IMPROVING LINT YIELD AND ITS COMPONENTS IN EARLY SEGREGATING GENERATIONS OF GIZA 45 X GIZA 75 COTTON CROSS

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Abstract

The present study was conceived in an effort to investigate: 1- The genetic, phenotypic and environmental variances and covariances among traits in an intraspecific population generated from a cross between two Egyptian cotton cultivars, Giza 45 (extra long staple ELS) and Giza 75 (long staple LS). 2- The magnitudes of the genotypic and phenotypic correlations between traits. 3- Compare the relative efficiencies of nine selection procedures measured in terms of the expected and realized response to selection. A field trial was carried out at Sakha Agricultural Research Station, A.R.C., Egypt during 2000-2002 growing seasons. The results indicated that F_4 means were higher than those of F_3 for all studied traits except seeds/boll. Maximum realized genetic advance for lint yield was achieved using the direct phenotypic trait selection for lint/seed (Ix_3). The selection index, I_{23} exhibited the highest predicted genetic advance from F_3 to F_4 for lint yield trait. From F_4 to F_5 the predicted genetic advance of lint yield exhibited maximum values using the index Ixw. Also, maximum predicted responses to selection for lint percentage and seed index in F_4 generation were achieved using the direct phenotypic trait selection for lint/seed and seeds/boll, respectively.

INTRODUCTION

The ultimate aim of cotton breeding programs is to increase yield as well as improving fiber properties. Therefore, in producing cotton varieties higher in yielding capacity and better in technological traits, cotton breeders can be guided in selection programs by selection indices which have received much attention in recent years. Undoubtedly, recent progress in statistical genetics and biometrics helped greatly in the construction and use of these indices. Smith (1936) and Hazel (1943) illustrated the procedure for constructing a selection index that gives maximum advance from selection. Walker (1960) mentioned that the lint yield of spaced individual plants was differentiated into three components viz.: bolls/plant, seeds/boll and lint/seed. El-Kilany (1976) found that seven selection indices and phenotypic individual character selection for lint/seed were efficient selection procedures for improving lint yield in both F_2 and F_3 generations. El-Okkiah (1979) reported that the highest predicted genetic advance for lint yield was achieved by selecting for yield alone. He also reported that selection for yield and two other yield components (seeds/boll and lint/seed) resulted in reduction of predicted advance. Predicted yield advance was decreased following deletion of any one of the two yield components.

The objectives of this study were to obtain information regarding, 1- Phenotypic, genotypic and environmental variances for lint yield and lint components, 2- Magnitude of the phenotypic and genotypic correlations between studied characters, and 3- Relative effectiveness of different selection procedures in improving lint yield.

MATERIALS AND METHODS

Field Procedures:

The present investigation was carried out at Sakha Experimental Farm, Sakha Agricultural Research Station, A.R.C., Egypt, during 2000-2002 growing seasons. The breeding materials used in this study were F_2, F_3 and F_4-generations of an intraspecific population generated from a cross between Giza 45 (extra long staple variety) and Giza 75 (long staple variety). In (2000), the F_2 generation along with the original parents were grown in non-replicated rows 7.5 meters long and 60 cm wide, with one skipped row between each two consecutive planted rows. Each row contained 15 single plants spaced 50 cm apart. All plants were self pollinated and 300 F_2 guarded plants were chosen in the field mainly on the basis of yield productivity. Five percent selection intensity in F_2 gave 15 superior plants for each phenotypic trait selection, viz. i.e., lint yield/plant (Xw), bolls/plant (X_1), seeds/boll (X_2) and lint/seed (X_3). The total selected plants by the four phenotypic traits selection were 50 plants. The selfed seeds for each selected plant was divided into two unequal parts. In 2001, part I of selfed seeds (F_3) were evaluated with the two parents and a random sample of F_3 seeds (bulked seeds). Each selected plant was grown in one row 4.5 meter in length and 60 cm in width, in hills spaced 30 cm and two plants were left per hill at thinning time. The progenies were evaluated in the field trial. The experimental design was randomized complete block design with three replications (R.C.B.D.). The 50 progenies were ranked using nine selection procedures involving the four characters and 10 selected progenies were evaluated with the two parents and a random sample of F_4 (bulked seeds) in RCB design with three replications in 2002. The same agronomic practices in 2001 were applied in 2002 experiment. Selection procedures were as follows:

I_{w123} = Selection index involving lint yield/plant, bolls/plant, seeds/boll and lint/seed.

I_{123} = Selection index involving bolls/plant, seeds/boll and lint/seed.

I_{12} = Selection index involving bolls/plant and seeds/boll.

I_{13} = Selection index involving bolls/plant and lint/seed.

I_{23} = Selection index involving seeds/boll and lint/seed.

I_{xw} = Phenotypic selection for lint yield/plant.

Ix_1 = Phenotypic selection for bolls/plant.

Ix_2 = Phenotypic selection for seeds/boll.

Ix_3 = Phenotypic selection for lint/seed.

The characters scored were: lint yield (g)/plant (X_w), bolls/plant (X_1), seeds/boll (X_2), lint (g)/seed (X_3), lint percentage and seed index (g).

Method of Analysis:

The formula suggested by Smith (1936) and Hazel (1943) was used in calculating various selection indices. The relative economic importance (a_i) was calculated according to Walker (1960). Predicted genetic advance in lint yield was estimated as given Walker (1960) and Miller and Rawlings (1967). The predicted changes in unselected characters were calculated according to Walker (1960). The phenotypic (PCV) and genotypic (GCV) coefficients of variation were estimated using the formula developed by Burton (1952). Phenotypic (r_p) and genotypic (r_g) correlation coefficients were calculated among the studied characters as outlined by Steel and Torrie (1960).

RESULTS AND DISCUSSION

1. Variance components:

Estimates of variance components for lint yield and its components are presented in Table 1. Both phenotypic and genotypic variances were larger in F_2 generation than F_3 and F_4 generations for all studied characters. In F_3 generation, significant phenotypic variances were detected for all studied characters. The phenotypic variances in F_4 generation were higher than F_3 generation for all studied characters except lint percentage. The increase in phenotypic and most genotypic variances in F_4 generation is due to the efficiency of selection procedures in creating substantial genetic variation. This finding is in agreement with those obtained by El-Okkiah (1979) and Gooda (2001). With regard to environmental variances, it is clear that all values with an exception of these pertaining to lint yield and bolls/plant were small in magnitude and would be minor to affect genetic parameters.

Table 1. Estimates of phenotypic, genotypic and environmental variances for lint yield and its components in F_2, F_3 and F_4 generations.

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

*, ** significant at 0.05 and 0.01 levels, respectively.
+ Estimates of phenotypic variance for 300 F_2 plants.

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

F_2 means for lint yield/plant, bolls/plant and seeds/boll (Table 2) were higher than those of the succeeding generations although intensive selection was practiced. Wide ranges in lint yield, bolls/plant and seeds/boll in F_2 generation were noticed compared with those of the other segregating generations. The difference among generation means may be due to the wider spacings between either rows or hills in F_2 than F_3 and F_4 generations, in addition the number of plants/hill differed from one plant/hill in F_2 to two plants per hill in both F_3 and F_4 generations.

PCV% and GCV % were larger in F_2 generation than those of the succeeding generations for all the studied characters. This indicates that, the magnitude of the genetic variability persisting in these material helps the breeder to provide substantial amounts of improvement through the selection of superior progenies. Similar results were obtained by El-Okkiah (1979) and Meena *et al.* (2001).

Comparing means of F_3 generation with those of F_4 generation, it is apparent that the means of F_4 were higher than those of F_3 for all studied characters except seeds/boll. Also, comparing the lowest and highest values of F_3 with those of F_4 (Table 2), it is clear that the lowest and the highest of F_4 surpassed those of F_3 for all studied characters except seeds/boll and lint percentage. This may be attributed to the efficiency of selection procedures applied in this study.

Table 2. 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.

Characters	Generations	Mean $\pm$ S $\overline{X}$	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

Low estimates of PCV% and GCV % in F_3 generation, were detected compared with F_4 ones for lint yield/plant, bolls/plant, seeds/boll and lint/seed. Both lint yield and bolls/plant exhibited the highest estimates of PCV% and GCV%. However, seeds/boll, lint/seed, lint percentage and seed index gave moderate to low variabilities.

Regarding heritability estimates in broad sense (Table 2), high estimates (> 50%) were found for all characters in the three generations except seeds/boll in F_2 and seed index in F_4 generations. However, high heritability estimates were detected from F_3 to F_4 generations for all characters except seed index.

3. 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 generations are presented in Table (3).

The phenotypic and genotypic correlations between lint yield/plant and bolls/plant in the three generations were positive and highly significant indicating that bolls/plant was the most effective yield-contributing variable. Similar results were reported by Abo-Sen (2001). Slight insignificant positive or negative correlations between lint yield/plant and seeds/boll were detected in F_2, F_3 and F_4 generations indicating variable relationship between the two traits. El-Okkiah (1979) and Hassaballa *et al.* (1987) reported similar findings.

The relationship between lint yield and lint/seed changed from low insignificant in F_2 to highly significant and positive in F_4. The change in correlation coefficient from low to high was also observed by El-Okkiah (1979) and Gooda (2001).

Phenotypic and genotypic correlation coefficients between lint yield and lint percentage were significant and positive in both F_2 and F_3 generations. Similar results were reported by Gooda (2001).

Lint yield/plant showed significant positive relationship with seed index in F_2 generation and increased in F_4 generation. 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 over the generations. 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 r_p and r_g between bolls/plant and each of lint/seed and lint percentage were positive and moderate to low in magnitude in the generations. This finding was similar to those obtained by El-Kilany (1976), Singh *et al.* (1985) and El-Harony (1999).

Generally, seeds/boll exhibited negative associations with each of lint/seed, lint percentage and seed index in F_2 and F_3 generations. 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.

The r_p and r_g between lint/seed and each of lint percentage and seed index were positive and highly significant for the most of studied generations.

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

Table 3. Estimates of phenotypic (r_p) and genotypic (r_g) correlation coefficients between studied characters in F_2, F_3 and F_4 generations.

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

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

4. Predicted and realized genetic advances of lint yield:

Table (4) 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. The results indicated that the highest predicted genetic advance of F_3 generation for lint yield occurred when index selection involved of lint/seed and seeds/boll (I_{23}). On the other hand, the lowest predicted genetic advances for lint yield were found when selecting for only one of the two traits. El-Okkiah (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 achieved when selecting for lint yield alone (I_{xw}). The lowest predicted genetic advances for lint yield occurred with the indices I_{x2} and I_{w123}.

The results indicate 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 useful value.

Table 4. 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.

Indices	Genetic advances lint (g)/plant			Advances from generation mean %		
	Predicted from F_3 to F4	Realized from F_3 to F4	Predicted from F_4 to F_5	Predicted from F_3 to F4	Realized from F_3 to F4	Predicted from F_4 to F_5
I_{w123}	2.11	2.99	0.12	17.27	22.43	0.78
I_{123}	3.00	1.89	1.21	24.55	14.18	7.86
I_{12}	2.74	1.89	1.08	22.42	14.18	7.01
I_{13}	2.45	2.14	0.90	20.05	16.05	5.84
I_{23}	4.90	2.37	0.94	40.10	17.78	6.10
Ix_w	2.43	1.89	4.04	19.89	14.18	26.23
Ix_1	2.15	1.80	3.14	17.59	13.50	20.39
Ix_2	0.68	2.34	0.40	5.56	17.55	2.60
Ix_3	1.24	4.19	3.09	10.15	31.43	20.06

$\overline{F_3}$ = 12.22 $\overline{F_4}$ = 15.40 Check mean = 13.33

5. Correlated response to selection for lint yield and unselected traits:

Predicted and realized responses to selection obtained from using nine different selection procedures for lint percentage and seed index are given in Table (5).

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 a 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 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) and Gooda (2001).

Table 5. Predicted and realized responses to selection using nine different selection procedures as estimated from F_3 and F_4 means for lint percentage and seed index.

Indices	Lint percentage						Seed index (g)					
	Predicted (g) from F_3 to F_4	Realized (g) from F_3 to F_4	Predicted (g) from F_4 to F_5	Predicted % from F_3 to F_4	Realized % from F_3 to F_4	Predicted % from F_4 to F_5	Predicted (g) from F_3 to F_4	Realized (g) from F_3 to F_4	Predicted (g) from F_4 to F_5	Predicted % from F_3 to F_4	Realized % from F_3 to F_4	Predicted % from F_4 to F_5
I_{w123}	0.49	1.07	0.13	1.44	3.10	0.38	-0.039	2.35	0.024	-0.43	26.80	0.21
I_{123}	0.34	0.87	0.10	1.00	2.52	0.29	-0.028	2.25	0.006	-0.31	25.66	0.05
I_{12}	0.26	0.87	0.06	0.77	2.52	0.17	-0.037	2.25	0.005	-0.41	25.66	0.04
I_{13}	1.01	0.94	0.15	2.98	2.72	0.43	0.012	2.37	0.021	0.13	27.02	0.19
I_{23}	2.01	1.03	0.14	5.92	2.98	0.40	0.073	2.45	0.130	0.81	27.94	1.16
Ixw	1.03	0.87	1.02	3.03	2.52	2.95	-0.111	2.25	0.345	-1.23	25.66	3.07
Ix_1	0.89	0.75	1.00	2.62	2.17	2.89	-0.161	1.88	-0.006	-1.79	21.44	-0.05
Ix_2	-0.26	-0.04	-1.05	-0.77	-0.12	-3.03	-0.140	2.11	0.595	-1.56	24.06	5.30
Ix_3	1.25	1.34	1.51	3.68	3.88	4.36	0.149	2.44	0.265	1.66	27.82	2.36

Generation means of lint percentage F_3 = 33.94 | Generation means of seed index F_3 = 8.99

F_4 = 34.60 | F_4 = 11.22

Check mean of lint percentage = 34.55 | Check mean of seed index = 8.77

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تحسين محصول الشعر ومكوناته فى الأجيال المبكرة لهجين القطن جيزه ٤٥ × جيزه ٧٥

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يهدف هذا البحث إلى دراسة:

١- التباينات والتباينات المرافقة المظهرية والوراثية والبينية لمحصول النبات من القطن الشعر ومكوناته للهجين (جيزه ٤٥ × جيزه ٧٥).
٢- التلازمات المظهرية والوراثية بين الصفات المدروسة.
٣- الكفاءة النسبية لأدلة الانتخاب (٥ أدلة) والانتخاب المظهرى المباشر للصفة (٤ أدلة).

ولتحقيق هذه الأهداف:

- فى عام ٢٠٠٠م تم انتخاب أعلى ٥% لكل من محصول القطن الشعر/نبات ، عدد اللوز/نبات ، عدد البذور/لوزة ووزن الشعر/بذرة لعشيرة الجيل الثانى للهجين (جيزه ٤٥ × جيزه ٧٥) وقد تم انتخاب أعلى ٥٠ نبات على أساس الصفات الأربع السابقة.
- فى عام ٢٠٠١م استخدم جزء من البذرة الذاتى للـ ٥٠ عائلة للتقييم مع الأبوين والعينة العشوائية للجيل الثالث (F_3) باستخدام تصميم قطاعات كاملة العشوائية ذات ثلاث مكررات.
- تم ترتيب العائلات المقيمة باستخدام تسع أدلة انتخابية المتضمنة الأربع صفات ثم انتخاب أعلى ٦% لكل دليل. وفى عام ٢٠٠٢م تم استعمال البذرة الذاتية لنسل هذه العائلات المنتخبة من حقل التربية فى زراعة الجيل الرابع مع الأبوين ومخلوط بذرة الجيل تحت الدراسة باستخدام تصميم قطاعات كاملة العشوائية ذات ثلاث مكررات بمحطة البحوث الزراعية بسخا.

ويمكن تلخيص النتائج المتحصل عليها كما يلى:

١- أظهر التباين المظهرى فى الجيل الرابع قيما أعلى من الجيل الثالث لكل الصفات المدروسة ماعدا صفة معدل الحليج ، وقد يرجع ذلك إلى فاعلية أدلة الانتخاب التى تسببت فى تلك الزيادة.
٢- أظهرت متوسطات الجيل الرابع قيما أعلى من الجيل الثالث لكل الصفات المدروسة عدا صفة عدد البذور/لوزة.
٣- أظهر الانتخاب المظهرى المباشر لصفة وزن الشعر/بذرة أعلى تحسين وراثى فعلى لمحصول القطن الشعر/نبات.
٤- أظهر دليل الانتخاب المتضمن عدد البذور/لوزة ووزن الشعر/بذرة أعلى تأثير فى تحسين محصول القطن الشعر حيث أعطى أقصي تحسين وراثى متوقع من الجيل الثالث إلى الجيل الرابع بينما أعطى الانتخاب المظهرى المباشر لصفة محصول القطن الشعر/نبات أقصى تحسين وراثى متوقع لمحصول القطن الشعر/نبات من الجيل الرابع إلى الجيل الخامس.
٥- أوضحت النتائج أن الزيادة فى محصول القطن الشعر/نبات قد صاحبها زيادة متوقعة لصفتى معدل الحليج ومعامل البذرة فى الجيل الرابع عند استخدام دليلى الانتخاب Ix_2, Ix_3 على التوالى.