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QUADRIALLEL ANALYSIS FOR SOME YIELD COMPONENTS AND FIBER TRAITS IN COTTON (*Gossypium barbadense* L.)

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ABSTRACT

Combining ability estimates for yield,its components and some fiber properties of the Egyptian cotton species were the ultimate aim of this investigation. The genetic materials used in the present study included six cotton genotypes and their 45 double crosses. In 2020 growing season, these genotypes were evaluated in a field experiment at sids Agricultural Research Station, Beni-suef Governorate for the following traits: boll weight (BW), number of bolls/plant (NB/P), seed cotton yield/plant (SCY/P), lint yield/plant (LY/P), lint percentage (LP), upper half mean (UHM), uniformity ratio(UR) ,fiber fineness (FF) and fiber strength (FS) . The results showed that the mean squares of genotypes were highly significant for all its components except for boll weight (BW) and lint percentage (LP) traits, the partition of crosses mean square to its components showed that the mean square due to 1-line general, 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 85 (P_2) was the best general combiner for most studied yield component traits such as NB/P, SCY/P, LY/P and LP. Also, the variety S106(P_6) showed a positive desirable value of general combining ability for the same previous traits and was also the best combiner for UHM. Concerning the 2-line interaction effect, (S^2_{12}), (S^2_{13}), (S^2_{24}), (S^2_{26}) and (S^2_{46}) showed positive (desirable) effects for most yield components. Moreover, the best combinations for UHM, UR and FS were shown by (S^2_{46}), (S^2_{34}) and (S^2_{25}), respectively. On the other hand the 3-line interaction effect cleared that the combinations (S^3_{124}),(S^3_{126}),(S^3_{136})and (S^3_{246}) showed great positive (desirable) effects for all yield and yield component traits In the same time, (S^3_{125}), (S^3_{134}) and (S^3_{256}) revealed the best combinations for FS. Beside (S^3_{125}), (S^3_{126}) and (S^3_{146}) for UHM as well as [(S^3_{125}) and (S^3_{346})] for UR property. Concerning, the 4-line interaction effect revealed that the best double cross combinations for SCY/P, LY/P was (S^4_{2456}). Moreover, (S^4_{1356}), (S^4_{1246}) (S^4_{1235}), and (S^4_{1346}) were the best double cross combinations for NB /P, LP, UHM, UR and (FS) respectively. With respect to the specific combining ability effects t^2 $_{(ij)}$ (..) showed that the best double cross combinations for B.W, SCY/P, LY/P and FF was $t^2_{(15)}$(..). The combinations $t^2_{(23)}$(..) and $t^2_{(26)}$(..), were the best combinations for NB./P, LP, UHM, UR and FS traits, respectively. It seams that the combinations [(P_1×P_3) x (P_2×P_5)], [(P_1×P_3)x(P_4×P_6)] and [(P_2×P_5)×(P_4× P_6)] appeared to be the best promising double crosses for breeding toward most studied yield traits potentiality. As for gene action, the magnitudes of dominance genetic variance (σ^2_D) were positive and larger than those of additive genetic variance (σ^2_A), for all studied traits except of BW, LP, FF and FS. Besides, the epistatic variances, additive by additive (σ^2_{AA}) and additive by dominance (σ^2_{AD}) were negative and considerable magnitude for all studied traits except for the same four previous traits BW, LP, FF and FS. Besides, the epistatic effects of dominance by dominance genetic variance (σ^2_{DD}) and additive by additive by additive genetic variance (σ^2_{AAA}) showed positive and considerable magnitude for all studied traits with the exception of BW, LP, FF and FS. Therefore, it could be recommended that production of double crosses to be involved in the selection breeding programs is the desirable way for improvement of these traits.

Key words: ***Cotton, Quadriallel analysis, Gene action and Combining ability.***

INTRODUCTION

Cotton is a fiber crop grown throughout tropical and sub-tropical areas of the world. Also it plays a principal role in the economy of a number of developing as well as developed countries. Among the cotton growing countries, yield increase is due to breeding programs, production improvement, and management techniques, in order to produce high yielding genotypes in Egypt. Cotton improvement has been carried out by conventional breeding techniques for many years. The main goal of cotton breeding is to increase yield and fiber quality.

A quadriallel is the first generation progeny of the crossing between unrelated F_1 hybrids viz., (a×b) × (c×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 (1962). 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 workers studied general and specific combining abilities among them; Meredith (1990) and Hemaida *et al* (2006). Jagtab and Kolhe (1987) showed that both additive and non-additive gene action played a significant role for the inheritance of boll weight, bolls number/plant, seed cotton yield and lint percentage. In the same time, Kosba *et al* (1991) found that fiber characters were controlled by additive and non-additive types of gene action. 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) found 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. . El-Hoseiny (2009) stated that parents, Australian (P_1) , BBB (P_2), and Giza 70 (P_4) had highest and negative value of 2-line general effect which were good specific combination of ($P_1 \times P_2$)(--) and ($P_2 \times P_4$)(--) when they go into another arrangement i.e. ($P_1 \times$ -)($P_2 \times$ -) and ($P_2 \times$ -)($P_4 \times$-) showed the positive 2-line specific effect for most earliness traits as undesirable direction. Said (2011) found that σ^2AA, σ^2AD and σ^2AAA genetic variances were positive with high magnitude for most studied traits. El-Hashash (2013) reported that additive by additive and additive by dominance genetic variances were observed and were higher than the other types of epistatic genetic variances for all yield components and fiber quality traits under study.

Thus, this investigation was carried out to estimate combining ability and gene action for some yield components and fiber properties using quadriallel crosses of six cotton Egyptian genotypes.

MATERIALS AND METHODS

The genetic material and mating design

The genetic materials used in this investigation included six cotton genotypes (*Gossypium barbadense* L.), namely, Giza 80 (P_1), Giza 85(P_2), Giza 90 (P_3) and Giza 95 (P_4), R101 (Russian stain) (P5) which are characterized by high early maturity, in addition to S106 (Pima stain) (P6). The pure seeds of all genotypes were obtained from Cotton Breeding Section, Cotton Research Institute, Agricultural Research Center, Giza, Egypt. These genotypes were used as parents to produce 45 possible double crosses (quadriallel crosses). A series of hybridizations were done to (double crosses) mating design as follows: In the growing season 2018, the six parents were planted and mated in a diallel fashion excluding reciprocals to obtain 15 single crosses. In 2019 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 combinations to obtain 45 double crosses; [number of double crosses = [P(P-1) (P-2) (P-3)/8] ,where, P: is number of parental genotypes.

Experimental design

In 2020 growing season, these 51 genotypes which included the six parental genotypes and their 45 double crosses were evaluated in a field trial experiment at Sids Agricultural Research Station, Beni-Suef governorate. The experimental design was a Randomized Complete Block Design (RCBD) with three replications. Each plot was one row 4.0 m. long and 0.65 m. wide. Hills were 0.40 m. apart to insure 10 hills per row. Hills were thinned to keep a constant stand of one plant per hill at seedling stage. Ordinary cultural practices were followed as the recommendations.

Data were recorded on the following traits: boll weight in grams (BW), number of opened bolls per plant(B/P), seed cotton yield per plant in grams (SCY/P), lint yield per plant in grams (LY/P), lint percentage (LP) , upper half mean (UHM), uniformity ratio (UR), fiber fineness (FF) and fiber strength (FS). The fiber properties were measured in the laboratories of Cotton Fiber Research Section, Cotton Research Institute according to (ASTM ;1967) D-1447-59, D-1447-60T and D-1447-67.

Biometrical analysis

Statistical procedures used in this study were done according to the analysis of variance for RCBD as outlined by Cochran and Cox (1957).

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

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 $(_{i\,j})(_{k\,l})$.

The theoretical aspect of quadriallel analysis has been illustrated by Rawling and Cockerham (1962) 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.

Table 1. Form of the analysis of variance of the double crosses.

SOV	df	SS	MS
Replications	r-1	$(8\sum Y^2 \ldots. m) /(r\ p\ p_1\ p_2\ p_3) - C.$	R
Hybrids	$3^6\ C_4$-1	$(\sum Y^2{}_{(i\ j)\ (kl)} /r) – C$	H
1-line general	P_1	$(2\sum Y^2{}_{i....} /r\ p_2\ p_3\ p_4) – (4p_1 / p_4)\ C$	G
2- line specific	$P\ P_3 /2$	$(2\sum Y^2\ ij... /3r\ p_4\ p_5) – (6pp_2 / p_4p_4)\ C –(3p_3 / p_5)\ G$	S_2
2- line arrangement	$P\ P_3/2$	$(2\sum Y^2\ (i\ j)\ (.\ .)./r\ p_1\ p_2) +(\sum Y_2\ (i\ .)\ (j\ .).\ /r\ p_1\ p_2) - (2\sum Y^2\ ij... /3r\ p_{1\ 2})$	T_2
3-line arrangement	$P\ P_2\ P_4/3$	$(\sum Y^2{}_{(i\ j)\ (k\ .)} ./r\ p_3) - (\sum Y^2{}_{ijk\ ..} /3r\ p_3 – (2p_2/ p_3)\ T_2$	T_3
4- line arrangement	$P\ P_1\ P_4\ P_5/12$	$(\sum Y^2{}_{(i\ j)\ (k\ 103l)} /r) - (\sum Y^2{}_{ijkl\ .} /3r) - T_2 - T_3$	T_4
Error	$(r-1)\ (3^6\ C_4 - 1)$	M - R - H	E
Total	3r6 C4 - 1	$\sum$Y2 (i j) (kl) m – C	

Estimation of combining Ability Effects

1- $gi = [\, Yi\ldots . / (r\ p1\ p2\ p3/2)] - \mu$ Where, $\mu = Y\ldots . / (p1\ p2\ p3/8)$

2- $S2ij = [Yij\ldots/(3r\ p2p3/2)] - \mu - gi - gj$

3- $S3ijk = (Yijk\ldots / 3r\ p3) - \mu - gi - gj - gk - Sij - Sik - Sjk$

4- $S4(ijkl) = [(Yijkl\ ../(3r)] - \mu - gi - gj - gk - gl - Sij - Sik - Sil - Sjk - Sjl - Skl - Sijk - Sijl - Sjkl - Sjkl$

5- $t2(ij)(..) = [Y(ij)(..). /(r\ p2p3/2)] - \mu - gi - gj - Sij$

6- $t2(i\ -)\ (j\ -) = [Y(i\ .)(j\ .). / r\ p2p3] - \mu - gi - gj - Sij$

7- $t3\ (ij)\ (k\ -) = [Y(ij)(k.). / r\ p3] - \mu - gi - gj - gk - Sij - Sik - Sjk - Sijk - t2ij - t2i.k - t2j.k$

8- $t4\ (ij)\ (k\ l) = [Y(ij)(kl). / r] - \mu - gi - gj - gk - gl - Sij - Sik - Sil - Sjk - Sjl - Skl - Sijk - Sijl - Sikl - Sjkl - Sijkl$
$- t2ij - t2kl - t2i.\ k - t2i\ .\ l - t2j.\ k - t2j.\ l - t3ij.\ k - t3ij.\ l - t3kl\ .i. - t3kl\ .j$

RESULTS AND DISCUSSION

The mean squares of genotypes and crosses were highly significant for yield and its components except for boll weight (BW) and lint percentage (LP) traits. Furthermore, the partition of crosses mean squares to its components (Table 2) showed that the mean square due to 1-line general were significant for all studied traits except for boll weight (BW) trait 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.

Table 2. The analysis of variance of the double crosses for yield component traits and some fiber properties.

SOV	df	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
Rep.	2	0.00233	10.25628	101.17758	18.43253	0.30685	0.48635	0.30465	0.04185	0.01308
Crosses	44	0.01538	12.38029**	158.76022**	28.10451**	0.56818	0.34674	0.46847	0.02981	0.15119
1_line general	5	0.00733	14.03659*	163.08935*	29.91855*	0.93426*	0.88328	0.46296	0.02753	0.19288
2_line specific	9	0.01190	4.66604	50.56584	8.83957	0.21239	0.24359	0.24402	0.04276	0.13707
2_line arrangement	9	0.02050	13.72804*	152.49726**	26.75406*	0.85664*	0.33091	0.17041	0.04234	0.20304
3_line arrangement	16	0.01888	14.61296**	210.38699**	37.23183**	0.55464	0.21103	0.63003	0.02208	0.14708
4_line arrangement	5	0.00930	15.03914*	195.24865**	34.19072**	0.36660	0.45859	0.89751	0.01094	0.05477
Error	88	0.01554	5.32095	56.04870	10.16543	0.37104	0.39243	0.39184	0.03202	0.10613

The estimates 2-line arrangement were significant and highly significant for all traits except for boll weight (BW) trait suggesting the presence of the non-additive variance in the inheritance of these traits. Also,3-line arrangement mean squares were highly significant for yield and its components except for boll weight (BW)and lint percentage (LP) traits indicating the contribution of additive by dominance interaction including all three factors or higher order interactions except all dominance types. Furthermore, the results tests of significant showed that the mean squares due to 4-line arrangement were significant and/or highly significant for all studied traits except for boll weight (BW) and lint percentage (LP) traits referred to the contribution of dominance by dominance genetic variances in the genetic expression of these traits and all three factor interactions, except all additive types.

General combining ability effects for each parental variety

The estimates of general combining ability effects (g_i) of parental genotypes were obtained for yield and yield component traits and some fiber properties (Table 3). Positive estimates would indicated 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 for fiber fineness (desirable = negative value). Comparison of the general combining ability effects (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 3. General line effect (gi) for yield component traits and some fiber properties.

Parents	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
G.80 (P_1)	**0.00**	**-0.24**	**-0.74**	**-0.28**	**0.00**	**0.04**	**0.06**	**0.00**	**0.03**
G.85 (P_2)	**0.00**	**0.17**	**0.60**	**0.34**	**0.11**	**-0.03**	**-0.04**	**-0.01**	**0.00**
G.90 (P_3)	**0.01**	**0.06**	**0.47**	**0.15**	**-0.03**	**-0.09**	**0.04**	**-0.01**	**-0.03**
G.95 (P_4).	**0.00**	**-0.04**	**-0.08**	**-0.01**	**0.02**	**-0.03**	**-0.01**	**0.02**	**0.00**
R101(P_5)	**-0.01**	**-0.31**	**-1.23**	**-0.56**	**-0.09**	**0.04**	**-0.05**	**0.00**	**0.03**
S106 (P_6)	**0.00**	**0.35**	**0.99**	**0.36**	**-0.02**	**0.07**	**-0.01**	**-0.01**	**-0.03**

The variety Giza 85 (P_2) was the best general combiner for most studied yield component traits such as B/P, SCY/P, LY/P and lint percentage (LP). Also, the variety S106 (P_6) had the positive desirable values of general combining ability for the same previous traits and the best combiner for upper half mean (UHM). Furthermore, the results revealed that the variety R101 (P_5) and Giza 80 (P_1) were the best combiner among this group of genotypes for fiber strength (FS), which had positive (desirable) value. Thus, it could be suggested that these parental genotypes 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 4.

Table 4. The 2-line interaction effect of lines i and j appearing together irrespective of arrangement S2ij for yield component traits and some fiber properties

S^2_{ij}	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
S^2 12	0.00	0.04	0.13	0.09	0.04	0.02	0.03	0.00	0.01
S^2 13	0.01	0.05	0.56	0.23	0.01	-0.03	-0.01	0.01	0.01
S^2 14	0.00	-0.25	-0.59	-0.23	0.00	0.00	0.01	-0.01	0.01
S^2 15	-0.01	-0.21	-0.85	-0.37	-0.04	0.02	0.00	-0.01	0.01
S^2 16	-0.01	0.13	0.02	0.00	-0.01	0.03	0.03	0.01	0.00
S^2 23	0.00	-0.10	-0.38	-0.16	-0.01	-0.03	-0.01	-0.02	0.00
S^2 24	0.00	0.19	0.55	0.27	0.05	-0.06	-0.03	0.01	-0.03
S^2 25	0.00	-0.06	-0.09	-0.04	-0.02	0.01	0.01	0.01	0.04
S^2 26	0.00	0.10	0.39	0.19	0.04	0.03	-0.04	-0.01	-0.01
S^2 34	0.00	0.03	0.14	0.02	-0.04	-0.02	0.04	0.00	0.01
S^2 35	-0.01	0.05	-0.05	-0.02	0.00	0.01	0.00	0.00	-0.01
S^2 36	0.00	0.03	0.20	0.09	0.00	-0.02	0.01	0.00	-0.04
S^2 45	0.00	-0.08	-0.40	-0.14	0.01	0.00	-0.04	0.01	0.00
S^2 46	0.00	0.08	0.22	0.08	-0.01	0.05	0.01	0.00	0.01
S^2 56	0.00	0.00	0.15	0.01	-0.04	-0.01	-0.02	-0.01	0.00

The results cleared that no hybrids exhibited desirable values for all studied traits. It could be noticed that ($S^2{}_{12}$), ($S^2{}_{13}$), ($S^2{}_{24}$), ($S^2{}_{26}$) and ($S^2{}_{46}$) showed positive (desirable) effects for most yield components. Moreover, the best combinations for (UHM) (UR) and (FS) were ($S^2{}_{46}$), ($S^2{}_{34}$) and ($S^2{}_{25}$), respectively.

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 5.

Table 5. The 3-line interaction effects of lines i, j and k appearing together irrespective of arrangement S3ijk for yield component traits and some fiber properties.

$S^3{}_{ijk}$	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
S^3 123	0.006	-0.004	0.193	0.089	0.015	-0.015	-0.009	-0.004	0.012
S^3 124	0.003	0.017	0.159	0.112	0.047	-0.037	-0.001	-0.003	-0.029
S^3 125	-0.002	-0.110	-0.356	-0.155	-0.025	0.036	0.050	0.002	0.033
S^3 126	-0.007	0.184	0.257	0.133	0.037	0.048	0.013	0.006	0.002
S^3 134	0.014	-0.100	0.220	0.062	-0.025	-0.023	0.014	0.001	0.028
S^3 135	0.001	0.047	0.160	0.067	0.010	0.004	-0.023	0.005	-0.010
S^3 136	0.002	0.157	0.544	0.234	0.020	-0.031	0.001	0.023	-0.019
S^3 145	-0.004	-0.351	-1.161	-0.453	-0.005	0.013	-0.029	-0.013	-0.005
S^3 146	-0.006	-0.065	-0.405	-0.173	-0.018	0.051	0.040	-0.007	0.023
S^3 156	-0.008	-0.015	-0.350	-0.197	-0.055	-0.005	0.008	-0.006	-0.002
S^3 234	-0.004	0.053	-0.022	-0.035	-0.020	-0.058	0.007	-0.006	-0.011
S^3 235	-0.006	-0.089	-0.460	-0.197	-0.020	0.025	0.023	-0.013	0.024
S^3 236	-0.001	-0.155	-0.476	-0.169	0.015	-0.004	-0.032	-0.021	-0.027
S^3 245	0.000	0.100	0.304	0.157	0.036	-0.039	-0.032	0.027	-0.008
S^3 246	0.002	0.209	0.661	0.298	0.047	0.007	-0.041	0.006	-0.021
S^3 256	0.012	-0.029	0.338	0.108	-0.024	0.005	-0.019	-0.004	0.027
S^3 345	-0.008	0.090	-0.026	-0.006	0.007	0.020	0.008	0.011	0.002
S^3 346	0.001	0.015	0.101	0.012	-0.033	0.019	0.059	0.004	0.011
S^3 356	0.002	0.051	0.234	0.094	0.002	-0.029	-0.008	-0.007	-0.040
S^3 456	0.003	-0.004	0.084	0.019	-0.012	0.013	-0.031	0.002	0.011

The results showed that no hybrids exhibited desirable values for all studied traits. The combinations (S^3_{124}),(S^3_{126}),(S^3_{136})and (S^3_{246}) showed great positive (desirable) effects for all yield and yield component traits In the same time, (S^3_{125}), (S^3_{134}) and (S^3_{256}) were the best combinations for (FS), while (S^3_{125}), (S^3_{126}) and (S^3_{146}) for (UHM) as well as [(S^3_{125}) and (S^3_{346})] for (UR) 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 6.

Table 6. The 4-line interaction effects of lines i, j, k and l appearing together irrespective of arrangement S4ijkl for yield component traits and some fiber properties.

S^4_{ijkl}	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
S^4 1234	0.02	-0.03	0.70	0.24	-0.03	-0.14	-0.01	-0.02	0.00
S^4 1235	0.00	-0.08	-0.24	-0.12	-0.03	0.10	0.05	-0.01	0.07
S^4 1236	0.00	0.10	0.12	0.15	0.10	0.00	-0.07	0.02	-0.03
S^4 1245	0.00	-0.31	-0.85	-0.25	0.06	-0.05	0.00	0.01	-0.05
S^4 1246	-0.01	0.39	0.63	0.35	0.11	0.08	0.01	0.00	-0.04
S^4 1256	0.00	0.06	0.03	-0.09	-0.10	0.06	0.10	0.00	0.07
S^4 1345	0.01	-0.21	-0.42	-0.14	0.03	0.04	-0.07	0.00	0.00
S^4 1346	0.01	-0.06	0.37	0.09	-0.07	0.03	0.13	0.03	0.08
S^4 1356	0.00	0.43	1.14	0.46	0.03	-0.12	-0.05	0.03	-0.11
S^4 1456	-0.02	-0.53	-2.21	-0.96	-0.10	0.05	-0.02	-0.05	0.03
S^4 2345	-0.03	0.28	-0.18	-0.08	-0.01	-0.02	0.04	0.03	0.01
S^4 2346	-0.01	-0.09	-0.59	-0.26	-0.03	-0.01	0.00	-0.02	-0.04
S^4 2356	0.01	-0.47	-0.96	-0.39	-0.03	0.00	-0.02	-0.06	-0.01
S^4 2456	0.03	0.33	1.95	0.81	0.06	-0.05	-0.13	0.04	0.01
S^4 3456	0.00	0.20	0.52	0.21	0.00	0.04	0.06	0.01	-0.01

The results revealed that no hybrids exhibited desirable values for all studied traits. The best double cross combinations for seed cotton yield/plant

(SCY/P), lint yield/plant (LY/P) was (S^4_{2456}). Moreover, (S^4_{1356}), (S^4_{1246}) (S^4_{1235}), and (S^4_{1346}) were the best double cross combinations for B/P, LP, UHM, UR and FS respectively.

Two-line interaction effect of lines i and j due to a 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 data are presented in Table 7. The results indicated that no hybrids exhibited desirable values for all studied traits. The best double combinations for boll weight (BW) seed cotton yield/plant (SCY /P), lint yield/plant (LY /P) and fiber fineness (FF) was $t^2(_{15})(..)$. The combinations $t^2(_{23})(..)$ and $t^2(_{26})(..)$ were the best combinations for LP, B/P, UHM, UR and FS traits, respectively.

Table 7. The 2- line interaction effect of lines i and j due to particular arrangement t2(ij)(..) for yield component traits and some fiber properties.

$t^2(_{ij})$ (..).	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
t^2 (12)(..).	0.00	-0.43	-1.37	-0.56	-0.01	-0.13	0.08	0.03	-0.02
t^2 (13)(..).	-0.01	-0.07	-0.53	-0.27	-0.07	0.05	0.02	0.07	0.01
t^2 (14)(..).	-0.03	1.05	2.02	0.67	-0.10	0.09	-0.09	-0.04	0.00
t^2 (15)(..).	0.06	0.85	4.68	2.05	0.23	0.13	0.06	-0.05	0.12
t^2 (16)(..).	-0.02	-1.40	-4.80	-1.88	-0.05	-0.14	-0.06	0.00	-0.11
t^2 (23)(..).	0.00	0.40	1.08	0.67	0.24	-0.04	-0.01	-0.06	-0.16
t^2 (24)(..).	0.03	-0.09	0.96	0.45	0.06	-0.13	0.01	0.04	0.12
t^2 (25)(..).	-0.02	-0.81	-2.96	-1.47	-0.31	0.03	-0.19	0.02	-0.07
t^2 (26)(..).	-0.01	0.92	2.29	0.92	0.02	0.28	0.11	-0.03	0.13
t^2 (34)(..).	-0.03	-0.07	-1.20	-0.80	-0.34	0.12	-0.02	-0.04	-0.01
t^2 (35)(..).	0.00	-0.72	-2.22	-0.74	0.11	-0.06	0.10	0.05	0.08
t^2 (36)(..).	0.04	0.46	2.87	1.14	0.05	-0.06	-0.09	-0.02	0.08
t^2 (45)(..).	0.00	-0.12	-0.45	0.01	0.18	-0.04	0.04	-0.02	-0.06
t^2 (46)(..).	0.03	-0.77	-1.32	-0.33	0.20	-0.02	0.05	0.05	-0.04
t^2 (56)(..).	-0.04	0.79	0.95	0.15	-0.21	-0.05	-0.01	0.00	-0.07

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 8. The results showed that no hybrids exhibited desirable values for all studied traits. It could be noticed that $t^2(_{1.})(_{6.})$, $t^2(_{2.})(_{5.})$ and $t^2(_{3.})(_{5.})$ were the best combinations for most yield components. Meanwhile, $t^2(_{2.})(_{4.})$, $t^2(_{2.})(_{5.})$ and $t^2(_{2.})(_{3.})$ were the best combinations for(UHM),(UR) , and (FS) properties, respectively.

Table 8. The 2-line interaction effect of lines i and j due to particular arrangement t2(i.)(j.). for yield component traits and some fiber properties.

$t^2(_{i.})(_{j.})$.	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
t^2(1.)(2.).	0.00	0.21	0.69	0.28	0.00	0.06	-0.04	-0.01	0.01
t^2(1.)(3.).	0.00	0.04	0.26	0.14	0.03	-0.03	-0.01	-0.03	0.00
t^2(1.)(4.).	0.02	-0.52	-1.01	-0.34	0.05	-0.04	0.05	0.02	0.00
t^2(1.)(5.).	-0.03	-0.43	-2.34	-1.02	-0.11	-0.06	-0.03	0.03	-0.06
t^2(1.)(6.).	0.01	0.70	2.40	0.94	0.03	0.07	0.03	0.00	0.05
t^2(2.)(3.).	0.00	-0.20	-0.54	-0.33	-0.12	0.02	0.00	0.03	0.08
t^2(2.)(4.).	-0.02	0.04	-0.48	-0.22	-0.03	0.07	-0.01	-0.02	-0.06
t^2(2.)(5.).	0.01	0.41	1.48	0.73	0.16	-0.01	0.10	-0.01	0.04
t^2(2.)(6.).	0.01	-0.46	-1.15	-0.46	-0.01	-0.14	-0.05	0.01	-0.07
t^2(3.)(4.).	0.01	0.04	0.60	0.40	0.17	-0.06	0.01	0.02	0.01
t^2(3.)(5.).	0.00	0.36	1.11	0.37	-0.06	0.03	-0.05	-0.03	-0.04
t^2(3.)(6.).	-0.02	-0.23	-1.44	-0.57	-0.02	0.03	0.04	0.01	-0.04
t^2(4.)(5.).	0.00	0.06	0.23	-0.01	-0.09	0.02	-0.02	0.01	0.03
t^2(4.)(6.).	-0.01	0.38	0.66	0.17	-0.10	0.01	-0.03	-0.03	0.02
t^2(5.)(6.).	0.02	-0.40	-0.47	-0.08	0.11	0.03	0.00	0.00	0.03

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 9.

Table 9. 3- line interaction effect of lines i, j and k due to particular arrangement t3(i j)(k-) for yield component traits and some fiber properties.

t^3 (i j)(k-)	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
t^3 (12)(3.).	-0.02	0.34	0.42	0.25	0.06	-0.01	-0.05	-0.04	-0.08
t^3 (12)(4.).	-0.01	-0.60	-2.07	-0.96	-0.13	-0.09	-0.28	0.00	0.00
t^3(12)(5.).	0.02	0.94	3.36	1.29	-0.01	0.07	0.26	0.01	-0.05
t^3 (12)(6.).	0.01	-0.24	-0.34	-0.02	0.09	0.16	-0.01	0.00	0.16
t^3 (13)(2.).	0.03	0.61	2.66	0.98	-0.03	0.06	-0.06	0.02	0.16
t^3 (13)(4.).	0.00	0.93	2.60	1.07	0.07	0.14	0.04	-0.04	0.01
t^3 (13)(5.).	-0.01	-0.80	-2.52	-0.97	-0.01	-0.12	0.10	-0.03	-0.05
t^3(13)(6.).	-0.01	-0.67	-2.21	-0.82	0.03	-0.13	-0.09	-0.02	-0.13
t^3 (14)(2.).	0.00	-0.85	-2.43	-1.01	-0.08	-0.18	0.04	0.01	-0.03
t^3 (14)(3.).	0.01	-0.80	-2.12	-0.74	0.07	0.01	0.08	-0.01	-0.01
t^3 (14)(5.).	-0.01	-0.27	-1.22	-0.48	-0.01	0.02	-0.17	0.02	0.04
t^3 (14)(6.).	0.04	0.87	3.76	1.56	0.11	0.07	0.14	0.02	-0.01
t^3 (15)(2.).	-0.04	-0.28	-2.29	-0.90	-0.02	0.05	-0.03	0.00	-0.02
t^3 (15)(3.).	0.02	0.06	0.71	0.16	-0.10	-0.03	-0.06	0.04	0.00
t^3 (15)(4.).	0.01	0.02	0.50	0.37	0.15	0.01	0.10	0.02	-0.03
t^3 (15)(6.).	-0.05	-0.66	-3.61	-1.67	-0.26	-0.16	-0.07	0.00	-0.08
t^3 (16)(2.).	0.01	0.30	1.37	0.64	0.12	0.01	0.10	-0.02	-0.12
t^3 (16)(3.).	-0.01	0.37	0.73	0.20	-0.06	0.05	0.03	0.04	0.09
t^3 (16)(4.).	-0.02	0.17	-0.02	-0.14	-0.14	-0.02	0.09	0.01	0.02
t^3 (16)(5.).	0.03	0.56	2.72	1.18	0.14	0.09	-0.16	-0.03	0.12
t^3 (23)(1.).	-0.01	-0.95	-3.09	-1.24	-0.03	-0.06	0.11	0.01	-0.08
t^3 (23)(4.).	-0.02	-0.78	-3.10	-1.37	-0.19	0.04	0.08	0.03	0.04
t^3(23)(5.).	0.01	0.65	2.22	0.85	-0.01	0.02	-0.09	-0.02	0.13
t^3 (23)(6.).	0.03	0.67	2.89	1.09	-0.01	0.05	-0.09	0.04	0.06
t^3 (24)(1.).	0.01	1.46	4.50	1.96	0.21	0.27	0.25	-0.01	0.03
t^3 (24)(3.).	-0.01	-0.40	-1.50	-0.72	-0.13	0.01	0.09	-0.03	-0.04
t^3 (24)(5.).	-0.02	-1.00	-3.71	-1.57	-0.13	-0.02	-0.28	-0.01	-0.02
t^3 (24)(6.).	-0.01	0.03	-0.25	-0.12	-0.01	-0.13	-0.07	0.01	-0.09

Table 9. Cont.

t^3 (i j)(k-)	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
t^3 (25)(1.).	0.02	-0.66	-1.07	-0.38	0.03	-0.12	-0.23	-0.01	0.07
t^3 (25)(3.).	0.03	0.43	2.35	1.19	0.28	0.05	0.04	0.03	0.08
t^3 (25)(4.).	-0.01	1.04	2.84	1.15	0.05	-0.02	0.17	0.01	-0.02
t^3 (25)(6.).	-0.03	0.00	-1.15	-0.50	-0.06	0.06	0.22	-0.06	-0.06
t^3 (26)(1.).	-0.02	-0.06	-1.03	-0.63	-0.21	-0.16	-0.09	0.02	-0.03
t^3 (26)(3.).	-0.01	-0.17	-0.73	-0.39	-0.10	-0.07	-0.08	0.00	-0.04
t^3 (26)(4.).	0.05	0.30	2.82	1.40	0.30	0.01	0.05	-0.02	0.04
t^3 (26)(5.).	-0.01	-0.99	-3.35	-1.30	-0.01	-0.05	0.01	0.03	-0.09
t^3 (34)(1.).	0.00	-0.13	-0.47	-0.33	-0.15	-0.15	-0.13	0.05	0.00
t^3 (34)(2.).	0.03	1.17	4.60	2.09	0.32	-0.04	-0.16	-0.01	-0.01
t^3 (34)(5.).	0.03	0.08	1.40	0.81	0.27	0.06	0.19	0.04	-0.02
t^3 (34)(6.).	-0.04	-1.06	-4.32	-1.77	-0.10	0.02	0.12	-0.04	0.04
t^3 (35)(1.).	-0.01	0.74	1.81	0.81	0.11	0.15	-0.04	-0.02	0.05
t^3 (35)(2.).	-0.04	-1.08	-4.57	-2.04	-0.28	-0.06	0.05	-0.01	-0.22
t^3 (35)(4.).	0.02	-0.23	-0.10	-0.10	-0.06	-0.07	-0.13	-0.04	0.02
t^3 (35)(6.).	0.04	1.29	5.08	2.07	0.11	0.04	0.01	0.01	0.07
t^3 (36)(1.).	0.02	0.30	1.48	0.62	0.04	0.08	0.06	-0.02	0.03
t^3 (36)(2.).	-0.02	-0.50	-2.16	-0.70	0.11	0.02	0.17	-0.04	-0.02
t^3 (36)(4.).	0.00	0.04	0.01	0.00	0.00	-0.05	0.00	0.03	-0.08
t^3 (36)(5.).	-0.04	-0.29	-2.21	-1.06	-0.20	0.01	-0.15	0.04	-0.02
t^3 (45)(1.).	0.00	0.24	0.72	0.12	-0.15	-0.03	0.07	-0.03	-0.02
t^3 (45)(2.).	0.03	-0.04	0.87	0.42	0.08	0.04	0.12	0.00	0.04
t^3 (45)(3.).	-0.05	0.15	-1.29	-0.71	-0.21	0.01	-0.06	0.01	0.00
t^3 (45)(6.).	0.02	-0.23	0.16	0.17	0.10	0.03	-0.17	0.05	0.04
t^3 (46)(1.).	-0.02	-1.04	-3.74	-1.41	0.03	-0.05	-0.23	-0.03	-0.01
t^3 (46)(2.).	-0.05	-0.33	-2.56	-1.28	-0.29	0.12	0.02	0.02	0.05
t^3 (46)(3.).	0.04	1.02	4.31	1.77	0.10	0.03	-0.13	0.01	0.04
t^3 (46)(5.).	0.00	1.12	3.31	1.25	-0.04	-0.08	0.29	-0.05	-0.03
t^3 (56)(1.).	0.02	0.10	0.89	0.48	0.12	0.06	0.23	0.03	-0.04
t^3 (56)(2.).	0.05	0.99	4.50	1.79	0.06	-0.01	-0.23	0.03	0.15
t^3 (56)(3.).	0.00	-0.99	-2.87	-1.01	0.09	-0.05	0.13	-0.05	-0.05
t^3 (56)(4.).	-0.02	-0.89	-3.47	-1.42	-0.06	0.05	-0.12	0.01	0.00

The results cleared that no hybrid exhibited desirable values for all studied traits. It could be noticed that $t^3(_{24})(_{1.})$, $t^3(34)(_{2.})$, $t^3(_{35})(_{6.})$, $t^3(46)(3.)$, $t^3(_{46})(_{5.})$ and $t^3(_{56})(_{2.})$ showed great positive (desirable) effects for number of opened bolls per plant(B/P), seed cotton yield/plant (SCY/P) and lint yield/plant (LY/P). Meanwhile, $t^3(_{24})(_{1.})$, $t^3(_{12})(_{6.})$, $t^3(_{13})(_{4.})$ and $t^3(_{35})(_{1.})$ were the best combinations for (UHM) property. Moreover, $t^3(_{12})(_{5.})$, $t^3(_{24})(_{1.})$, $t^3(_{25})(_{6.})$, $t^3(_{46})(_{5.})$ and $t^3(_{56})(_{1.})$ were the best combinations for (UR) trait. In similar manner, $t^3(_{12})(_{6.})$, $t^3(_{13})(_{2.})$, $t^3(_{16})(_{5.})$, $t^3(_{23})(_{5.})$ and $t^3(_{56})(_{2.})$ were the best combinations for (FS) trait.

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

The specific combining ability effects t4 (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 10. The results revealed that no hybrids exhibited desirable values for all studied traits. However, 18, 24, 21,21,24, 24, 24, 15, and 24 out of 45 quadriallel crosses showed desirable specific combining ability effects t4 (ij)(kl) values for boll weight (BW), number of bolls/plant (B/P), seed cotton yield/plant (SCY/P), lint yield/plant (LY/P), lint percentage (LP), upper half mean (UHM), uniformity ratio(UR)) , fiber fineness (FF) and fiber strength (FS), 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 genotypes, 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 t4 (ij) (kl). In conclusion, from the preivous results it could be concluded that the combinations $[(P_1 \times P_3) \times (P_2 \times P_5)]$, $[(P_1 \times P_3) \times (P_4 \times P_6)]$ and $[(P_2 \times P_5) \times (P_4 \times P_6)]$ appeared to be the best promising double crosses for breeding toward most studied yield traits potentiality. In general, $[(P_1 \times P_5) \times (P_2 \times P_6)]$, $[(P_1 \times P_5) \times (P_3 \times P_4)]$ and $[(P_2 \times P_6) \times (P_3 \times P_4)]$ would be good combinations for most studied yield traits.

Table 10. The 4-line interaction effect of lines i, j, k and l due to particular arrangement t4 (i j)(k l) for yield component traits and some fiber properties.

t^4(i j)(k l)	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
t^4(12)(34)	-0.01	-0.18	-0.77	-0.36	-0.06	-0.04	-0.06	0.03	0.04
t^4(12)(35)	0.02	0.08	1.21	0.50	0.02	-0.11	-0.29	-0.01	-0.06
t^4(12)(36)	-0.02	0.09	-0.44	-0.14	0.04	0.16	0.35	-0.02	0.03
t^4(12)(45)	-0.02	0.09	-0.44	-0.14	0.04	0.16	0.35	-0.02	0.03
t^4(12)(46)	0.02	0.08	1.21	0.50	0.02	-0.11	-0.29	-0.01	-0.06
t^4(12)(56)	-0.01	-0.18	-0.77	-0.36	-0.06	-0.04	-0.06	0.03	0.04
t^4(13)(24)	-0.01	-0.78	-2.53	-1.17	-0.18	-0.16	-0.03	0.00	0.00
t^4(13)(25)	0.01	1.32	4.29	1.78	0.13	0.08	0.27	0.00	0.05
t^4(13)(26)	-0.01	-0.54	-1.76	-0.61	0.05	0.08	-0.24	0.00	-0.05
t^4(13)(45)	-0.01	-0.54	-1.76	-0.61	0.05	0.08	-0.24	0.00	-0.05
t^4(13)(46)	0.01	1.32	4.29	1.78	0.13	0.08	0.27	0.00	0.05
t^4(13)(56)	-0.01	-0.78	-2.53	-1.17	-0.18	-0.16	-0.03	0.00	0.00
t^4(14)(23)	0.01	0.96	3.30	1.53	0.24	0.21	0.09	-0.03	-0.04
t^4(14)(25)	0.00	-0.47	-1.30	-0.63	-0.12	-0.19	-0.28	0.04	-0.06
t^4(14)(26)	-0.02	-0.49	-2.01	-0.90	-0.13	-0.01	0.19	-0.01	0.10
t^4(14)(35)	-0.02	-0.49	-2.01	-0.90	-0.13	-0.01	0.19	-0.01	0.10
t^4(14)(36)	0.00	-0.47	-1.30	-0.63	-0.12	-0.19	-0.28	0.04	-0.06
t^4(14)(56)	0.01	0.96	3.30	1.53	0.24	0.21	0.09	-0.03	-0.03
t^4(15)(23)	-0.04	-1.41	-5.49	-2.28	-0.16	0.03	0.02	0.01	0.01
t^4(15)(24)	0.02	0.38	1.73	0.77	0.08	0.04	-0.08	-0.02	0.04
t^4(15)(26)	0.02	1.03	3.76	1.51	0.08	-0.07	0.06	0.00	-0.05
t^4(15)(34)	0.02	1.03	3.76	1.51	0.08	-0.07	0.06	0.00	-0.05
t^4(15)(36)	0.02	0.38	1.73	0.77	0.08	0.04	-0.08	-0.02	0.04
t^4(15)(46)	-0.04	-1.41	-5.49	-2.28	-0.16	0.03	0.02	0.01	0.01
t^4(16)(23)	0.02	0.45	2.19	0.76	-0.09	-0.24	-0.11	0.02	0.02
t^4(16)(24)	-0.01	0.40	0.80	0.40	0.10	0.13	0.10	0.02	-0.03
t^4(16)(25)	-0.02	-0.85	-2.99	-1.15	-0.02	0.11	0.01	-0.04	0.01
t^4(16)(34)	-0.02	-0.85	-2.99	-1.15	-0.02	0.11	0.01	-0.04	0.01
t^4(16)(35)	-0.01	0.40	0.80	0.40	0.10	0.13	0.10	0.02	-0.03
t^4(16)(45)	0.02	0.45	2.19	0.76	-0.09	-0.24	-0.11	0.02	0.02
t^4(23)(45)	0.02	0.45	2.19	0.76	-0.09	-0.24	-0.11	0.02	0.02
t^4(23)(46)	-0.04	-1.41	-5.49	-2.28	-0.16	0.03	0.02	0.01	0.01
t^4(23)(56)	0.02	0.96	3.30	1.53	0.24	0.21	0.09	-0.03	-0.04

Table 10. Cont.

$t^4(ij)(kl)$	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
t^4(24)(35)	-0.01	0.40	0.80	0.40	0.10	0.13	0.10	0.02	-0.03
t^4(24)(36)	0.02	0.38	1.73	0.77	0.08	0.04	-0.08	-0.02	0.04
t^4(24)(56)	-0.01	-0.78	-2.53	-1.17	-0.18	-0.16	-0.03	0.00	0.00
t^4(25)(34)	-0.02	-0.85	-2.99	-1.15	-0.02	0.11	0.01	-0.04	0.01
t^4(25)(36)	0.00	-0.47	-1.30	-0.63	-0.12	-0.19	-0.28	0.04	-0.06
t^4(25)(46)	0.01	1.32	4.29	1.78	0.13	0.08	0.27	0.00	0.05
t^4(26)(34)	0.02	1.03	3.76	1.51	0.08	-0.07	0.06	0.00	-0.05
t^4(26)(35)	-0.02	-0.49	-2.01	-0.90	-0.13	-0.01	0.19	-0.01	0.10
t^4(26)(45)	-0.01	-0.54	-1.76	-0.61	0.05	0.08	-0.24	0.00	-0.05
t^4(34)(56)	-0.01	-0.18	-0.77	-0.36	-0.06	-0.04	-0.06	0.03	0.04
t^4(35)(46)	0.02	0.08	1.21	0.50	0.02	-0.11	-0.29	-0.01	-0.06
t^4(36)(45)	-0.02	0.09	-0.44	-0.14	0.04	0.16	0.35	-0.02	0.03

Genetic parameters:

The Genetic parameters estimates were obtained and the results are presented in Table 11.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 boll weight (BW), lint percentage (LP), fiber fineness (FF) and fiber strength (FS).

Table 11. The estimation of genetic variances for yield components and some fiber properties.

Genetic parameters	BW	B/P	SCY	LY	LP	UHM	UR	FF	FS
σ^2_A	-0.04	-4.64	-45.67	-8.07	-0.43	-0.31	-0.25	-0.12	-0.37
σ^2_D	-0.09	33.15	361.75	59.30	-1.19	1.05	2.44	-0.17	-0.75
σ^2_{AA}	0.15	-27.17	-350.03	-56.77	2.12	-0.05	-2.07	0.36	1.35
σ^2_{AD}	0.38	-175.54	-2355.73	-397.00	5.41	-2.14	-11.81	0.84	3.16
σ^2_{DD}	-0.24	169.48	2571.03	440.25	-2.73	-1.38	8.00	-0.68	-1.85
σ^2_{AAA}	-0.76	351.09	4711.46	794.00	-10.81	4.28	23.61	-1.67	-6.33

Concerning epistatic variances, additive by additive genetic variance (σ^2_{AA}) and additive by dominance genetic variance (σ^2_{AD}) showed negative and considerable magnitude for all studied traits except for the same f0ur previous traits .While, dominance by dominance genetic variance (σ^2_{DD}) and additive by additive by additive genetic variance (σ^2_{AAA}) showed positive and considerable magnitude for all studied traits with the exception of the boll weight (BW), lint percentage (LP), fiber fineness (FF) and fiber strength (FS).

It could be concluded that fiber properties and yield components were mainly controlled by dominance by dominance (σ^2_{DD}) and additive by additive by additive (σ^2_{AAA}) 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 لبعض مكونات المحصول وصفات التيلة في القطن

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اشتملت الدراسة على ستة تراكيب وراثيه من القطن الباربادنس هى: جيزه ٨٠، جيزه ٥ ، جيزه ٩٠، جيزه ٩٥، R101، S106. طبقا لنظام التزاوج الدائرى النصف كامل أدخلت هذه الأباء فى سلسلة من التهجينات لتنتج ١٥ هجين جيل أول خلال موسم النمو ٢٠١٨ وفى موسم النمو ٢٠١٩ تم تزاوج هجن الجيل الأول معا لإنتاج ٤٥ هجين رباعى (زوجى) (بشرط ظهور أي أب في الهجين الرباعى مرة واحدة). وفى موسم النمو ٢٠٢٠، تم تقييم هذه التراكيب الوراثية المختلفة (الأباء الستة، ٤٥ هجين رباعى) بمحطة البحوث الزراعية بسدس حيث تم قياس الصفات الآتية: وزن اللوزة، عدد اللوز المتفتح للنبات، محصول القطن الزهر للنبات ، محصول القطن الشعر للنبات، معامل الحليج، طول التيلة، معامل الانتظام، نعومة التيلة، متانة 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 معنوياً أو عالي المعنوية بين هذه التراكيب الوراثية لمعظم الصفات المدروسة لصفات المحصول 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 والتباين المضيف× المضيف×المضيف). من خلال تحليل الهجن الرباعية كان أفضل الأصناف قدرة عامة على التآلف التركيبين جيزه ٨٥ و S106 لمعظم صفات المحصول ومكوناته بالإضافة لصفة طول التيلة. القدرة الخاصة علي التآلف : توجد سبعة أنواع من القدرة الخاصة علي التآلف تندرج تحت ثلاث مجاميع كالتالي: المجموعة الاولي: قدرة خاصة بين سلالتين: 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 جـــ٨٠ مع جـــ ٩٠أو جـــ٨٥ مع جـــ٩٥ لمعظم صفات المحصول. في هذا النوع يشترط وجود السلالتين معا في نفس الهجين الفردى وكانت أفضل الاتحادات عند تواجد جـــ٨٠ مع R101 أو جـــ٨٥ مع S106لمعظم صفات المحصول. في هذا النوع يشترط وجود إحدى السلالتين في هجين فردى والسلالة الأخري في الهجين الفردي الثاني وكانت افضل الأتحادات عند تواجد جـــ٨٠ في هجين فردى و S106 في هجين فردى آخر لنفس الهجين الزوجى لصفة طول التيله بجانب صفات المحصول. المجموعة الثانية: قدرة خاصة بين ثلاث سلالات: في هذا النوع لا يهم ترتيب السلالات (اي سلالتين في هجين فردي والسلالة الثالثة في الهجين الفردى الآخر) وكانت أفضل الاتحادات عند تواجد جـــ٨٥ مع جـــ٩٥ معS106 لمعظم صفات المحصول. في هذا النوع يشترط وجود السلالتين الأولي والثانية في الهجين الفردى الأول والسلالة الثالثة في الهجين الفردي الثاني) وكانت افضل الاتحادات عند تواجد جـــ٩٠ معR101 في الهجين الفردى الأول و S106 في الهجين الفردى الثانى لصفات المحصول. المجموعة الثالثة: قدرة خاصة بين أربع سلالات: في هذا النوع لا يهم ترتيب السلالات (اي سلالتين في هجين فردي والسلالتين الأخريين في الهجين الفردى الأخر) وكانت أفضل الاتحادات عند تواجد جـــ٨٥و جـــ٩٥ و R101 و S106 معا لمعظم صفات المحصول. في هذا النوع يشترط وجود السلالتين الأولي والثانية في الهجين الفردى الأول والسلالتين الثالثة والرابعة في الهجين الفردي الثاني) وكانت أفضل الاتحادات عند تواجد جـــ٨٠ مع R101 في الهجين الفردى الاول و جـــ٨٥ مع بيماس ٦في الهجين الفردى الثانى أو تواجد جـــ٨٠ مع R101 في الهجين الفردى الأول و جـــ٩٠ مع جـــ٩٥ فى الهجين الفردى الثانى أو تواجد جـــ٨٥ مع S106 في الهجين الفردى الاول و جـــ٩٠ مع جـــ٩٥ في الهجين الفردى الثانى لصفات المحصول. أظهرت الهجن التالية أفضل إمكانية لإستخدامها في برامج التربية لتحسين صفات المحصول ومكوناته وفى مقدمتها محصول القطن الزهر ومحصول القطن الشعر وعدد اللوز المتفتح الكلى للنبات ثم باقى المكونات الأخرى للمحصول وهذه الهجن هى: [(جيزه ٨٠×جيزه ٩٠) (جيزه ٨٥× R101]، [(جيزه ٨٠×جيزه ٩٠) (جيزه٩٥× S106] و[(جيزه٨٥× R101) (جيزه٩٥× S106]. 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.

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