traits (independent culling levels selection) (I4) were selected from each population).

In 2002 season, part of seeds of the F_2 selected plants in the three populations were sown to raise F_3 plants and for evaluation with the corresponding parents. A RBCD with three replications was used, where each progeny was grown in one ridge 4.5 m long. Seeds were sown in hills spaced 30 cm and two plants were left per hill. The remaining sister seed of F_2 selected plants for the three populations were raised to give F_3 plants that were selfed to produce F_4 seeds.

In each F_3 field trial, observations were scored on 15 single plants; five guarded plants per replication were chosen at random. The selection procedures were based on progeny performance in the replicated trials.

The 10% superior progenies of each character i.e., lint yield, lint percentage and halo length, were chosen from each population. The numbers of the best selected progenies were 16, 20 and 23, where some plants represented more than one selection criterion.

In 2003 season, selfed seeds of F_3 plants of the three populations were sown to raise F_4 progenies evaluated with two original parents in a randomized complete block design with three replications.

Estimates of phenotypic and genotypic variances for F_3 and F_4 generations

The variance components from the regular analysis of a randomized complete block design were used to obtain estimates for the phenotypic and genotypic variances as outlined in Tables (1) and (2).

The estimates of variance components were obtained according to the following formula :

$[\sigma^2_p = \sigma^2_g + \sigma^2_e/r + \sigma^2_s/ri,$ $\quad \sigma^2_g = (M_F - M_E)/ri$

$\sigma^2_e = (M_E - M_s)/I$ $\quad \sigma^2_s = Ms$

Where : r = Number of replicates. , i = Number of plants per plot.

Table 1. Analysis of variance of i plants per plot in F_3 of three populations.

S.O.V.	D.F.	Mean squares	Expected mean squares
Replication	(r-1)		
Families	(f-1)	M_F	$\sigma^2_s+i\sigma^2_e+ri\sigma^2_g$
Experimental Error	(r-1)(f-1)	M_E	$\sigma^2_s+i\sigma^2_e$
Sampling error	rf (i-1)	Ms	σ^2_s
Total	(rfi-1)		

Table 2. Analysis of variance on mean plot basis in F4 generation of the three populations.

S.O.V.	D.F.	Mean squares	Expected mean squares
Replication	(r-1)		
Families	(f-1)	M_F	$\sigma^2_e + r\sigma^2_g$
Error	(r-1)(f-1)	M_E	σ^2_e

The estimates of variance components were obtained according to the following formulae:

$\sigma^2_p = \sigma^2_g + \sigma^2_e/r$, $\sigma^2_g = (M_F - M_E)/r$ and $\sigma^2_e = M_E$

Rank correlation coefficient of the three studied traits was calculated using the data of the three successive generations using the formula given by Spearman and mentioned by Kang (1988).

$$r = \frac{1-6\sum d^2}{n\,(n^2-1)} \quad \text{(Spearman's rank correlation)}$$

Efficiency of repeated crosses in the three populations

Seven superior plants from each of the crosses; G. 45 × G. 85, G. 88 × Menofy and G. 80 × Suvin were selected in F_2 for three characters, three plants superior in lint yield, two elite plants having lint percentage and two plants showing the best halo length were selected to produce the first cycle of recurrent selection in 2001 season.

In 2002 season, selfed seeds of the above selected seven F_2 plants were crossed where; the high yielding three plants were used as top parents. It was assumed that yield trait depends on more variable factors than the other traits under study. Finally, 12 hybrids produced were for each population.

In 2003 season, the 12 hybrids for three populations with two original parents were planted in a randomized complete block design with three replications, in a similar manner of spacing as that followed with phenotypic selection.

The studied traits were :

Lint percentage (%), Lint yield (g)/plant, Halo length (mm), Boll weight (g),
Seed index (g), Lint index (g) and Earliness index, as ratio of first pick to total seed cotton yield.

RESULTS AND DISCUSSION.

Means, ranges, phenotypic and genotypic coefficients of variation and heritability estimates in Table (3) showed that the means of F_2 were higher than F_3 and F_4 means for lint yield of the three populations. The differences between generation means were due to wide spacing resulted from skipping

Table 3. Means, ranges, phenotypic (PCV) and genotypic (GCV) coefficients of variation and broad sense heritability (h^2b) in F_2, F_3 and F_4 generations of the three populations.

Traits	Generations	$\overline{X}$	Range	PCV %	GCV %	h^2_b
Population 1 (Giza 45 x Giza 85)						
Lint yield (g)/plant	F_2	15.1	2.6-70.6	73.2	65.8	80.7
	F_3	14.5	9.1-19.7	10.6	4.68	19.5
	F_4	12.6	8.6-17.2	17.4	16.4	94.0
Lint percentage %	F_2	31.6	26.6-40.0	8.13	7.71	89.9
	F_3	36.2	33.4-39.2	3.37	3.03	81.0
	F_4	36.5	34.0-38.1	3.78	3.22	77.0
Halo length (mm)	F_2	34.7	28.5-39.5	6.86	5.93	74.8
	F_3	36.1	32.5-38.6	3.30	3.00	83.0
	F_4	36.2	32.3-37.9	4.43	4.32	94.9
Population II (Giza 88 x Menofy)						
Lint yield (g)/plant	F_2	21.6	2.6-65.5	54.6	48.0	77.3
	F_3	17.3	14.0-23.1	10.8	3.15	8.52
	F_4	12.6	7.90-15.2	14.4	13.0	82.0
Lint percentage %	F_2	30.9	25.2-36.2	6.96	5.93	73.7
	F_3	36.8	35.1-39.1	2.58	1.98	58.9
	F_4	37.7	37.1-39.6	2.61	2.60	99.1
Halo length (mm)	F_2	36.6	28.7-40.2	5.45	4.58	70.6
	F_3	37.9	35.9-39.6	2.24	1.92	73.6
	F_4	36.9	35.0-38.1	2.82	2.80	80.6
Population III (Giza 80 x Suvin).						
Lint yield (g)/plant	F_2	41.1	5.1-90.4	47.0	40.4	73.8
	F_3	17.3	12.2-24.1	14.6	10.3	50.1
	F_4	15.1	8.83-19.6	20.2	19.1	89.1
Lint percentage %	F_2	36.0	28.6-42.3	6.91	4.88	50.0
	F_3	36.5	34.0-40.6	4.33	4.12	90.6
	F_4	37.7	33.2-41.2	7.12	7.06	98.5
Halo length (mm)	F_2	34.6	25.3-39.8	5.32	5.32	63.5
	F_3	35.7	31.3-39.7	5.28	4.94	87.5
	F_4	34.7	28.2-39.5	8.60	8.34	94.1

of one ridge between each two planted ridges in F_2 generation. While the means of lint percentage and halo length of F_2 were lower than F_3 and F_4 generations of the three populations. Similarly, wide ranges in the aforementioned three traits in three populations were shown for F_2 than F_3 and F_4 generations. The results indicated that the means of F_3 were higher than F_4 generation for lint yield. However, El-Lawendey (2003) found that the mean of lint yield increased for F_4 than F_3. This may be due to the adverse environmental effects which is supported by Esmail *et al* (1986).

Similar results were obtained by Mahdy *et al* (1987) who found that the mean of lint yield increased from F_3 to F_4 generation, while an obvious decrease occurred in the F_5.

The results showed that phenotypic and genotypic coefficients of variability were larger in F_2 generation than those of the succeeding generations for all the studied characters of the three populations (Table (3). But, the phenotypic and genotypic coefficients of variability were lower in F_3 than F_4 generations, with the exceptions that both coefficients in F_2 for lint percentage and halo length were lower than that of succeeding generations in population III.

High estimates of heritability in broad sense (>50%) were obtained for lint yield in F_2 and F_4 but it was low in F_3 (19.5%, 8.52% and relatively low (50.1%) in three populations, respectively. Similar results were obtained by Abdel-Hafez *et al* (2003). Heritability estimates were high for lint percentage and halo length in the three populations (Table 3). The results indicated that the heritability estimates in broad sense differed between the three populations and the highest values of heritability were observed in F_4 than the two other generations. Burton (1952) suggested that a genetic coefficient of variation together with heritability would give the best indication of the amount of genetic variance to be expected from selection.

The differences between generations may be due to the various genotypes scored by each selection index, the genetic variability within F_2 plots that would be greater than within F_3 progeny rows, the genotype by environment interactions which may be of large magnitude and the possible considerable dominance gene action present and expressed in an F_2 population which is the one we consider most likely (Meredith and Bridge 1973).

Means, phenotypic and genotypic variances and phenotypic and genotypic coefficients of variation of seven traits for four different selection procedures; I_1: phenotypic selection for lint percentage, I_2: phenotypic selection for lint yield, I_3: phenotypic selection for halo length and I_4: independent culling levels selection exerted on three traits (lint percentage, lint yield and halo length) for three populations are presented in Table (4). Data for the first population reported that in the phenotypic selection on lint percentage (I_1), the mean was higher than that of other selection criteria for lint percentage and lint yield. Therefore, the phenotypic selection (I_1), appeared to be more efficient in selection of best genotypes.

Also, the results showed that σ^2_p, σ^2_g, PCV and GCV for lint percentage were lower than for lint yield and halo length, indicating that the phenotypic selection for lint percentage (I_1) in F_3 was efficient. This was reflected in high heritability estimates for the lint percentage.

Table 4. Means $\overline{X}$, phenotypic (σ^2_p) and genotypic (σ^2_g) variances and phenotypic (PCV) and genotypic (GCV) coefficients of variation for seven traits of the four selection procedures as evaluated from F_3 selected families and their F_4 progenies for population I (Giza 45 x Giza 85).

Selection criteria	Traits	$\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_1	Lint percentage (%)	37.2	2.38	0.6	4.1	2.08
	Lint yield (g)/plant	13.5	6.97**	6.24	19.6	18.5
	Halo length (mm)	35.7	4.24**	4.07	5.76	5.65
	Boll weight (g)	2.66	0.083	0.057	10.8	8.98
	Seed index (g)	10.2	0.217	0.083	4.57	2.82
	Lint index (g)	6.04	0.001	0.043	3.47	0.01
	Earliness index	59.0	13.4	3.53	6.20	3.18
I_2	Lint percentage (%)	36.8	1.15	0.997	2.9	2.7
	Lint yield (g)/plant	12.5	3.57	3.02	15.1	13.9
	Halo length (mm)	35.7	1.20**	1.07	3.06	2.90
	Boll weight (g)	2.75	0.031	0.013	6.44	4.15
	Seed index (g)	10.4	0.118	0.08	3.30	2.72
	Lint index (g)	6.1	0.117*	0.095	5.62	5.05
	Earliness index	58.7	14.4	0	6.46	0
I_3	Lint percentage (%)	35.1	0.85	0.447	2.63	1.90
	Lint yield (g)/plant	11.6	3.68**	3.35	16.5	15.8
	Halo length (mm)	37.1	0.787**	0.734	2.39	2.31
	Boll weight (g)	2.81	0.015	0.003	4.41	1.95
	Seed index (g)	10.6	0.194**	0.162	4.16	3.80
	Lint index (g)	5.8	0.025	0	2.73	0
	Earliness index	57.6	16.7*	12.3	7.09	6.09
I_4	Lint percentage (%)	36.3	0.531	0.323	2.01	1.57
	Lint yield (g)/plant	12.0	2.00**	1.67	11.8	10.8
	Halo length (mm)	36.7	0.507**	0.490	1.94	1.91
	Boll weight (g)	2.79	0.033	0.015	6.51	4.39
	Seed index (g)	10.5	0.071	0.035	2.54	1.78
	Lint index (g)	6.0	0.060	0.039	4.08	3.29
	Earliness index	60.5	7.82	0	4.62	0

I_1 = Based on lint percentage. I_2 = Based on lint yield.
I_3 = Based on halo length. I_4 = Based on three traits (ICL)
0 Negative value for genotypic variance
* and ** significant at 0.05 and 0.01 levels of probability, respectively.

Phenotypic selection based on lint yield (I_2), the mean for lint yield was lower (12.5) than the lint yield when the selection based on lint percentage (13.5). The estimated σ^2_P, σ^2_g, PCV and GCV for lint yield criterion (I_2) were lower than that by other selection criteria except for criterion (I_4). Therefore, selection in early generations to improve lint yield by the criterion (I_2) was not effective and selection in the later generations should be more effective than in early generations.

El-Lawendey (2003) obtained the highest realized genetic advances for lint yield when applied the selection criteria (Ix_3) (phenotypic selection for lint/seed) in one population, index (I_{123}, selection index involving bolls/plant, seeds/boll and lint/seed) in a second population and Ix_2 (phenotypic selection for seeds/boll) was better than Ix_w (phenotypic selection for lint yield/plant).

Phenotypic selection based on halo length (I_3), the mean of lint percentage and lint yield was lower than other selection criteria, but the mean for halo length was high. Estimated σ^2_p, σ^2_g, PCV and GCV for halo length for criterion (I_3) were lower than other selection criteria except for I_4, indicating that the criteria (I_3) and (I_4) were effective for improving halo length.

The data in Table (5), showed that, in population II the mean, σ^2_p, σ^2_g, PCV and GCV for criterion (I_1) were higher than other selection criteria. The increase of variability within criterion I, indicated that the performance of some families for this criterion differed from F_3 to F_4, which may be due to genotype by environment interaction or the effect of dominance gene action if present and expressed in an F_3 population. While, in criterion (I_2), the mean of lint yield was higher than that other selection criteria, but σ^2_p, σ^2_g, PCV and GCV were lower. The results showed that criterion (I_2) can be more efficient in improving and selection to high yield. The results indicated that the means of halo length and lint yield were higher and similar to that for selection criteria i.e., I_2, I_3 and I_4 than those in criterion I.Therefore, the strains with high fiber length should be expected to result in high yielding strains.

The means for I_4 (ICL) were nearly similar with those of all criteria to the same trait, therefore, selection by ICL procedure (I_4) was more efficient than either phenotypic individual trait selection procedure. Similar results were reported by El-Kilany (1978).

The results in Table (6) for population III, cleared that the mean for lint percentage for criterion (I_1) was higher than the others but σ^2_p, σ^2_g, PCV and GCV were low, indicating that the phenotypic expression of these families in F_3 generation were indicative of their genetic behavior, similar to the results reported by criterion (I_2) and criterion (I_3). These findings indicated that selection in early generations was efficient in improving these traits.

The results showed that the differences between trait means were not significant for boll weight and earliness index under all selection criteria, while, and were significant for seed index and lint index under all selection criteria except for criterion I for lint index. This suggests that correlation existed between the two traits and lint percentage, lint yield and halo length.

Table 5. Means($\overline{X}$), phenotypic (σ^2_p) and genotypic (σ^2_g) variances and phenotypic (PCV) and genotypic (GCV) coefficients of variation for seven traits of the four selection procedures as evaluated from F_3 selected families and their F_4 progenies for population II (Giza 88 × Menofy).

Selection criteria	Traits	$\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_1	Lint percentage (%)	38.1	11.4**	9.32	8.87	8.02
	Lint yield (g)/plant	11.2	3.72**	3.37	17.2	16.4
	Halo length (mm)	35.9	1.95**	1.89	3.89	3.83
	Boll weight (g)	3.12	0.070*	0.05	8.48	7.17
	Seed index (g)	10.4	0.14*	0.100	3.50	3.04
	Lint index (g)	6.36	0.071*	0.053	4.20	3.62
	Earliness index	56.9	22.6*	18.6	8.35	7.58
I_2	Lint percentage (%)	37.4	0.947**	0.923	2.60	2.57
	Lint yield (g)/plant	13.8	0.692	0.455	6.03	4.89
	Halo length (mm)	37.4	0.162**	0.150	1.08	1.04
	Boll weight (g)	3.26	0.033	0.009	5.60	2.89
	Seed index (g)	10.6	0.042	0.006	1.93	0.75
	Lint index (g)	6.44	0.116	0.109	5.28	5.13
	Earliness index	57.0	16.01	7.43	7.04	4.78
I_3	Lint percentage (%)	37.6	0.309*	0.248	1.48	1.32
	Lint yield (g)/plant	12.5	2.06*	1.68	11.5	10.4
	Halo length (mm)	37.6	0.106	0.014	0.870	0.31
	Boll weight (g)	3.31	0.008	0.003	2.70	1.65
	Seed index (g)	10.5	0.112	0.057	3.19	2.27
	Lint index (g)	6.32	0.040*	0.030	3.15	2.74
	Earliness index	58.9	18.5	7.53	7.30	4.66
I_4	Lint percentage (%)	37.3	1.49**	1.28	3.28	3.03
	Lint yield (g)/plant	13.0	1.65	0.721	9.88	6.53
	Halo length (mm)	37.3	0.158*	0.117	1.07	0.92
	Boll weight (g)	3.24	0.084	0	8.95	0
	Seed index (g)	10.6	0.080	0.046	2.69	2.02
	Lint index (g)	6.21	0.110*	0.088	5.35	4.78
	Earliness index	57.4	28.4**	24.10	9.28	8.55

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

Table 6. Means, phenotypic (σ^2_p) and genotypic (σ^2_g) variances and phenotypic (PCV) and genotypic (GCV) coefficients of variation for seven traits of the four selection procedures as evaluated from F_3 selected families and their F_4 progenies for population III (Giza 80 × Suvin).

Selection criteria	Traits	$\overline{X}$	σ^2_p	σ^2_g	PCV %	GCV %
I_1	Lint percentage (%)	40.4	0.441*	0.320	1.64	1.40
	Lint yield (g)/plant	14.9	8.79**	8.21	19.9	19.2
	Halo length (mm)	31.5	2.723*	1.884	5.25	4.36
	Boll weight (g)	2.99	0.032	0.001	5.98	1.06
	Seed index (g)	9.62	0.336*	0.251	6.03	5.21
	Lint index (g)	6.51	0.071	0.015	4.09	1.88
	Earliness index	63.8	11.3	4.77	5.27	3.42
I_2	Lint percentage (%)	37.5	4.88**	4.70	5.89	5.78
	Lint yield (g)/plant	16.7	3.46*	2.34	11.1	9.20
	Halo length (mm)	33.8	8.84**	8.27	8.80	8.51
	Boll weight (g)	3.10	0.037	0.006	6.20	2.50
	Seed index (g)	10.5	0.504**	0.452	6.76	6.40
	Lint index (g)	6.27	0.195**	0.165	7.04	6.48
	Earliness index	63.5	6.53	0.80	4.02	1.41
I_3	Lint percentage (%)	35.1	1.909**	1.838	3.94	3.86
	Lint yield (g)/plant	14.5	11.4**	10.6	23.3	22.5
	Halo length (mm)	37.6	1.71**	1.56	3.48	3.32
	Boll weight (g)	3.20	0.116	0.091	10.7	9.43
	Seed index (g)	11.1	0.526**	0.500	6.52	6.35
	Lint index (g)	6.03	0.266**	0.273	8.66	8.55
	Earliness index	65.7	9.13	1.20	4.60	1.67
I_4	Lint percentage (%)	37.2	6.157**	6.091	6.67	6.63
	Lint yield (g)/plant	14.7	11.4**	10.2	23.0	21.7
	Halo length (mm)	36.5	5.07**	4.76	6.17	6.00
	Boll weight (g)	3.13	0.053	0.033	7.36	5.80
	Seed index (g)	10.6	0.577**	0.505	7.16	6.70
	Lint index (g)	6.28	0.321**	0.303	9.02	8.77
	Earliness index	64.7	10.5	0	5.01	0

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

Rank correlation among three generations

Rank correlations between F_2 and F_3, between F_2 and F_4 and between F_3 and F_4 in three populations for the three traits are presented in Table (7). The correlations for lint percentage and halo length were significant and positive but were insignificantly negative for lint yield in population 1.

Table 7. Rank correlation coefficients between generations for selected characters in the three populations.

Traits	Generations	Giza 45 × Giza 85		Giza 88 × Minofy		Giza 80 × Suvin	
		F_3	F_4	F_3	F_4	F_3	F_4
Lint percentage	F_2	0.71**	0.62*	0.58*	0.17	0.58**	0.76**
	F_3	-	0.67*	-	0.25	-	0.74**
Lint yield	F_2	-0.49*	-0.11	0.28	0.31	0.36	0.13
	F_3	-	0.06	-	0.30	-	0.32
Halo length	F_2	0.50*	0.60*	0.53*	0.52*	0.82**	0.81**
	F_3	-	0.78**	-	0.63**	-	0.89**

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

The correlations of lint percentage were significant for F_2 and F_3, while, it were insignificant for F_2 and F_4 and F_3 and F_4. The correlation was insignificant for lint yield, while, it was positively significant for halo length in population II.

The correlation coefficients were highly significant and positive for lint percentage and halo length, while were positive and insignificant for lint yield in population III. The results indicated that the correlation between F_2 and F_3, F_2 and F_4 and F_3 and F_4 were significantly positive for some traits in the three populations. Therefore, the F_2 and F_3 does give some information to F_4 for lint percentage and halo length, while, the insignificant correlation for lint yield provides nothing or little information between different generations. Therefore, the selection in F_2 to improve lint percentage and halo length was effective because the highest plants for the two traits in F_2 were often the highest in later generations, but the highest plants for lint yield in F_2 were not the highest in later generations; F_3 or F_4. Thus, the rank correlation coefficients differs according to the genetic constitution of the trait under study and its interaction with the environment, through the segregating generations. Meredith and Bridge (1973) reported that the most considered and most likely is the existence of considerable dominance gene action

The results of evaluation of families in F_4 generation in the three populations is presented in Table (8). It showed the means of original parents and 16 families in F_4 for seven traits, in population 1. The means of most families were higher than better parent for lint yield, while, means of lint percentage and halo length were insignificantly different as compared to better parent.

Regarding population I, most of the families showed significant positive increase for lint yield over better parent while, some families were similar to the high fiber length of Giza 45 (P_1) and lint percentage of Giza 85 (P_2). Such results, could explain the superiority of some families in lint yield, lint percentage and fiber length. Also, using selection in this population may result in increase of the frequency of favorable genes. In this phase recombination of desirable characters should be increased.

Table 8. Mean performance of F_4 families for seven traits in population I (Giza 45 x Giza 85).

F_4 Families	Lint yield (g/plant)	Lint percentage %	Halo length (mm)	Boll weight (g)	Seed index (g)	Lint index (g)	Ear. index (%)
1	12.7^{+}	35.6	37.5	2.8	10.5	5.8	52.2
2	15.0^{+}	38.1	34.5	2.6	10.7	6.6	55.4
3	10.6	34.0	37.7	2.9	11.4	5.9	59.3
4	8.6	34.0	37.8	2.9	10.8	5.6	52.7
5	14.3^{+}	35.5	36.2	2.7	10.3	5.7	59.8
6	13.0^{+}	37.3	35.2	2.5	10.0	5.9	64.8
7	16.1^{+}	36.7	34.9	2.4	9.9	5.7	55.5
8	12.4^{+}	38.1	32.3	2.4	10.0	6.1	55.6
9	12.1^{+}	37.4	37.2	2.6	10.3	6.2	62.3
10	11.6^{+}	36.1	35.7	2.7	10.2	5.8	59.9
11	11.0	36.8	36.5	2.8	10.7	6.3	58.9
12	12.9^{+}	38.1	34.4	2.7	10.0	6.2	58.0
13	17.2^{+}	37.9	37.9	2.6	9.9	6.0	56.8
14	12.0^{+}	36.7	36.9	3.0	10.9	6.3	60.8
15	12.5^{+}	35.6	37.6	2.9	10.7	5.9	61.7
16	10.2	36.4	37.1	3.1	10.8	6.2	60.3
P_1 (Giza 45)	8.0	32.6	37.0	2.2	9.9	4.8	51.4
P_2 (Giza 85)	9.5	36.4	32.7	3.2	11.0	6.3	57.5
L.S.D. 0.05	2.10	1.86	1.04	-	0.76	0.51	-

+ Significantly higher F_4 families than original better parent at 0.05 level of probability.

The results in Table (9) showed that families of population II contained highly significant or significant variations for all traits indicating the presence of real differences among families, but, all families showed significantly higher than better parent for all traits except for lint yield and seed index. Four families were higher than better parent in lint percentage and six families in halo length. Also, the results indicated that some families had high halo length or high yielding i.e., families 3, 5, 6, 13 and 17. However, low values were obtained among the last five families.

The analysis of variance for 23 families of population III in F_4 Table (10), clearly showed that families exhibited highly significant differences for all traits except for earliness index. The results indicated that five, six and eight families were higher than better parent in lint yield, halo length and seed index, respectively, but no family was higher than better parent in lint percentage and lint index in population III.

Table 9. Mean performance of F_4 families for seven traits in population II (Giza 88 × Menofy).

F_4 Families	Lint yield (g/plant)	Lint percentage %	Halo length (mm)	Boll weight (g)	Seed index (g)	Lint index (g)	Ear. index (%)
1	14.9	38.1	37.2	3.27	10.5	6.57	52.6
2	13.9	38.3	37.0	3.10	10.5	6.63	56.7
3	13.4	35.6	37.6$^+$	3.07	10.6	5.87	64.4$^+$
4	7.9	39.1$^+$	36.6	3.10	10.1	6.43	59.4
5	12.9	37.4	38.1$^+$	3.53$^+$	10.5	6.37	57.7
6	14.1	38.2	38.0$^+$	3.33	10.3	6.47	65.3$^+$
7	12.8	37.8	37.5	3.40	11.0	6.87	55.5
8	10.5	37.0	37.8$^+$	3.27	9.93	5.97	62.8$^+$
9	15.2	38.0	37.2	3.23	10.5	6.47	58.9
10	11.7	37.3	37.2	3.30	10.3	6.33	56.9
11	11.8	35.9	36.6	3.27	10.2	5.70	60.6$^+$
12	11.2	37.1	35.0	3.43	10.6	6.27	56.8
13	12.5	38.1	37.7$^+$	3.43	10.9	6.43	54.2
14	11.9	37.8	37.1	3.20	10.8	6.40	49.0
15	14.9	37.3	37.3	3.17	10.5	6.33	55.4
16	11.9	39.1$^+$	34.4	2.80	10.3	6.63	50.4
17	12.1	37.0	37.7$^+$	3.33	10.7	6.23	55.7
18	13.6	38.5$^+$	37.4	3.27	10.3	6.37	57.3
19	10.2	39.6$^+$	35.0$^-$	2.90	9.87	6.50	56.0
20	14.2	38.0	37.2	3.17	10.6	6.50	58.8
P_1 (Giza 88)	14.3	38.1	37.3	3.17	10.8	6.57	48.6
P_2 (Menofy)	12.7	37.8	36.3	3.10	10.7	6.43	52.7
L.S.D.0.05	2.20	0.267	0.317	0.305	0.578	0.350	7.11

+ Significantly higher F_4 families than original better parent at 0.05 level of probability.

Some families had similarly high halo length and/or high yielding ability i.e., 2, 7, 14, 15 and 23 but were moderate or low for lint percentage. This may be due to insignificant correlation between lint yield and lint percentage and negative and significant correlations between lint percentage and halo length.

Meredith and Bridge (1973) reported that lint percent was increased by selection, while seed index and 2.5% span length were decreased. Quisenberry *et al* (1978) in segregating generation reported an increase in lint yield while, fiber tended to be weaker and coarser with unchanged of fiber length. However, Shaheen *et al* (2000) reported no trend for response to selection in the different segregating generations. For example the response to selection was absent in the F_3 for boll weight and seed index in one population and returned in the expected mean of F_4 generation.

Table 10. Mean performance of F_4 families for seven traits in population III (Giza 80 x Savin).

F_4 Families	Lint yield (g/plant)	Lint percentage %	Halo length (mm)	Boll weight (g)	Seed index (g)	Lint index (g)	Ear. index (%)
1	17.4	35.0	31.1	3.23	10.3	5.57	65.3
2	19.6^+	33.8	38.5^+	3.13	10.5	5.37	70.9
3	15.2	40.8	31.6	2.73	9.20	6.33	61.5
4	12.1	36.1	36.4	2.80	9.80	5.50	64.4
5	10.9	34.2	37.7^+	3.53	12.0^+	6.17	63.5
6	14.0	40.8	32.3	2.90	9.20	6.33	63.7
7	16.2	35.0	37.9^+	2.97	11.8^+	6.33	64.7
8	16.1	38.2	35.1	3.07	9.70	6.00	61.8
9	16.5	39.8	32.9	2.83	9.50	6.30	64.5
10	11.5	40.8	32.4	2.80	9.50	6.57	65.9
11	18.5^+	36.3	36.7	3.40	10.9^+	6.20	68.3
12	12.8	35.0	30.3	3.13	10.9^+	5.83	60.0
13	8.8	41.2	34.7	3.03	9.00	6.30	59.5
14	19.5^+	40.2	36.3	3.13	10.3	6.93	69.3
15	18.9^+	37.8	38.2^+	3.43	10.9^+	6.60	60.1
16	13.2	35.3	35.5	3.20	11.3^+	6.17	67.9
17	17.1	39.4	32.3	2.93	10.4	6.77	67.0
18	13.2	40.9	28.9	3.00	9.13	6.33	69.4
19	16.1	40.4	33.1	3.27	10.2	6.93	60.2
20	18.4^+	39.9	32.6	3.20	10.2	6.77	64.6
21	16.9	36.7	35.1	3.07	10.4	6.00	64.6
22	10.7	33.2	38.5^+	3.23	11.2^+	5.57	63.9
23	14.6	37.3	39.5^+	3.33	11.6^+	6.93	61.9
P_1 (Giza 80)	12.5	42.0	31.6	2.80	9.2	6.63	73.7
P_2 (Savin)	15.0	36.1	35.0	3.10	10.1	5.70	65.6
L.S.D.0.05	2.09	0.93	2.06	0.44	0.70	0.47	-

+ Significantly higher F_4 families than original better parent at 0.05 level of probability.

The results in Table (11) showed means of 12 hybrids and original parents of population 1. Five hybrids (4, 8, 9, 11 and 12) showed significant positive increase for lint yield over better parent and eight hybrids were also significantly higher above the better parent in lint percentage.

No significant increase was found over better parent for halo length. Two hybrids (9 and 12) were similar to the high fiber length of Giza 45 with high yielding ability. Six hybrids (1,2,3,5,6 and 7) were similar to better parent for lint yield intermitting in early generations followed by selection and also, similar to better parent for halo length. Most hybrids had high means over better parent for lint yield and lint percentage while no hybrids were higher than better parent for halo length and other traits.

Table 11. Mean performance of one cycle recurrent selection hybrids traits in population 1 (Giza 45 × Giza 85).

Hybrids	Lint yield (g)/plant	Lint percentage %	Halo length (mm)	Seed index (g)	Lint index (g)	Boll weight (g)
1	9.3	36.7	37.3	9.90	5.73	2.77
2	8.4	37.1	38.1	10.0	5.90	2.80
3	11.3	38.7+	36.0	9.30	5.83	2.67
4	14.0^{+}	39.4+	35.2^{-}	8.80	5.70	2.87
5	8.4	37.2	36.9	9.10	5.40	2.53
6	8.9	38.0^{+}	36.5	9.10	5.57	2.53
7	8.7	38.9^{+}	36.8	9.90	6.33	3.33
8	15.5^{+}	38.4^{+}	35.7	9.70	6.07	2.97
9	18.9^{+}	37.4	36.8	9.80	5.87	3.33
10	12.3	38.7^{+}	35.0	9.90	6.23	2.83
11	15.6^{+}	38.7^{+}	35.5	9.70	6.13	3.00
12	14.8^{+}	38.9^{+}	36.2	8.70	5.50	3.00
P_1 (Giza 45)	8.0	32.6	37.0	9.9	4.8	2.20
P_2 (Giza 85)	9.5	36.4	32.7	11.0	6.3	3.20
L.S.D. 0.05	3.40	1.35	1.20	-	-	0.44

+ Significantly higher hybrids than original better parent at 0.05 level of probability.

Mean performance of lint yield and other traits for recurrent selection hybrids in the population II are presented in Table (12). Four hybrids, one hybrid and four hybrids were higher than better parent for lint yield, lint percentage and halo length, respectively. No significant increase was found over better parent for seed index, lint index and boll weight. Two hybrids were lower than better parent for halo length with high yielding over better parent, rest hybrids were similar with better parent for halo length. Two hybrids (8 and 10) showed significant positive increase for lint yield over better parent with similar means for halo length. There is chance for next cycle to reach properties of the variety Giza 45 with high yielding ability. The superiority of hybrids in any traits may be 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 to other parents. 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).

Table 12. Means of traits of one cycle recurrent selection hybrids traits in population II (Giza 88 × Menofy).

Hybrids	Lint yield (g)/plant	Lint percentage %	Halo length (mm)	Seed index (g)	Lint index (g)	Boll weight (g)
1	15.1	37.4	38.7$^+$	9.97	5.73	3.10
2	12.9	38.6	37.6	10.30	5.90	3.0
3	12.6	39.3$^+$	37.8	9.30	5.83	2.57
4	12.0	38.5	37.1	9.77	5.70	2.70
5	11.9	38.0	39.1$^+$	10.80	5.40	2.80
6	12.5	38.5	37.0	10.80	5.57	3.20
7	15.2	38.7	38.8$^+$	10.00	6.33	2.90
8	22.3$^+$	38.1	37.9	10.00	6.07	2.73
9	14.3	39.8$^+$	38.4$^+$	10.30	5.87	3.10
10	19.1$^+$	37.6	37.7	9.43	6.23	2.60
11	25.9$^+$	36.0	36.3	9.77	6.13	3.10
12	21.3$^+$	36.6	35.9	10.10	5.50	2.83
P_1 (Giza 88)	14.3	38.1	37.3	10.80	6.57	3.17
P_2 (Menofy)	12.7	37.8	36.3	10.70	6.43	3.10
L.S.D. 0.05	3.02	1.24	0.91	0.66	-	0.30

+ Significantly higher hybrids than original better parent at 0.05 level of probability.

Mean performances of hybrids and better parent are shown in Table (13), of population III,. Some hybrids were higher than better parent for lint yield and halo length. Six and four hybrids showed significant positive increase for lint yield and halo length over better parent, respectively. While, all hybrids were lower than better parent for lint percentage except for one hybrid (6) that was similar to better parent. All hybrids were similar to better parent for seed index except for two hybrids (5 and 6). Three hybrids were similar to better parent and rest hybrids were lower for lint index. Intercrossing in early generations with selection for desirable segregates is recommended (Tyagi 1987).

The results indicated that, in case, the original parents or any parent had high performance in some traits i.e., lint percentage and halo length, the means for most hybrids were low or similar with better parent. Thus, the response to selection in high trend for some traits is limited, may be due to number of genes, gene action, effect of individual gene (major or minor genes) and genotype × environment interaction. Also, the parents in population I and III were different. Population I (Giza 45, extra long staple

Table 13. Mean performance of one cycle recurrent selection hybrids traits in population III (Giza 80 × Suvin).

Hybrids	Lint yield (g)/plant	Lint percentage %	Halo length (mm)	Seed index (g)	Lint index (g)	Boll weight (g)
1	12.4	36.1	36.7+	10.2	5.77	2.63
2	18.1	37.1	33.8	9.70	5.77	2.70
3	23.1^{+}	37.3	36.3	10.3	6.37	2.87
4	19.2^{+}	39.4	36.0	9.17	5.97	2.87
5	12.9	40.0	35.1	8.57	5.70	2.50
6	19.8^{+}	42.4	36.9+	8.73	6.43	2.57
7	19.7^{+}	37.5	38.1+	9.43	5.67	2.73
8	16.1	38.9	34.6	9.43	6.03	2.63
9	21.5^{+}	40.1	35.1	9.43	6.33	2.83
10	18.9^{+}	36.9	37.2+	9.90	5.77	3.03
11	17.3	37.0	35.2	9.90	5.83	2.97
12	16.1	37.8	36.1	9.53	5.73	2.97
P_1 (Giza 80)	12.5	42.0	31.6	9.17	6.63	2.80
P_2 (Suvin)	15.0	36.1	35.0	10.1	5.70	3.10
L.S.D. 0.05	3.84	1.42	1.52	0.69	0.31	0.28

+ Significantly higher hybrids than original better parent at 0.05 level of probability.

× Giza 85, long staple and population III (Giza 80, long staple × Suvin, Indian, *barbadense*). But the differences for lint yield were insignificant may be due to the effect of environment. However, there were some hybrids higher than better parent (199% and 154%). In the parents in population II (Giza 88, extra long staple) × Menofy, extra long staple), there were some hybrids higher than better parent (181%, 156%) for lint yield. Patil *et al* (1997) and Smith and Coyle (1997) suggested that inter-mating would be necessary to rule out pleiotropic effect.

The relative number of lines significantly higher or lower than better parent are presented in Table (14). The results showed that, no particular lines appeared to be superior for all traits except for lint yield (75%) in first population I for pedigree method while in recurrent selection, there was 66.7% for lint percentage.

In second population, there were relative number of lines significantly higher than better parent for lint percentage and halo length in pedigree

Table 14. The relative numbers of lines* with significantly higher (H) and lower (L) values than better parent of three populations for the two methods.

Traits	I (Giza 45 × Giza 85)				II (Giza 88 × Menofy)				III (Giza 80 × Suvin)			
	(P)		(R)		(P)		(R)		(P)		(R)	
	H%	L%	H%	L%	H%	L%	H%	L%	H%	L%	H%	L%
Lint percentage	0.0	12.5	66.7	0.0	20	0.0	16.7	16.7	0.0	95.7	0.0	91.7
Lint yield	75.5	0.0	41.7	0.0	0.0	45	33.3	0.0	21.7	17.4	50.0	0.0
Halo length	0.0	37.5	0.0	33.3	25	25	33.3	16.7	26.1	43.5	33.3	0.0
Boll weight	0.0	0.0	0.0	25.0	0.0	5.0	0.0	50.0	0.0	0.0	0.0	67.5
Seed index	0.0	37.5	0.0	0.0	0.0	20.0	0.0	58.3	34.8	13.0	0.0	25.0
Lint index	0.0	25.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	30.4	0.0	75.0

The remaining relative values within each breeding method, population and trait are those not significantly different from better parent at the 5% level of probability.

P = Pedigree selection. , R = Recurrent selection.

selection. For lint yield and halo length percentage, recurrent selection, resulted in more superior lines in three selected traits (lint percentage, lint yield and halo length). While, the unselected traits were lower than better parents. These results indicated the efficiency of the selection to improve different traits.

In population III, insignificantly higher lines than better parent for lint percentage may be due to superiority of the original parent ($\overline{X} = 42.0$) and most lines were lower than better parent in both two methods. While, number of superior line in recurrent selection was higher than in the pedigree method for lint yield and halo length.

In general, the results indicated that intercrossing in early generations with selection for desirable segregates is recommended because recurrent selection increases the frequency of favourable genes in each population.

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كفاءة طريقتين من طرق التربية لتحسين بعض الصفات فى القطن

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على الرغم من أنه مازالت طريقة الانتخاب مع تسجيل النسب هى المتبعة فى تحسين وتربية أصناف القطن المصرية ، فان طريقة الانتخاب المتكرر لها القدرة على زيادة تكرار الجينات المرغوبة، ولهذا أجرى هذا البحث فى محطة البحوث الزراعية بسخا فى الأعوام 2001، 2002 و 2003 ثلاثة عشائر من القطن المصرى هي (جيزة 45 x جيزة 85 ، جيزة 88 x منوفى و سوفين x جيزة 80) وذلك لتقدير مدى فاعلية بعض أسس الانتخاب وكفاءة الهجن المتكررة داخل تلك العشائر.

اتضح من النتائج أن المكافىء الوراثى بالمعنى الواسع كان أعلى فى F_2 و F_4 عن F_3 فى صفة المحصول ولكنه كان عالى بالنسبة لمحصول الحليج وطول التيلة بالنسبة للثلاث عشائر . كان المكافىء الوراثى فى حالة الانتخاب المظهرى على أساس كل من طول التيلة ومعدل الحليج ذا كفاءة فى تحسين تلك الصفات، بينما

كان الانتخاب على أساس المحصول للهجينين (جيزة 88 x منوفى ، سوفين x جيزة 80) ذا كفاءة الا أنه فى حالة الانتخاب على أساس معدل الحليج تم الحصول علي تحسين فى المحصول أعلى من الانتخاب على أساس المحصول نفسه فى العشيرة الأولى (جيزة 45 x جيزة 85).

كان الانتخاب على أساس ثلاث صفات (ICL) ذا كفاءة لتحسين الصفات مع بعضها عن التحسين لكل صفة على حده . ووجد أن معاملات ارتباط الرتب بين F_2 , F_3 , F_4 كانت معنوية وموجبة بين صفتى معدل الحليج وطول التيلة بين جميع الأجيال ولذلك اتضح أن الانتخاب المبكر لتلك الصفتين أعطى معلومات متوقعة عن الجيل الرابع. بينما أعطى قيما غير معنوية موجبه لمعامل الارتباط بين الأجيال لصفة المحصول، وبالتالى فان العائلات ذات المحصول العالى فى الأجيال المبكرة لاتكون بالضرورة ذات محصول عالى فى الجيل الرابع . واتضح أيضا أن الهجن الناتجه من طريقة الانتخاب المتكرر تفوق تلك المتحصل عليها من طريقة تسجيل النسب.

والدراسه توضح أن التهجين ولو لدورة واحدة فى الأجيال المبكرة مع الانتخاب يساعد على زيادة فى تكرارات الجينات المرغوبة أثناء عملية الانتخاب.