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QUADRIALLEL ANALYSIS FOR YIELD COMPONENTS AND FIBER TRAITS IN *Gossypium barbadense* L.

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ABSTRACT

Combining ability estimates for yield and yield components traits and some fiber properties of *Gossypium barbadense* L. were the ultimate aim of this investigation. The genetic materials used in the present study included six cotton varieties and their 45 double crosses. In 2006 growing season, these genotypes were evaluated in a field trial experiment at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate for the following traits: seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), boll weight (BW), number of bolls/plant (N.B./P.), lint percentage (L.%), fiber fineness (F.F), fiber strength (F.S) and upper half mean (UHM).

The results showed that the mean squares of genotypes were highly significant for all studied traits, the partition of crosses mean square to its components showed that the mean square due to 1-line general , 2-line specific , 2-line arrangement , 3-line arrangement and 4-line arrangement were either significant or highly significant for most studied traits.This result suggesting the presence of the additive and non-additive genetic variance in the inheritance of these traits . The variety Giza 89 (P_6) was the best general combiner among studied varieties for most studied yield component traits such as (S.C.Y./P.), (L.Y./P.) and (N.B./P.). Also, the variety TNB1 (P_2) had the positive desirable values of general combining ability for the same previous traits in addition to (BW) and (UHM).

Concerning the two-line interaction effect, (S^2_{12}), (S^2_{26}) and (S^2_{36}) showed positive (desirable) effects for most yield components. Moreover, the best combinations for (F.F), (F.S) and (UHM) were (S^2_{24}), (S^2_{34}) and (S^2_{15}), respectively. The three-line interaction effect cleared that the combinations (S^3_{123}), (S^3_{136}), (S^3_{236}) and (S^3_{246}) had great positive (desirable) effects for (S.C.Y./P.), (L.Y./P.) and (N.B./P.). In the same time, (S^3_{135}), (S^3_{156}) and (S^3_{246}) were the best combinations for (F.S), while (S^3_{134}), (S^3_{234}) and (S^3_{256}) for (UHM) as well as (S^3_{124}) and (S^3_{146}) for (F.F) trait. Furthermore, the four-line interaction effect revealed that the best double cross combinations for (S.C.Y. /P.), (L.Y. /P.) was (S^4_{1236}). Moreover, (S^4_{1345}), (S^4_{2456}) (S^4_{1245}), (S^4_{1246}), (S^4_{1456}) and (S^4_{1256}) were the best double cross combinations for (L. %), (B.W), (N.B. /P.), (F.F), (F.S) and (UHM), respectively.

The specific combining ability effects $t^2_{(ij)}(..)$ showed that the combinations $t^2_{(34)}(..)$, $t^2_{(23)}(..)$, $t^2_{(24)}(..)$, $t^2_{(56)}(..)$, $t^2_{(34)}(..)$, $t^2_{(15)}(..)$, $t^2_{(36)}(..)$ and $t^2_{(16)}(..)$ were the best combinations for (S.C.Y./P.), (L.Y./P.), (L.%), (B.W), (N.B./P.), (F.S), (F.F) and (UHM) traits, respectively.

In conclusion, from the preivous results it could be concluded that the combinations [(P_1 x P_3) x (P_2 x P_6)], [(P_1 x P_3) x (P_4 x P_5)] and [(P_2x P_6) x (P_4x P_5)] appeared to be the best promising double crosses for breeding toward most studied yield traits potentiality.

The results revealed that the magnitudes of dominance genetic variance (σ^2D) were positive and larger than those of additive genetic variance (σ^2A), for all studied traits except of the (L. %) and (UHM). Concerning epistatic variances, additive by additive genetic variance (σ^2AA) and additive by dominance genetic variance (σ^2AD) showed negative and considerable magnitude for all studied traits except for the same two previous traits [(L. %) and (UHM)]. While, dominance by dominance genetic variance (σ^2DD) and additive by additive by additive genetic variance (σ^2AAA) showed positive and considerable magnitude for all studied traits with the exception of the (L.%) and (UHM). Therefore, it could be recommended that production of double crosses to involved in the selection breeding programs is the desirable way for improvement these traits.

Keywords: Cotton, Quadriallel analysis, Gene action and Combining ability

INTRODUCTION

A double cross or a quadriallel is the first generation progeny of the crossing between unrelated F_1 hybrids viz., (a x b) (c x d) where a, b, c and d are the four parents and a x b and c x d are the two unrelated F_1 hybrids involving these parents. Taking 'P' as the number of parents, all possible double crosses would be P (P – 1) (P – 2) (P – 3) /8. The theoretical aspect of quadriallel analysis has been dealt with by Rawling and Cockerham (1962b). Double cross analysis provides information about nature of gene action for interested traits. The genetic components valid in these analyses are additive, dominance and epistatic variances. The epistatic variance include additive x additive (σ^2AA), additive x dominance (σ^2AD), dominance x dominance (σ^2DD) and additive x additive x additive (σ^2AAA) component of variance. This technique also gives information on the order in which parents should be crossed for obtaining superior recombinants (Singh and Narayanan, 2000). Many investigators studied general and specific combining abilities among them; Meredith (1990), Hemaida *et al.* (2006) and Eman *et al* (2007). Jagtab and Kolhe (1987) found that both additive and non-additive gene action played a significant role for the inheritance of bolls number/plant, boll weight, seed cotton yield and lint percentage. In the same time, Kosba *et al.* (1991) found that fiber traits were controlled by additive and non-additive types of gene actions. In addition, Kumar and Raveendran (2001) cleared that both additive and dominance genetic variance components were detected for number of bolls/plant and boll weight in the studied crosses. Abd El-Bary (2003) revealed that the magnitude of additive genetic variance was positive and larger than that of dominance genetic variance with respect to all studied yield component traits. In addition, the results revealed that the three types of epistatic variance (σ^2AA, σ^2AD and σ^2DD) were contributed in the genetic expression of most studied traits except for boll weight, lint percentage and lint index.

Thus, the present investigation was carried out to estimate combining ability and gene action for some yield components and fiber properties using quadriallel system of six cotton varieties.

MATERIALS AND METHODS

The genetic materials used in the present investigation included six cotton varieties belong to *Gossypium barbadense* L., three of them are Egyptian long staple cotton varieties: Giza 86 (P_1) very late in maturity, high in yield characters, long staple (33.2 mm.), coarse lint (4.3 Micronaire value) and strong lint (11.0 Pressley index), Giza 85 (P_5) exhibited fiber strength (10.4) and Micronaire value (3.8) and Giza 89 (P_6) early in maturing, moderate in yield characters with high number of bolls per plant, long staple (32.0 mm.) and coarse lint (Pressley index 4.1). The other three varieties were TNB1 Sea Island (P_2) an extra long staple, it characterized by

Micronaire value is (3.1), Pressley index (10.3), lint length (33.7 mm.) and boll weight (2.7g.), Suvin (P_3) [Indian long staple germplasm. It is characterized by earliness, high yield and its components] and CB -58 (P_4): American Egyptian variety, a medium long staple. It characterized by high lint percentage and earliness. The inbred seeds of all varieties were obtained from Cotton Breeding Section, Cotton Research Institute, Agricultural Research Center, Giza, Egypt.

These six varieties were involved in a series of hybridization according to quadariallel crosses (double crosses) mating design as following:In the growing season of 2004, the six parents were planted and mated in a diallel fashion excluding reciprocals to obtain 15 single crosses. The parental varieties were also self-pollinated to obtain enough seed for further investigations. In 2005 growing season, single crosses were again mated in a diallel fashion to produce double cross hybrid with the restriction that no parent should appear more than once in the same double cross combination to obtain 45 double crosses;number of double crosses = P(P-1) (P-2) (P-3)/8 where, P : is number of parental varieties.

These 51 genotypes which included the six parental varieties and their 45 double crosses were evaluated in 2006 growing season. The experimental design used was a randomized complete blocks design with three replications . Each plot was one row 4.0 m. long and 0.6 m. wide. Hills were 0.4 m. apart to insure 10 hills per row. Hills were thinned to keep a constant stand of one plant per hill at seedlings stage. Ordinary cultural practices were followed as the recommendations.

Data were recorded on the following traits : Seed cotton yield per plant in grams (S.C.Y. / P.); lint yield per plant in grams (L.Y./P.); boll weight in grams (B.W.) and number of open bolls per plant (N.B. /P.); lint percentage (L %), fiber fineness (F.F.) fiber strength (F.S.) and upper half mean (UHM) as a measure of span length in mm. The fiber properties were measured in the laboratories of Cotton Fiber Research Section , Cotton Research Institute according to (A.S.T.M.D-1448-59, D-1445-60T and D-1447-67).

Statistical procedures used in this study were done according to the analysis of variance for a randomized complete blocks design as outlined by Cochran and Cox (1957).The amount of heterosis were estimated as the percentage increase of the overall means of the double crosses by comparing their average mean over all by the average mean of the six parents as well as the mean of the best one. Therefore, the values of heterosis could be estimated from the following two equations:

$H(Q,M.P)\ \% = [(Q-M.P) / M.P\ ] \times 100$ and $H(Q,B.P)\ \% = [(Q-B.P) / B.P\ ] \times 100$

The significance of means and heterosis were determined using the least significant difference value (L.S.D) at 0.05 and 0.01 levels, according to the following equation, which was calculated as suggested by Steel and Torrie (1980).

Considering $Y_{(ij)(kl)m}$ as the measurement recorded on a double cross $G_{(ij)(kl)m}$ the statistical model takes the following form:

$Y_{(ij)(kl)m} = \mu + r_m + G_{(ij)(kl)} + e_{(ij)(kl)m}$

Where:

$Y_{(ij)(kl)m}$: the observation on double cross (ij) (kl) grown in replication m, m = 1, ...; r, i, j, k, l = 1, ...; p where no two of i j, k, and l can be the same

μ : the general mean

r_m : effects of replication *m*.

$G_{(ij)(kl)}$: the genotypic effect of the double cross hybrid (ij) (kl)

$e_{(ij)(kl)}$: a random error.

Further, $G_{(ij)(kl)} = (g_i + g_j + g_k + g_l) + (s_{ij} + s_{ik} + s_{jk} + s_{il} + s_{jk} + s_{jl} + s_{kl}) + (s_{ijk} + s_{ijl} + s_{ikl} + s_{jkl}) + (s_{ijkl}) + (t_{ij} + t_{kl}) + (t_{i.k} + t_{i\cdot l} + t_{j\cdot k} + t_{j\cdot l}) + (t_{ij\cdot k} + t_{ij\cdot l} + t_{kl\cdot i} + t_{kl\cdot j}) + (t_{ijkl})$

g_i : the average general effect of the line i

s_{ij} : the 2-line interaction effect of lines i and j appearing together irrespective of arrangement.

s_{ijk} : the 3-line interaction effect of lines i, j and k appearing together irrespective of arrangement.

s_{ijkl} : the 4-line interaction effect of lines i, j, k and l appearing together irrespective of arrangement.

t_{ij} : the 2-line interaction effect of lines i and j due to the particular arrangement (ij)(--).

$t_{i.j}$: the 2-line interaction effect of lines i and j due to the particular arrangement (i -)(j -).

$t_{ij.k}$: the 3-line interaction effect of lines i, j and k due to the particular arrangement (i j)(k -).

$t_{ij.k}$: the 4-line interaction effect of lines i, j, k and l due to the particular arrangement (i j)(k l).

Table 1: Form of the analysis of variance of the double crosses and expectation of mean squares

S.O.V.	d.f	S.S	M.S
Replications	r-1	$(8\Sigma Y^2 .... m) /(r\, p\, p_1\, p_2\, p_3) - C.$	R
Hybrids	$3^6 C_4 - 1$	$(\Sigma Y^2_{(i\,j)\,(kl)} / r) - C$	H
1-line general	P_1	$(2\Sigma Y^2_{i....} / r\, p_2\, p_3\, p_4) - (4p_1 / p_4)\, C$	G
2- line specific	$P\, P_3 / 2$	$(2\Sigma Y^2\, ij... / 3r\, p_4\, p_5) - (6pp_2 / p_4 p_4)\, C - (3p_3 / p_5)\, G$	S_2
2- line arrangement	$P\, P_3 / 2$	$(2\Sigma Y^2\, (i\,j)\,(.\,.).\, / r\, p_1\, p_2) + (\Sigma Y_2\, (i\,.)\,(j\,.).\, / r\, p_1\, p_2) - (2\Sigma Y^2\, ij... / 3r\, p_{1\,2})$	T_2
3-line arrangement	$P\, P_2\, P_4 / 3$	$(\Sigma Y^2_{(i\,j)\,(k\,.)}. / r\, p_3) - (\Sigma Y^2_{ijk..} / 3r\, p_3 - (2p_2 / p_3)\, T_2$	T_3
4- line arrangement	$P\, P_1\, P_4\, P_5 / 12$	$(\Sigma Y^2_{(i\,j)\,(k\,l)} / r) - (\Sigma Y^2_{ijkl.} / 3r) - T_2 - T_3$	T_4
Error	$(r-1)\,(3^6 C_4 - 1)$	M - R - H	E
Total	$3r^6 C_4 - 1$	$\Sigma Y^2\, (i\,j)\,(kl)\, m - C$	

The theoretical aspect of quadriallel analysis has been illustrated by Rawlign and Cockerham (1962b) and outlined by Singh and Chaudhary (1985). The form of the analysis of variance of the quadriallel crosses and expectation of mean squares are presented in Table 1.

Estimation of combining Ability Effects:

1- $g_i = [Y_{i....} / (r\, p_1\, p_2\, p_3/2)] - \mu$ Where, $\mu = Y_{....} / (p_1\, p_2\, p_3/8)$
2- $S^2_{ij} = [Y_{ij...} / (3r\, p_2 p_3/2)] - \mu - g_i - g_j$
3- $S^3_{ijk} = (Y_{ijk...} / 3r\, p_3) - \mu - g_i - g_j - g_k - S_{ij} - S_{ik} - S_{jk}$

4- $S^4_{(ijkl)} = [(Y_{ijkl..}/(3r)] - \mu - g_i - g_j - g_k - g_l - S_{ij} - S_{ik} - S_{il} - S_{jk} - S_{jl} - S_{kl} - S_{ijk} - S_{ijl} - S_{jkl} - S_{jkl}$

5- $t^2_{(ij)(..)} = [Y_{(ij)(..).}/(r\,p_2p_3/2)] - \mu - g_i - g_j - S_{ij}$

6- $t^2_{(i-)(j-)} = [Y_{(i.)(j.).}/r\,p_2p_3] - \mu - g_i - g_j - S_{ij}$

7- $t^3_{(ij)(k-)} = [Y_{(ij)(k.).}/r\,p_3] - \mu - g_i - g_j - g_k - S_{ij} - S_{ik} - S_{jk} - S_{ijk} - t^2_{ij} - t^2_{i.k} - t^2_{j.k}$

8- $t^4_{(ij)(kl)} = [Y_{(ij)(kl).}/r] - \mu - g_i - g_j - g_k - g_l - S_{ij} - S_{ik} - S_{il} - S_{jk} - S_{jl} - S_{kl} - S_{ijk} - S_{ijl} - S_{ikl} - S_{jkl} - S_{ijkl} - t^2_{ij} - t^2_{kl} - t^2_{i.k} - t^2_{i.l} - t^2_{j.k} - t^2_{j.l} - t^3_{ij.k} - t^3_{ij.l} - t^3_{kl.i.} - t^3_{kl.j}$

RESULTS AND DISCUSSION

Analysis of variance of 6 parents and their 45 double crosses were made for all studied component traits [seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), boll weight (B.W.), lint percentage (L.%) and number of bolls/plant (N.B./P.)] and some fiber properties [fiber fineness (F.F.), fiber strength (F.S.) and upper half mean (UHM)] and the mean square are presented in Table 2.

Table 2: The analysis of variance and mean squares of 6 parents and their 45 quadriallel crosses for yield component traits and some fiber properties

S .O .V	d f	S.C.Y/ P	L.Y. / P	L. %	B. W.	N. B./ P	F.F	F.S	UHM
Rep.	2	207.08**	91.66**	24.524**	0.029	5.845	0.000	0.004	0.182
Geno.	50	2003.95**	276.47**	9.420**	0.178**	195.05**	0.404**	0.995**	5.967**
P.	5	189.15**	30.30	5.325	0.192**	21.980*	0.979**	1.151**	5.533**
C.	44	2253.85**	303.04**	5.805**	0.167**	218.010**	0.347**	0.817**	5.885**
P. Vr. C	1	82.65	339.25**	188.96**	0.587**	50.158**	0.000*	8.006**	11.762**
E	100	46.760	14.046	3.701	0.028	7.123	0.067	0.281	0.813

The results indicated that the magnitudes of the parents mean squares of all studied traits were significant or highly significant except lint yield/plant (L.Y./P.) and lint percentage (L.%), while the parents vs. crosses mean squares were highly significant for all studied traits except seed cotton yield/plant (S.C.Y./P.) and fiber fineness (F.F.) indicating to the presence of heterotic effect in the studied traits except for (S.C.Y./P.) and (F.F.). Furthermore, The mean squares of genotypes and crosses were highly significant for all studied traits. The partition of crosses mean squares to its components (Table 3) showed that the mean square due to *1-line general* were significant or highly significant for all studied traits suggesting the presence of the additive variance in the inheritance of these traits, subsequently the selection through the advanced segregating generations would be efficient to improve these characters.

The estimates due to 2-line specific and 2-line arrangement were significant or highly significant for all studied traits except (L. %) suggesting the presence of the non-additive variance in the inheritance of these traits. 3-line arrangement mean squares were significant or highly significant for all studied traits. These results indicated that the contribution of additive by dominance interaction including all three factors or higher order interactions except all dominance types.

Table 3: The analysis of variance of the double crosses for yield component traits and some fiber properties

S .O .V	d f	S.C.Y. / P	L.Y. / P	L. %	B. W.	N. B./ P	F.F	F.S	UHM
Rep.	2	109.69	117.08**	41.061**	0.012	3.029	0.004	0.660**	0.118
Crosses	44	2253.85**	303.04**	5.805**	0.167**	218.010**	0.347**	0.817**	5.885**
1_line general	5	3140.80**	370.98**	9.971*	0.234**	205.303**	0.849**	0.806**	8.493**
2_line specific	9	391.07**	49.63**	4.252	0.099**	55.075**	0.553**	0.646**	2.546**
2_line arrangement	9	3791.05**	558.52**	5.712	0.159**	371.499**	0.203**	0.389**	14.754**
3_line arrangement	16	2173.26**	286.16**	6.182*	0.197**	225.696**	0.170**	1.003**	3.686**
4_line arrangement	5	2210.79**	285.34**	3.395	0.143**	223.121**	0.303**	1.314**	0.354
Error	88	39.09	12.80	3.160	0.023	6.207	0.058	0.134	0.918

In addition, the results indicated that tests of significant showed that the mean squares due to 4-line arrangement were significant for most studied traits referred to the contribution of dominance × dominance genetic variances in the genetic expression of these traits and all three factor interactions, except all additive types.

The amounts of heterosis versus the mid-parents (M.P) and the better-parent (B.P) for yield component traits and some fiber properties were presented in Table 4.

Table 4: The amounts of heterosis over the mid-parents (M.P) and better-parent (B.P) for yield and yield component traits and fiber quality properties

Comparisons	S.C.Y. / P	L.Y. / P	L. %	B. W.	N. B./ P	F.F	F.S	UHM
M.P	105.87	35.14	33.21	2.81	37.78	4.09	9.03	32.51
B.P	120.00	39.84	35.42	3.23	41.74	3.35	9.90	34.20
M.Q	108.15	39.65	36.65	3.00	36.03	4.09	9.74	33.37
B.Q	172.05	65.19	39.36	3.48	54.71	3.10	10.75	35.65
Q - M.P.%	2.15	12.84**	10.39**	6.84**	-4.63*	-0.13	7.86**	2.65**
LSD 5%	3.40	1.86	0.96	0.08	1.33	0.13	0.26	0.45
1%	4.50	2.46	1.26	0.11	1.75	0.17	0.35	0.59
Q - B.P.%	-9.88**	-0.47	3.49	-7.00*	-13.69**	21.98**	-1.58	-2.43
LSD 5%	7.90	4.33	2.22	0.19	3.08	0.30	0.61	1.04
1%	10.46	5.73	2.94	0.26	4.08	0.40	0.81	1.38

The results indicated the presence of desirable heterosis over mid-parents (M.P) for (S.C.Y. /P.), (L.Y. /P.), (B.W), (L %), (F.F.), (F.S.) and (UHM) traits which were highly significant for most of these traits. The amounts of desirable heterosis over mid-parents (M.P) ranged from -0.13 % to 12.84% for (F.F.), and (L.Y. /P.), respectively. On the other hand, the estimated values of heterobeltiosis [superiority of double crosses over the better-parent] were undesirable for all studied traits except (L. %) with value of 3.49%. In general, these results indicated that most of double crosses showed superiority over their mid-parents for yield component attributes. These results were in common agreement with the results obtained by many authors among them Meredith (1990), Abd El-Bary (1999 and 2003), Bharad *et al.* (2000) and Tuteja and Singh (2001). In spite of the average overall double crosses did not exceed the best better parent in most of studied yield component traits, some double crosses exhibited superiority over their four parents such as [(P_1 x P_3) x (P_2 x P_6)], [(P_1 x P_3) x (P_4 x P_5)] for most studied yield traits potentiality.

General combining ability effects for each parental variety

The estimates of general combining ability effects (g_i) of parental varieties were obtained for yield and yield component traits and some fiber properties and the obtained results are shown in Table 5. Positive estimates would indicate that a given variety is much better than the average of the group involved with it in the quadriallel crosses for all studied traits except fiber fineness (desirable = negative value). Comparison of the general combining ability effect (g_i) of individual parent exhibited that no parent was the best combiner for all yield and its component traits and/or fiber properties. In multiple crossing programs prior information on the order effect of lines could be of great value (Singh and Chaudhary 1985).

Table 5: General line effect (g_i) for yield component traits and some fiber properties

Parents	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
G.86	0.349	0.010	-0.114	0.012	-0.089	0.014	0.103	0.046
TNB1	3.812	1.097	-0.293	0.050	0.743	-0.036	-0.008	0.214
Suvin	-0.978	-0.186	0.209	0.003	-0.284	0.045	-0.060	-0.079
CB-58	-5.302	-2.002	-0.091	-0.049	-1.162	-0.102	-0.027	0.074
G.85	-2.393	-0.557	0.265	-0.015	-0.667	0.070	-0.042	-0.347
G.89	4.511	1.638	0.024	0.000	1.458	0.010	0.033	0.091

The variety Giza 89 (P_6) was the best general combiner for most studied yield component traits such as seed cotton yield/plant (S.C.Y. /P.), lint yield/plant (L.Y. /P.) and number of bolls/plant (N.B. /P.). Also, the variety TNB1 (P_2) had the positive desirable values of general combining ability for the same previous traits and the best combiner for boll weight (BW) and upper half mean (UHM). Furthermore, the results revealed that the variety CB-58 (P_4) was the best combiner among this group of varieties for fiber fineness (F.F.) which had a negative (desirable) value. Moreover, the variety Giza 85 (P_5) was the best combiner for lint percentage (L %). The variety Giza 86 (P_1) was the best combiner for fiber strength (F.S.). Thus, it could be suggested that these parental varieties could be utilized in a breeding program for improving these traits to pass favorable genes for improving hybrids and subsequently producing improved genotypes through the selection in segregating generations.

Specific combining ability effects

Two-line specific effects

The two-line interaction effect of lines i and j appearing together irrespective of arrangement (S^2_{ij}). It refers to the specific combining ability effect of the two lines used as the parents involved in the same single cross (first or second single cross) [(first and second) or (third and fourth) parent] or one of the two lines used as a parent involved in the first single cross and the second line used as a parent involved in the second single cross [(first and third) or (second and fourth) parent] for all combinations, with respect to the studied yield components traits and some fiber properties were obtained and the results are presented in Table 6. The results cleared that no hybrids exhibited desirable values for all studied traits. It could be noticed that (S^2_{12}), (S^2_{26}) and (S^2_{36}) showed positive (desirable) effects for most yield components. Moreover, the best combinations for (F.F), (F.S) and (UHM) were (S^2_{24}), (S^2_{34}) and (S^2_{15}), respectively.

Table 6: The 2-line interaction effect of lines i and j appearing together irrespective of arrangement S^2ij for yield component traits and some fiber properties

S^2_{ij}	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
S^2 12	1.203	0.408	-0.040	-0.007	0.533	-0.041	-0.044	-0.041
S^2 13	-0.033	0.027	0.044	0.026	-0.326	0.014	0.022	0.058
S^2 14	-2.269	-0.729	0.085	-0.020	-0.551	-0.023	-0.001	-0.023
S^2 15	0.571	0.238	0.019	0.011	0.026	0.086	0.073	-0.029
S^2 16	0.877	0.066	-0.222	0.001	0.228	-0.021	0.053	0.080
S^2 23	0.975	0.241	-0.133	0.022	0.042	0.019	0.031	0.059
S^2 24	0.463	0.029	-0.152	0.003	0.160	-0.056	0.039	0.056
S^2 25	-0.834	-0.307	-0.037	0.004	-0.337	0.002	-0.018	0.022
S^2 26	2.005	0.727	0.068	0.028	0.344	0.040	-0.016	0.117
S^2 34	-3.051	-1.103	0.063	-0.005	-0.893	0.009	-0.065	0.119
S^2 35	-0.824	-0.171	0.111	-0.029	0.064	-0.032	-0.033	-0.243
S^2 36	1.955	0.820	0.124	-0.012	0.827	0.036	-0.014	-0.073
S^2 45	-0.713	-0.271	0.016	-0.006	-0.179	0.014	-0.036	-0.071
S^2 46	0.268	0.071	-0.102	-0.022	0.299	-0.045	0.036	-0.007
S^2 56	-0.593	-0.046	0.156	0.005	-0.241	0.000	-0.027	-0.027

Three-line specific effects

The three-line interaction effect of lines i, j and k appearing together irrespective of arrangement (S^3_{ijk}). It refers to the specific combining ability effect of any two lines used as the parents involved in any single cross and the third line used as a parent involved in the second single cross (as male or female) for all combinations. With respect to the studied yield components traits and some fiber properties, the results are presented in Table 7. The results showed that no hybrids exhibited desirable values for all studied traits. The combinations (S^3_{123}), (S^3_{136}), (S^3_{236}) and (S^3_{246}) showed great positive (desirable) effects for seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.) and number of bolls/plant (N.B./P.). In the same time, (S^3_{135}), (S^3_{156}) and (S^3_{246}) were the best combinations for (F.S), while (S^3_{134}), (S^3_{234}) and (S^3_{256}) for (UHM) as well as [(S^3_{124}) and (S^3_{146})] for (F.F) property.

Four-line specific effects

The four- line interaction effect of lines i, j, k and l appearing together irrespective of arrangement (S^4_{ijkl}). It refers to the specific combining ability effect of any two lines used as the parents involved in any single cross and the other two lines used as parents involved in the second single cross (as male or female) for all double combinations.With respect to the studied yield components traits and some fiber properties were obtained and the results are presented in Table 8. The results revealed that no hybrids exhibited desirable values for all studied traits. The best double combinations for seed cotton yield/plant (S.C.Y. /P.), lint yield/plant (L.Y. /P.) was (S^4_{1236}). Moreover, (S^4_{1345}), (S^4_{2456}) (S^4_{1245}), (S^4_{1246}), (S^4_{1456}) and (S^4_{1256}) were the best double combinations for (L. %), (B.W), (N.B. /P.), (F.F), (F.S) and (UHM), respectively.

Table 7: The 3-line interaction effect of lines i, j and k appearing together irrespective of arrangement S^3ijk for yield component traits and some fiber properties

S^3_{ijk}	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
S^3 123	1.084	0.369	-0.062	0.019	0.127	-0.016	-0.003	0.017
S^3 124	-0.223	0.006	0.059	-0.028	0.312	-0.080	-0.028	-0.119
S^3 125	0.351	0.155	-0.010	-0.007	0.226	0.031	-0.007	-0.018
S^3 126	1.194	0.286	-0.065	0.001	0.402	-0.018	-0.049	0.039
S^3 134	-3.376	-1.078	0.190	0.014	-1.257	0.014	-0.049	0.141
S^3 135	0.721	0.338	0.054	0.009	0.111	0.024	0.061	-0.087
S^3 136	1.505	0.426	-0.094	0.011	0.368	0.006	0.036	0.046
S^3 145	0.038	0.088	0.099	0.003	-0.064	0.083	0.024	-0.047
S^3 146	-0.977	-0.474	-0.179	-0.028	-0.092	-0.063	0.052	-0.020
S^3 156	0.032	-0.106	-0.105	0.018	-0.221	0.034	0.068	0.094
S^3 234	-0.790	-0.470	-0.164	0.019	-0.456	0.002	0.036	0.164
S^3 235	-0.830	-0.355	-0.119	-0.015	-0.161	-0.037	0.016	-0.091
S^3 236	2.486	0.938	0.079	0.020	0.575	0.089	0.013	0.028
S^3 245	0.210	-0.062	-0.133	0.006	0.006	-0.017	0.010	0.027
S^3 246	1.728	0.583	-0.066	0.009	0.458	-0.019	0.060	0.040
S^3 256	-1.399	-0.352	0.189	0.025	-0.745	0.028	-0.055	0.127
S^3 345	-1.697	-0.630	0.062	-0.020	-0.303	-0.014	-0.092	-0.078
S^3 346	-0.239	-0.028	0.037	-0.023	0.230	0.015	-0.025	0.011
S^3 356	0.157	0.304	0.225	-0.032	0.481	-0.038	-0.051	-0.231
S^3 456	0.023	0.062	0.004	-0.002	0.004	-0.024	-0.015	-0.044

Table 8: The 4-line interaction effect of lines i, j, k and l appearing together irrespective of arrangement S^4ijkl for yield component traits and some fiber properties

S^4_{ijkl}	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
S^4 1234	-3.897	-1.220	0.178	0.029	-1.514	-0.080	-0.072	0.176
S^4 1235	1.594	0.578	-0.240	-0.016	0.602	-0.044	0.102	-0.186
S^4 1236	5.557	1.748	-0.126	0.045	1.293	0.075	-0.040	0.059
S^4 1245	2.332	1.008	0.138	-0.038	1.307	0.053	-0.015	-0.231
S^4 1246	0.898	0.229	-0.140	-0.075	1.144	-0.212	0.002	-0.302
S^4 1256	-2.873	-1.120	0.071	0.032	-1.231	0.083	-0.108	0.361
S^4 1345	-2.309	-0.554	0.474	0.033	-1.168	0.147	-0.072	0.046
S^4 1346	-3.921	-1.461	-0.082	-0.022	-1.088	-0.026	-0.005	0.199
S^4 1356	2.878	0.991	-0.073	0.009	0.900	-0.031	0.152	-0.121
S^4 1456	0.091	-0.189	-0.314	0.013	-0.332	0.049	0.160	0.043
S^4 2345	-2.230	-1.451	-0.575	-0.009	-0.685	-0.086	0.023	0.103
S^4 2346	3.757	1.261	-0.095	0.037	0.832	0.174	0.157	0.214
S^4 2356	-1.854	-0.194	0.459	-0.022	-0.401	0.019	-0.078	-0.189
S^4 2456	0.530	0.258	0.037	0.065	-0.603	-0.018	0.022	0.208
S^4 3456	-0.552	0.116	0.288	-0.083	0.946	-0.102	-0.227	-0.382

Two-line interaction effect of lines i and j due to particular arrangement

The specific combining ability effects $t^2{}_{(ij)(..)}$ refers to the specific combining ability effect of the two lines (i and j) used as the parents involved together in the same single cross for all combinations.With respect to the studied yield components traits and some fiber properties were obtained and the results are presented in Table 9. The results indicated that no hybrids exhibited desirable values for all studied traits. The combinations $t^2_{(34)}(..)$, $t^2_{(23)}(..)$, $t^2_{(24)}(..)$, $t^2_{(56)}(..)$, $t^2_{(34)}(..)$, $t^2_{(15)}(..)$, $t^2_{(36)}(..)$ and $t^2_{(16)}(..)$ were the best combinations for (S.C.Y. /P.), (L.Y. /P.), (L. %), (B.W), (N.B. /P.), (F.S), (F.F) and (UHM) traits, respectively.

Table 9: The 2- line interaction effect of lines i and j due to particular arrangement $t^2(ij)(..)$. for yield component traits and some fiber properties

$t^2_{(ij)}$ (..).	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
t^2 (12)(..).	-3.937	-1.878	-0.280	-0.018	-0.734	-0.072	0.106	0.303
t^2 (13)(..).	-13.903	-5.020	0.210	-0.024	-4.429	0.075	-0.017	0.381
t^2 (14)(..).	-9.937	-3.660	-0.105	0.099	-4.515	0.042	-0.194	0.067
t^2 (15)(..).	11.531	4.658	0.262	-0.048	4.556	0.011	0.206	-1.897
t^2 (16)(..).	16.247	5.899	-0.087	-0.009	5.123	-0.056	-0.100	1.147
t^2 (23)(..).	16.268	6.251	0.085	0.123	3.586	0.036	0.036	-0.064
t^2 (24)(..).	5.679	3.209	1.063	0.032	1.514	0.058	0.178	0.194
t^2 (25)(..).	-17.014	-7.323	-0.959	-0.042	-5.044	-0.106	-0.242	0.625
t^2 (26)(..).	-0.996	-0.260	0.090	-0.095	0.678	0.083	-0.078	-1.058
t^2 (34)(..).	16.652	5.404	-0.703	-0.081	6.472	0.037	0.000	-0.175
t^2 (35)(..).	-0.622	0.286	0.531	0.063	-0.863	0.023	-0.042	0.617
t^2 (36)(..).	-18.394	-6.921	-0.123	-0.081	-4.766	-0.171	0.022	-0.758
t^2 (45)(..).	-4.716	-1.928	-0.104	-0.104	-0.543	-0.105	-0.031	-0.050
t^2 (46)(..).	-7.678	-3.025	-0.150	0.055	-2.928	-0.032	0.047	-0.036
t^2 (56)(..).	10.821	4.307	0.270	0.131	1.894	0.176	0.108	0.706

Two - line interaction effect of lines i and j due to particular arrangement

The specific combining ability effects $t^2_{(i.)(j.)}$ refers to the specific combining ability effect of the two lines (i and j) where i is a parent involved in the first single cross (as male or female) and j is a parent involved in the second single cross (as male or female) for all combinations. The studied yield components traits and some fiber properties were obtained and the results are presented in Table 10. The results showed that no hybrids exhibited desirable values for all studied traits. It could be noticed that $t^2_{(1.)(3.)}$, $t^2_{(2.)(5.)}$ and $t^2_{(3.)(6.)}$ were the best combinations for most yield components. Meanwhile, $t^2_{(5.)(6.)}$, $t^2_{(1.)(4.)}$ and $t^2_{(1.)(5.)}$ were the best combinations for (F.F), (F.S) and (UHM) properties, respectively.

Three-line interaction effect of lines i, j and k due to particular arrangement

The specific combining ability effects $t^3_{(ij)(k.)}$ refers to the specific combining ability effect of the three lines (i, j and k) where i and j are two parents involved together in the same single cross and k is a third parent involved in the another single cross for all combinations. The studied yield components traits and some fiber properties were obtained and the results are presented in Table 11. The results cleared that no hybrids exhibited desirable values for all studied traits. It could be noticed that $t^3_{(12)(4.)}$, $t^3_{(14)(5.)}$, $t^3_{(26)(3.)}$, $t^3_{(34)(2.)}$, $t^3_{(36)(4.)}$ showed great positive (desirable) effects for seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.). Meanwhile, $t^3_{(13)(6.)}$, $t^3_{(23)(1.)}$, $t^3_{(46)(1.)}$ and $t^3_{(56)(4.)}$ were the best combinations for (F.F) property.

Moreover, $t^3(_{12})(_{5.})$, $t^3(_{13})(_{2.})$, $t^3(_{24})(_{3.})$, $t^3(_{26})(_{4.})$ and $t^3(_{45})(_{2.})$ were the best combinations for (F.S) trait. In similar manner, $t^3(_{14})(_{6.})$, $t^3(_{15})(_{3.})$, $t^3(_{26})(_{1.})$, $t^3(_{26})(_{5.})$ and $t^3(_{34})(_{1.})$ were the best combinations for (UHM) property.

Table 10: The 2-line interaction effect of lines i and j due to particular arrangement t^2(i.)(j.). for yield component traits and some fiber properties

$t^2(_{i.})(_{j.})$.	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
t^2(1.)(2.).	1.969	0.939	0.140	0.009	0.367	0.036	-0.053	-0.151
t^2(1.)(3.).	6.951	2.510	-0.105	0.012	2.214	-0.037	0.008	-0.190
t^2(1.)(4.).	4.969	1.830	0.053	-0.049	2.258	-0.021	0.097	-0.033
t^2(1.)(5.).	-5.765	-2.329	-0.131	0.024	-2.278	-0.006	-0.103	0.949
t^2(1.)(6.).	-8.124	-2.950	0.043	0.005	-2.561	0.028	0.050	-0.574
t^2(2.)(3.).	-8.134	-3.126	-0.043	-0.062	-1.793	-0.018	-0.018	0.032
t^2(2.)(4.).	-2.840	-1.605	-0.532	-0.016	-0.757	-0.029	-0.089	-0.097
t^2(2.)(5.).	8.507	3.661	0.479	0.021	2.522	0.053	0.121	-0.313
t^2(2.)(6.).	0.498	0.130	-0.045	0.048	-0.339	-0.042	0.039	0.529
t^2(3.)(4.).	-8.326	-2.702	0.352	0.041	-3.236	-0.019	0.000	0.087
t^2(3.)(5.).	0.311	-0.143	-0.266	-0.032	0.431	-0.012	0.021	-0.308
t^2(3.)(6.).	9.197	3.461	0.062	0.041	2.383	0.086	-0.011	0.379
t^2(4.)(5.).	2.358	0.964	0.052	0.052	0.272	0.052	0.015	0.025
t^2(4.)(6.).	3.839	1.513	0.075	-0.027	1.464	0.016	-0.024	0.018
t^2(5.)(6.).	-5.411	-2.153	-0.135	-0.065	-0.947	-0.088	-0.054	-0.353

Four-line interaction effect of lines i, j, k and l due to particular arrangement

The specific combining ability effects t^4 $(_{ij})$ $(_{kl})$ refers to the specific combining ability effect of the four lines (i, j, k and l) where [i and j] are two parents involved together in the first single cross and [k and l] are two parents involved together in the second single cross for all double combinations. Concerning the studied yield components traits and some fiber properties were obtained and the results are presented in Table 12. The results revealed that no hybrids exhibited desirable values for all studied traits. However, 18, 21, 21,18,15, 27, 21 and 21 out of 45 quadriallel crosses showed desirable specific combining ability effects t^4 $(_{ij})(_{kl})$ values for seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), lint percentage (L. %), boll weight (B.W.), number of bolls/plant (N.B./P.), fiber fineness (F.F.), fiber strength (F.S.) and upper half mean (UHM), respectively. These quadriallel crosses involved [(poor x poor) x (poor x good)] or [(poor x poor) x (good x good)] or [(poor x good) x (good x good)] general combiners varieties, indicating to the presence of important epistatic gene action. Thus, it is not necessary that parents having high general combination ability effect (gi) would also contribute to high specific combining ability effects t^4 $(_{ij})$ $(_{kl})$. For instance, in the crosses [(P_1 x P_2) x (P_3 x P_6)], [(P_1 x P_2) x (P_5 x P_6)], [(P_1x P_5) x (P_2x P_6)] and [(P_1 x P_6) x (P_2 x P_3)]for seed cotton yield/plant (S.C.Y./P.) and lint yield/plant (L.Y./P.), boll weight (B.W.), number of bolls/plant (N.B./P.), three out of four parents had the best general combining ability effects (g_i) as mentioned earlier, but these combinations gave comparatively low specific combining ability effects t^4 $(_{ij})(_{kl})$ for the same previous four traits. In contrast, the crosses [(P_1 x P_3) x (P_4 x P_5)], [(P_2x P_5) x (P_3x P_4)] and [(P_3 x P_5) x (P_4x

P_6)] involved three out of four parents with poor general combining ability effects (g_i) for these traits, gave high specific combining ability effects $t^4\,(_{ij})(_{kl})$ values for these traits.

Table 11: 3- line interaction effect of lines i, j and k due to particular arrangement t^3(i j)(k-) for yield component traits and some fiber properties

$t^3\,(_{ij})(_{k.})$	S.C.Y./P	L.Y./P	L. %	B. W	N. B./P	F.F	F.S	UHM
t^3 (12)(3.).	-9.925	-2.633	0.892	-0.019	-3.122	0.094	-0.129	-0.272
t^3 (12)(4.).	17.643	6.362	-0.017	0.031	5.219	-0.039	-0.242	0.400
t^3 (12)(5.).	-1.328	-1.491	-0.904	-0.027	-0.291	-0.053	0.276	-0.322
t^3 (12)(6.).	-2.452	-0.360	0.309	0.032	-1.072	0.069	-0.011	-0.108
t^3 (13)(2.).	8.673	2.422	-0.782	0.107	1.733	0.057	0.321	0.144
t^3 (13)(4.).	4.771	1.918	0.136	-0.048	1.975	-0.091	0.003	-0.757
t^3 (13)(5.).	-5.037	-1.275	0.402	-0.039	-0.941	0.070	-0.201	0.507
t^3 (13)(6.).	5.496	1.955	0.035	0.004	1.662	-0.111	-0.106	-0.275
t^3 (14)(2.).	-14.563	-5.636	-0.368	-0.111	-3.519	-0.026	0.192	0.037
t^3 (14)(3.).	-0.627	-0.723	-0.386	-0.083	0.984	-0.058	-0.064	-0.069
t^3 (14)(5.).	13.110	5.632	0.931	0.082	3.446	0.000	0.076	-0.563
t^3 (14)(6.).	12.017	4.387	-0.072	0.014	3.605	0.042	-0.010	0.528
t^3 (15)(2.).	-3.547	-0.225	1.065	0.009	-1.256	-0.011	-0.474	0.411
t^3 (15)(3.).	6.696	2.008	-0.391	0.113	0.483	0.032	0.032	0.740
t^3 (15)(4.).	-7.742	-3.409	-0.621	-0.019	-2.149	-0.004	0.160	0.317
t^3 (15)(6.).	-6.937	-3.032	-0.315	-0.054	-1.634	-0.029	0.076	0.429
t^3 (16)(2.).	7.468	2.500	-0.055	-0.013	2.676	-0.056	0.014	-0.442
t^3 (16)(3.).	-3.096	-1.162	-0.010	-0.023	-0.559	-0.031	0.153	-0.208
t^3 (16)(4.).	-19.640	-6.701	0.449	0.085	-7.303	0.155	-0.018	0.074
t^3 (16)(5.).	-0.979	-0.537	-0.298	-0.040	0.064	-0.012	-0.049	-0.571
t^3 (23)(1.).	1.251	0.211	-0.110	-0.088	1.389	-0.151	-0.192	0.128
t^3 (23)(4.).	-19.030	-6.903	0.076	0.024	-6.029	0.078	-0.003	0.346
t^3 (23)(5.).	9.538	3.628	0.135	0.057	2.294	0.073	0.028	-0.071
t^3 (23)(6.).	-8.027	-3.187	-0.186	-0.115	-1.240	-0.036	0.131	-0.339
t^3 (24)(1.).	-3.080	-0.726	0.385	0.080	-1.700	0.065	0.050	-0.438
t^3 (24)(3.).	4.953	1.041	-0.741	-0.004	1.372	-0.022	0.401	0.125
t^3 (24)(5.).	-9.920	-3.997	-0.367	-0.125	-1.678	-0.091	-0.375	0.182
t^3 (24)(6.).	2.368	0.473	-0.340	0.018	0.492	-0.011	-0.254	-0.064
t^3 (25)(1.).	4.875	1.716	-0.161	0.018	1.547	0.064	0.197	-0.089
t^3 (25)(3.).	-0.523	0.320	0.438	0.111	-1.268	0.019	-0.139	-0.054
t^3 (25)(4.).	5.048	2.342	0.419	-0.105	2.605	0.005	0.088	-0.464
t^3 (25)(6.).	7.614	2.945	0.262	0.018	2.159	0.019	0.096	-0.018
t^3 (26)(1.).	-5.015	-2.140	-0.254	-0.019	-1.604	-0.014	-0.003	0.550
t^3 (26)(3.).	13.629	4.397	-0.547	-0.026	4.811	-0.073	-0.115	0.169
t^3 (26)(4.).	-0.821	-0.196	0.054	0.065	-1.038	-0.015	0.246	-0.185
t^3 (26)(5.).	-6.797	-1.801	0.657	0.075	-2.846	0.019	-0.050	0.524
t^3 (34)(1.).	-4.144	-1.195	0.250	0.131	-2.959	0.149	0.061	0.826
t^3 (34)(2.).	14.077	5.862	0.665	-0.020	4.657	-0.056	-0.399	-0.471
t^3 (34)(5.).	-11.773	-4.650	-0.331	-0.012	-3.776	-0.087	0.142	-0.086
t^3 (34)(6.).	-14.812	-5.421	0.119	-0.017	-4.394	-0.043	0.196	-0.094
t^3 (35)(1.).	-1.658	-0.733	-0.010	-0.073	0.458	-0.102	0.169	-1.247
t^3 (35)(2.).	-9.016	-3.948	-0.573	-0.167	-1.026	-0.091	0.111	0.125
t^3 (35)(4.).	3.150	1.203	0.082	0.089	-0.158	0.067	-0.029	0.176
t^3 (35)(6.).	8.147	3.192	-0.030	0.088	1.589	0.103	-0.210	0.329
t^3 (36)(1.).	-2.400	-0.793	-0.025	0.019	-1.102	0.142	-0.047	0.483
t^3 (36)(2.).	-5.601	-1.210	0.733	0.141	-3.571	0.109	-0.015	0.169
t^3 (36)(4.).	19.435	6.485	-0.645	-0.106	7.447	-0.036	0.029	0.147
t^3 (36)(5.).	6.961	2.440	0.060	0.027	1.992	-0.044	0.011	-0.042
t^3 (45)(1.).	-5.367	-2.223	-0.311	-0.063	-1.297	0.003	-0.236	0.246
t^3 (45)(2.).	4.873	1.656	-0.052	0.230	-0.927	0.087	0.288	0.282
t^3 (45)(3.).	8.623	3.447	0.249	-0.077	3.934	0.020	-0.113	-0.090
t^3 (45)(6.).	-3.413	-0.952	0.218	0.013	-1.167	-0.005	0.092	-0.387
t^3 (46)(1.).	7.623	2.314	-0.377	-0.099	3.698	-0.197	0.028	-0.601
t^3 (46)(2.).	-1.547	-0.277	0.286	-0.083	0.547	0.025	0.008	0.249
t^3 (46)(3.).	-4.623	-1.064	0.526	0.123	-3.054	0.078	-0.225	-0.053
t^3 (46)(5.).	6.225	2.051	-0.285	0.004	1.737	0.125	0.142	0.442
t^3 (56)(1.).	7.916	3.569	0.613	0.094	1.570	0.041	-0.028	0.142
t^3 (56)(2.).	-0.817	-1.143	-0.919	-0.093	0.687	-0.037	-0.046	-0.506
t^3 (56)(3.).	-15.107	-5.632	-0.031	-0.115	-3.581	-0.059	0.199	-0.288
t^3 (56)(4.).	-2.813	-1.100	0.067	-0.017	-0.570	-0.120	-0.233	-0.054

Table 12: The 4-line interaction effect of lines i, j, k and l due to particular arrangement t^4 (i j)(k l) for yield component traits and some fiber properties

t^4(i j)(k l)	**S.C.Y./P**	**L.Y./P**	**L. %**	**B. W**	**N. B./P**	**F.F**	**F.S**	**UHM**
t^4(12)(34)	-2.729	-1.182	-0.207	-0.091	-0.057	-0.074	-0.162	0.044
t^4(12)(35)	6.611	2.567	0.313	-0.005	2.219	-0.024	-0.133	0.053
t^4(12)(36)	-3.882	-1.385	-0.106	0.096	-2.162	0.098	0.296	-0.097
t^4(12)(45)	-3.882	-1.385	-0.106	0.096	-2.162	0.098	0.296	-0.097
t^4(12)(46)	6.611	2.567	0.313	-0.005	2.219	-0.024	-0.133	0.053
t^4(12)(56)	-2.729	-1.182	-0.207	-0.091	-0.057	-0.074	-0.163	0.044
t^4(13)(24)	-10.838	-3.536	0.573	-0.008	-3.246	0.112	-0.129	-0.018
t^4(13)(25)	-6.269	-2.718	-0.622	0.010	-2.141	-0.063	0.350	0.149
t^4(13)(26)	17.107	6.254	0.049	-0.001	5.387	-0.049	-0.221	-0.131
t^4(13)(45)	17.107	6.254	0.049	-0.001	5.387	-0.049	-0.221	-0.131
t^4(13)(46)	-6.269	-2.718	-0.622	0.010	-2.141	-0.063	0.350	0.149
t^4(13)(56)	-10.838	-3.536	0.573	-0.008	-3.246	0.112	-0.129	-0.018
t^4(14)(23)	13.567	4.717	-0.366	0.100	3.303	-0.038	0.292	-0.026
t^4(14)(25)	-4.351	-1.148	0.628	0.002	-1.662	0.134	-0.454	-0.022
t^4(14)(26)	-9.216	-3.569	-0.262	-0.102	-1.641	-0.096	0.163	0.049
t^4(14)(35)	-9.216	-3.569	-0.262	-0.102	-1.641	-0.096	0.163	0.049
t^4(14)(36)	-4.351	-1.148	0.628	0.002	-1.662	0.134	-0.454	-0.022
t^4(14)(56)	13.567	4.717	-0.366	0.100	3.303	-0.038	0.292	-0.026
t^4(15)(23)	-0.341	0.151	0.309	-0.005	-0.078	0.087	-0.217	-0.201
t^4(15)(24)	8.233	2.534	-0.523	-0.099	3.824	-0.232	0.158	0.119
t^4(15)(26)	-7.891	-2.685	0.213	0.104	-3.746	0.145	0.058	0.082
t^4(15)(34)	-7.891	-2.685	0.213	0.104	-3.746	0.145	0.058	0.082
t^4(15)(36)	8.233	2.534	-0.523	-0.099	3.824	-0.232	0.158	0.119
t^4(15)(46)	-0.341	0.151	0.309	-0.005	-0.078	0.087	-0.217	-0.201
t^4(16)(23)	-13.225	-4.869	0.057	-0.095	-3.225	-0.049	-0.075	0.228
t^4(16)(24)	2.605	1.002	-0.050	0.107	-0.578	0.120	-0.029	-0.101
t^4(16)(25)	10.620	3.866	-0.006	-0.012	3.803	-0.071	0.104	-0.126
t^4(16)(34)	10.620	3.866	-0.006	-0.012	3.803	-0.071	0.104	-0.126
t^4(16)(35)	2.605	1.002	-0.050	0.107	-0.578	0.120	-0.029	-0.101
t^4(16)(45)	-13.225	-4.869	0.057	-0.095	-3.225	-0.049	-0.075	0.228
t^4(23)(45)	-13.225	-4.869	0.057	-0.095	-3.225	-0.049	-0.075	0.228
t^4(23)(46)	-0.341	0.151	0.309	-0.005	-0.078	0.087	-0.217	-0.201
t^4(23)(56)	13.567	4.717	-0.366	0.100	3.303	-0.038	0.292	-0.026
t^4(24)(35)	2.605	1.002	-0.050	0.107	-0.578	0.120	-0.029	-0.101
t^4(24)(36)	8.233	2.534	-0.523	-0.099	3.824	-0.232	0.158	0.119
t^4(24)(56)	-10.838	-3.536	0.573	-0.008	-3.246	0.112	-0.129	-0.018
t^4(25)(34)	10.620	3.866	-0.006	-0.012	3.803	-0.071	0.104	-0.126
t^4(25)(36)	-4.351	-1.148	0.628	0.002	-1.662	0.134	-0.454	-0.022
t^4(25)(46)	-6.269	-2.718	-0.622	0.010	-2.141	-0.063	0.350	0.149
t^4(26)(34)	-7.891	-2.685	0.213	0.104	-3.746	0.145	0.058	0.082
t^4(26)(35)	-9.216	-3.569	-0.262	-0.102	-1.641	-0.096	0.162	0.049
t^4(26)(45)	17.107	6.254	0.049	-0.001	5.387	-0.049	-0.221	-0.131
t^4(34)(56)	-2.729	-1.182	-0.207	-0.091	-0.057	-0.074	-0.163	0.044
t^4(35)(46)	6.611	2.567	0.313	-0.005	2.219	-0.024	-0.133	0.053
t^4(36)(45)	-3.882	-1.385	-0.106	0.096	-2.162	0.098	0.296	-0.097

In conclusion, from the preivous results it could be concluded that the combinations [(P_1 x P_3) x (P_2 x P_6)], [(P_1 x P_3) x (P_4 x P_5)] and [(P_2x P_6) x (P_4x P_5)] appeared to be the best promising double crosses for breeding toward most studied yield traits potentiality. In general, [(P_1 x P_5) x (P_2 x P_4)], [(P_1 x P_5) x (P_3 x P_6)] and [(P_2x P_4) x (P_3x P_6)] would be good combinations for most studied yield traits and all fiber properties. Meanwhile, [(P_1 x P_3) x (P_2 x P_6)], [(P_1 x P_3) x (P_4 x P_5)] and [(P_2x P_6) x (P_4x P_5)] would be the best for most studied yield traits and fiber strength (F.S.) property. In addition, the combinations [(P_1 x P_6) x (P_2 x P_3)], [(P_1 x P_6) x (P_4 x P_5)], [(P_2x P_3) x (P_4x P_5)] and [(P_2x P_5) x (P_4x P_6)] appeared to be the best promising for upper half mean (UHM) property. Most of these combinations involved at least one of the best general combiners for yield. This indicates that predications of superior crosses based on the general combining ability effects of the parents would generally be valid and the contribution of non-allelic interaction in the inheritance of these traits. These findings may explain the superiority of the double crosses over their four parents for these traits.

Table 13: The estimation of genetic variances for yield components and some fiber properties

Genetic Parameters	S.C.Y. / P	L.Y. / P	L. %	B. W.	N. B./ P	F.F	F.S	UHM
σ^2A	861.9	104.2	-9.82	-0.16	18.30	-0.98	-0.77	-4.95
σ^2D	10112.4	1287.0	-17.27	0.22	963.43	1.73	5.93	-8.47
σ^2AA	-11450.8	-1444.1	33.02	-0.05	-1041.49	-0.09	-5.27	18.35
σ^2AD	-46585.6	-5711.6	57.07	-1.95	-4546.73	-7.51	-30.56	52.88
σ^2DD	46051.8	5723.3	-17.44	2.72	4583.35	5.63	26.14	-5.49
σ^2AAA	31057.1	3807:7	-38.05	1.30	3031.16	5.01	20.37	-35.25

Genetic parameters:

The Genetic parameters estimates were obtained and the results are presented in Table 13.The results revealed that the magnitudes of dominance genetic variance (σ^2D) were positive and larger than those of additive genetic variance (σ^2A), for all studied traits except for (L. %) and (UHM).

Concerning epistatic variances, additive by additive genetic variance (σ^2AA) and additive by dominance genetic variance (σ^2AD) showed negative and considerable magnitude for all studied traits except for the same two previous traits (L.%) and (UHM). While, dominance by dominance genetic variance (σ^2DD) and additive by additive by additive genetic variance (σ^2AAA) showed positive and considerable magnitude for all studied traits with the exception of the (L.%) and (UHM). It could be concluded that fiber properties and yield components were mainly controlled by dominance by dominance (σ^2DD) and additive by additive by additive (σ^2AAA) epistatic variances. This finding may explain the superiority of most studied double crosses than their parents in most of yield components traits. Therefore, it could be recommended that production of double crosses to involved in the selection breeding programs is the desirable way for improvement these traits. These results are partially agreement with those obtained by Abd El-Bary (2003), Yehia (2005) and Hemaida *et al* (2006).

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تحليل الهجن الرباعية لمكونات المحصول وصفات التيلة في القطن

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اشتملت الدراسة على ستة أصناف من القطن الباربادنس هى : جيزه ٨٦ ، TNB1 ، Suvin ، CB-58 ، جيزه ٨٥ و جيزه ٨٩. طبقا لنظام التزاوج الدائرى النصف كامل أدخلت هذه الأباء فى سلسلة من التهجينات لتنتج ١٥ هجين جيل أول خلال موسم النمو ٢٠٠٤ وفى موسم النمو ٢٠٠٥ تم تزاوج هجن الجيل الأول معا لإنتاج ٤٥ هجين رباعى (زوجى) (بشرط ظهور اي أب في الهجين الرباعى مرة واحدة). وفى موسم النمو ٢٠٠٦ ، تم تقييم هذه التراكيب الوراثية المختلفة (الأباء الستة ، ٤٥ هجين رباعى) بمحطة البحوث الزراعية بسخا حيث تم قياس الصفات الآتية: محصول القطن الزهر للنبات ، محصول القطن الشعر

للنبات ، وزن اللوزة ، عدد اللوز المتفتح للنبات ، معامل الحليج ، متانة التيلة ،نعومة التيلة، طول التيلة .
هذا ويمكن تلخيص النتائج المتحصل عليها من هذه الدراسة فى النقاط التالية:

- اختبار المعنوية لمتوسط المربعات الخاصة بالتراكيب الوراثية أشار إلى أن هناك اختلافا إما معنويا أو عالي المعنوية بين هذه التراكيب الوراثية لكل الصفات المدروسة كما أظهرت تجزئة متوسط المربعات الخاصة بالهجن لمكوناته أهمية وجود التباين المضيف و التباين غير المضيف بكل مكوناته (التباين السيادى ، التباين المضيف × السيادى، التباين السيادى × السيادى ، التباين المضيف × المضيف و التباين المضيف × المضيف × المضيف).
- من خلال تحليل الهجن الرباعية كان أفضل الأصناف قدرة عامة على التآلف الصنفين جيزه ٨٩ و TNB1 لصفات المحصول ومكوناته بالإضافة لصفة طول التيلة و الصنف جيزه ٨٦ لصفات نعومة التيلة، طول التيلة و وزن اللوزة .
- **القدرة الخاصة علي التآلف** : توجد سبعة أنواع من القدرة الخاصة علي التآلف تندرج تحت ثلاث مجاميع كالتالي

المجموعة الاولي : قدرة خاصة بين سلالتين

١- في هذا النوع لا يهم ترتيب السلالتين سواءاً كانتا معا في نفس الهجين الفردى أو كل سلالة في هجين فردى مستقل وكانت افضل الأتحادات عند تواجد جـ٨٩ مع TNB1 أو جـ٨٩ معSuvin لمعظم صفات المحصول.

٢- في هذا النوع يشترط وجود السلالتين معا في نفس الهجين الفردى وكانت أفضل الاتحادات عند تواجد Suvin مع TNB1 أو CB-58 مع Suvin لمعظم صفات المحصول.

٣- في هذا النوع يشترط وجود إحدى السلالتين في هجين فردى والسلالة الأخري في الهجين الفردي الثاني وكانت افضل الأتحادات عند تواجد TNB1 في هجين فردى و جـ٨٥ في هجين فردى آخر لنفس الهجين الزوجى لصفة متانة التيلة بجانب صفات المحصول .

المجموعة الثانية : قدرة خاصة بين ثلاث سلالات

٤- في هذا النوع لا يهم ترتيب السلالات (اي سلالتين في هجين فردي والسلالة الثالثة في الهجين الفردى الآخر) وكانت أفضل الاتحادات عند تواجد TNB1 مع Suvin مع جـ٨٩ لمعظم صفات المحصول.

٥- في هذا النوع يشترط وجود السلالتين الأولي والثانية في الهجين الفردى الأول والسلالة الثالثة في الهجين الفردي الثاني) وكانت افضل الاتحادات عند تواجد Suvin مع جـ٨٩ في الهجين الفردى الأول و CB-58 في الهجين الفردى الثاني لصفات المحصول .

المجموعة الثالثة : قدرة خاصة بين أربع سلالات

٦- في هذا النوع لا يهم ترتيب السلالات (اي سلالتين في هجين فردي والسلالتين الأخريين في الهجين الفردى الأخر) وكانت أفضل الاتحادات عند تواجد TNB1 و Suvin وCB-58 و جـ٨٩ معا لمعظم صفات المحصول والتيلة أو تواجد جـ٨٦ وTNB1 و Suvin و جـ٨٩ معا لصفات المحصول .

٧- في هذا النوع يشترط وجود السلالتين الأولي والثانية في الهجين الفردى الأول والسلالتين الثالثة والرابعة في الهجين الفردي الثاني) وكانت أفضل الاتحادات عند تواجد Suvin مع جـ٨٦ في الهجين الفردى الاول و جـ٨٩ مع TNB1 في الهجين الفردى الثاني أو تواجد Suvin مع جـ٨٦ في الهجين الفردى الأول و جـ٨٥ مع CB-58 في الهجين الفردى الثانى أو تواجد جـ٨٩ مع TNB1 في الهجين الفردى الاول و جـ٨٥ مع CB-58 في الهجين الفردى الثانى لصفات المحصول .

- أوضحت النتائج وجود قوة الهجين بصفة أساسية عند تقديرها من متوسط الأباء لمعظم الصفات. أما قوة الهجين عند تقديرها من أفضل الأباء فلم تكن ذات أهمية اقتصادية فى أغلب الصفات.
- أظهرت الهجن التالية أفضل إمكانية لإستخدامها في برامج التربية لتحسين صفات المحصول ومكوناته وفى مقدمتها محصول القطن الزهر ومحصول القطن الشعر وعدد اللوز المتفتح الكلي للنبات ثم باقى المكونات الأخرى للمحصول وهذه الهجن هى : [(جيزه ٨٦ × Suvin) (TNB1× جيزه ٨٩)] ، [(جيزه ٨٦ × Suvin) (CB-58× جيزه ٨٥)] و[(TNB1× جيزه ٨٩) (CB-58× جيزه ٨٥)] .
- أظهرت الهجن : [(جيزه ٨٦ × جيزه ٨٥) (TNB1× CB-58)]، [(جيزه ٨٦ × جيزه ٨٥) (Suvin × جيزه ٨٩)] [(TNB1 × CB-58) (Suvin × جيزه ٨٩)] افضل امكانية لإستخدامها فى تحسين صفات المحصول و التيلة معا.
- أوضحت النتائج أن قيم التباين السيادى كانت موجبة و أعلي من التباين المضيف لمعظم الصفات المدروسة.
- بينت النتائج أن قيم التباين المضيف × السيادى و التباين المضيف × المضيف × المضيف تلعب دوراً هاماً فى توارث معظم الصفات المدروسة ولذلك يجب على مربى القطن أن يستخدم هذه النتائج من اجل استنباط سلالات عالية الإنتاج من خلال تصميم برنامج انتخابى فى الأجيال الانعزالية المتقدمة من الهجن الرباعية المتفوقة.